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The Impact of Simulation-Based Postoperative Pain Management Education on Nursing Students: A Quasi-Experimental Study

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Abstract

Background: Undergraduate nursing programs commonly include pain management education. However, studies indicate that nursing curricula often do not provide sufficient content and effective instructional methods to adequately prepare students for managing patients' pain. Simulation-based education offers experiential learning opportunities and is recognized as an effective strategy for enhancing learning outcomes.

Aim: This study aimed to compare the effects of simulation-based education and traditional instruction on nursing students' knowledge, attitudes, and self-efficacy related to postoperative pain management.

Methods: A quasi-experimental, comparative research design was employed. Students were assigned to groups based on the last digit of their student identification number. A total of 103 students participated in the study. Data were collected using the Descriptive Information Form, the Knowledge and Attitudes Survey Regarding Pain, and the Pain Management Self-Efficacy Scale. The educational program lasted four weeks and covered key topics in postoperative pain management. In addition to traditional instruction, the experimental group received high-fidelity simulation training. Data were analyzed using the independent samples t-test, Mann-Whitney U test, and Wilcoxon signed-rank test.

Results: The mean age of participants in both groups was 21 years. In response to the item "Participants' Opinions on the Effectiveness Level of Nurses in Pain Management," 68.6% of the experimental group and 71.2% of the control group rated it as "Effective." The experimental group demonstrated significantly higher scores in knowledge and attitudes toward postoperative pain management compared to the control group. However, no significant difference was observed between the groups in terms of self-efficacy. Notably, both groups showed an increase in self-efficacy levels over time.

Conclusion: Simulation-based training enhances knowledge and attitudes related to postoperative pain management; however, it does not produce short-term improvements in self-efficacy. Future research should investigate the long-term effects of simulation-based education on clinical competence.

Keywords: High-fidelity simulation training, nursing education, nursing student, postoperative pain, simulation

Introduction

Pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage," according to the International Association for the Study of Pain (IASP).[1] However, due to its inherently subjective nature, pain assessment remains challenging, as individuals may perceive and express pain differently.[2,3] Generally, pain arises from any stimulus that causes or has the potential to cause tissue damage. In addition, it functions as a warning mechanism, alerting individuals to pathological conditions in the body and enabling them to avoid harmful stimuli or pathogens. However, when this intrinsic warning system malfunctions and pain becomes chronic, it may evolve into a debilitating condition, exerting adverse effects on both physical health and psychological well-being.[2] Among the various types of pain, postoperative pain remains one of the most common and clinically significant challenges encountered in hospital settings. To prevent pain-related complications, it is essential to ensure that postoperative pain management is delivered appropriately, effectively, and with timely interventions.[3]

Given their continuous and close contact with patients, nurses are uniquely positioned to implement effective postoperative pain management strategies. These strategies are not only vital for patient comfort but also serve as indicators of the quality of care provided. Effective postoperative pain management reduces existing pain, accelerates recovery, shortens hospital stays, and improves quality of life and patient satisfaction.[4,5] However, numerous studies in the literature suggest that nurses often lack sufficient knowledge regarding pain management and may hold inappropriate attitudes toward it.[4,7] These gaps in nurses' knowledge and attitudes underscore the importance of undergraduate nursing education as a foundational stage for developing effective pain management competencies.

Undergraduate nursing programs commonly include pain management education. However, studies indicate that nursing curricula frequently do not provide sufficient depth or scope to adequately prepare students for effective pain management.[8,9] Enhancing nursing students' understanding of this topic is essential for promoting effective pain management practices in both clinical training and professional practice. Research examining the impact of pain education has demonstrated positive effects on nursing students' knowledge, attitudes

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toward pain management, and self-efficacy.[10] Despite the recognized importance of knowledge, attitudes, and self-efficacy in effective postoperative pain management, traditional didactic teaching methods may be insufficient to fully support the development of these competencies in nursing students. Postoperative pain management requires not only cognitive understanding but also clinical judgment, confidence, and the ability to apply knowledge in complex and dynamic patient situations. Educational approaches that rely primarily on theoretical instruction may limit opportunities for experiential learning, reflective practice, and the integration of cognitive and affective skills essential for effective pain management. Such limitations may influence not only students' knowledge levels but also their confidence in applying this knowledge in clinical settings. Consequently, self-efficacy emerges as a central construct in postoperative pain management education.

Bandura[11] conceptualized self-efficacy as individuals' beliefs in their capability to organize and execute the actions required to achieve specific goals. According to this theory, individuals' behaviors and performance vary based on their perceived level of self-efficacy, with lower self-efficacy often associated with reduced motivation and diminished self-confidence.[12] Within Bandura's framework,[11] self-efficacy is regarded as a dynamic construct that develops through learning and experience. Importantly, it is shaped by four principal sources: mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states. Simulation-based education is particularly well aligned with these sources. First, simulation provides mastery experiences by enabling nursing students to actively perform postoperative pain assessment and management interventions in a realistic yet controlled environment. Second, vicarious experiences are supported through exposure to modeled clinical practices embedded in standardized simulation scenarios, allowing students to observe and internalize effective pain management behaviors. Third, verbal persuasion is facilitated through immediate, structured feedback and guided debriefing processes that reinforce learners' confidence in their clinical capabilities. Finally, simulation enables students to experience and reinterpret physiological and emotional responses, such as stress or anxiety, within a safe learning environment, thereby reducing negative self-appraisals and strengthening adaptive efficacy beliefs. Through these mechanisms, simulation-based education is theoretically positioned as a more effective approach than traditional didactic instruction for enhancing nursing students' self-efficacy in postoperative pain management.[11]

In this context, providing nursing students with targeted education and structured guidance in pain management may contribute not only to improved knowledge but also to greater confidence in assessing and managing postoperative pain. Therefore, examining the effects of simulation-enhanced education on nursing students' knowledge, attitudes, and self-efficacy related to postoperative pain management is essential for informing evidence-based educational strategies and improving the quality of pain management in clinical practice.

Hypotheses

This study tested the following hypotheses:

H_1: There is a difference between the experimental and control groups in terms of students' knowledge and attitudes regarding postoperative pain management.

H_2: There is a difference between the experimental and control groups in terms of students' perceived self-efficacy regarding postoperative pain management.

Materials and Methods

Study Design and Setting

This study employed a quasi-experimental design. It compared the effects of traditional postoperative pain education alone with those of traditional education combined with simulation-based training among students enrolled in the Surgical Nursing course. The study was conducted during the 2023–2024 academic year in the nursing faculty of a public university located in northwestern Türkiye. Data collection took place between April and June 2024. Participants were recruited at the beginning of the semester, and outcome assessments were conducted upon completion of the intervention phase. The study was completed as planned without premature termination or major modifications to the design. The manuscript was prepared in accordance with the TREND (Transparent Reporting of Evaluations with Nonrandomized Designs) reporting guidelines.

Study Sample

Students enrolled in the Surgical Nursing course were invited to participate in the study. Although the intervention was conducted outside the formal course curriculum, only students registered for the Surgical Nursing course during the study period were eligible, as prior completion of this course was considered an exclusion criterion. The inclusion criteria were: a) enrollment in the Surgical Nursing course for the first time, b) no prior education on postoperative pain management, and c) provision of written informed consent before participation.

To determine the sample size, G*Power 3.1 software was used. To estimate the effect size, we calculated the mean effect size derived from previous quasi-experimental studies investigating similar interventions in nursing education.[13–15] Using this average effect size, a power analysis was conducted with α=0.05 and ß=0.80, indicating that a minimum of 35–40 participants per group would be sufficient to detect a meaningful effect. However, to increase statistical power, enhance the reliability of the results, and improve the generalizability of the findings, we aimed to include all eligible students enrolled in the Surgical Nursing course. Of the 120 students registered for the course,[13] were excluded because they were repeating the course, and 4 declined to participate due to time constraints. A total of 103 nursing students who met the inclusion criteria were recruited and included in the final analysis (Experimental=51; Control=52). The experimental group received both Postoperative Pain Education and Simulation Training, whereas the control group received only Postoperative Pain Education. The intervention was completed by all participants, and no attrition occurred during the study period.

Randomization and Allocation

Assignment to the experimental and control groups were not performed using a true randomization procedure. Instead, students were allocated based on the last digit of their student identification number: those with even numbers were assigned to one group, and those with odd numbers were assigned to the other. As this allocation method does not constitute full randomization, the study is classified as quasi-experimental.[16] Accordingly, no blinding procedures were implemented, and both participants and researchers were aware of group assignments. To minimize potential bias, data analysis was conducted by an independent biostatistician who was blinded to group allocation.

Data Collection Tools

Student Description Form: This form consisted of three questions assessing the sociodemographic characteristics of nursing students (age and gender) and their perspectives on the effectiveness of nurses in pain management.

Knowledge and Attitudes Survey Regarding Pain (NKASRP): Originally developed by Ferrell et al.,[17] this instrument was designed to measure nurses' knowledge and attitudes regarding pain management. The Turkish version, validated and tested for reliability by Yıldırım et al.,[18] consists of 39 items assessing knowledge of pain control as well as attitudes toward pharmacological and non-pharmacological pain management strategies. Of these items, 22 are in a true/false format,[14] are multiple-choice, and 2 are case-based items, each containing two sub-questions. Each correct response was scored as 1 point, whereas incorrect or unanswered items were scored as 0. The minimum possible score on the scale is 0, and the maximum is 39. Higher scores indicate a more accurate understanding of and more appropriate attitudes toward pain management.[18] In the present study, the Cronbach's alpha coefficient for this scale was 0.50. Although this value is relatively low, Cronbach's alpha assumes a unidimensional and internally consistent scale structure. The NKASRP comprises heterogeneous item formats and multiple content domains designed to assess knowledge and attitudes related to pain management rather than a single latent construct, which may limit the suitability of Cronbach's alpha as the sole indicator of internal consistency.[19]

Pain Management Self-Efficacy Scale (PMSEQ): The scale was originally developed by Macindo et al.[20] and subsequently adapted into Turkish and validated by Aydın Sayılan et al.[21] It consists of 21 items grouped into three subscales: 14 items under "Comprehensive Pain Management Self-Efficacy," 4 under "Assessment Pain Management Self-Efficacy," and 3 under "Supportive Pain Management Self-Efficacy." Responses are rated on a 6-point Likert scale ranging from 0 ("not confident at all") to 5 ("completely confident"). Total and subscale scores are calculated by summing the item scores, with all items positively worded.[20,21] In our study, the Cronbach's alpha coefficient for the PMSEQ was 0.94.

Table 1. Postoperative pain management training program

Postoperative pain management training program	Content	Learning Outcomes
- Day 1 - Duration: 40 minutes	- What is pain? - Physiology of pain - Types of pain	- Understanding the fundamental definition and mechanisms of pain - Gaining knowledge about the physiological processes involved in pain - Identifying and distinguishing between different types of pain
- Day 2 - Duration: 40 minutes	- What is postoperative pain? - Why is postoperative pain management important? - Assessment of postoperative pain - Scales used in the assessment of postoperative pain	- Understanding the characteristics and importance of postoperative pain management - Learning methods for assessing postoperative pain - Developing the ability to recognize and use pain assessment scales
- Day 3 - Duration: 40 minutes	- Approach to patients with postoperative pain - Treatment of postoperative pain - Pharmacological and non-pharmacological methods used in postoperative pain management	- Developing an appropriate approach to patients experiencing postoperative pain - Differentiating between pharmacological and non-pharmacological treatment methods for postoperative pain - Formulating an effective pain management plan
- Day 4 - Duration: 40 minutes	- Evaluation of pain treatment - Discharge education	- Assessing the effectiveness of pain management interventions - Providing patient education on pain management at discharge - Promoting patient awareness of pain management during the postoperative period
- Teaching strategies	- Lecture - PowerPoint presentation - Group discussion and feedback	

Intervention

During the course registration week, researchers invited students to participate in the study. It was clearly stated that participation was voluntary and would not affect academic evaluations. After obtaining written informed consent, students were assigned to their respective groups. In the first session, students in both groups completed the Student Description Form and the Pain Management Self-Efficacy Scale. All students received postoperative pain management training at a scheduled time.

Both groups participated in a standardized four-week theoretical education program on postoperative pain management, delivered through lectures covering pain assessment, pharmacological and non-pharmacological interventions, and nursing responsibilities (Table 1). Students in the control group received no additional educational intervention beyond this theoretical training. In contrast, students in the experimental group participated in an individual simulation-based training session focused on postoperative pain management. The simulation was conducted using a high-fidelity patient simulator and followed a predefined clinical scenario designed to reinforce pain assessment, intervention selection, and clinical decision-making skills. Each simulation session was delivered individually and followed a standardized sequence consisting of scenario implementation and structured debriefing. The duration and content of the simulation sessions were consistent for all participants. Post-test assessments were conducted one week after completion of the theoretical education in the control group and one week after the simulation session in the experimental group to ensure equivalent timing between the intervention and outcome measurement (Fig. 1).

Intervention Fidelity

To ensure intervention fidelity, all students in the experimental group participated in individual simulation sessions based on a single predefined postoperative pain management scenario. The same scenario structure, learning objectives, clinical cues, and expected nursing interventions were applied consistently across all 52 simulation sessions. Each session followed an identical implementation framework, including standardized scenario delivery and structured debriefing. A uniform feedback protocol was used for all participants, focusing on pain assessment, selection of appropriate interventions, and clinical decision-making in postoperative pain management.

All simulation sessions were facilitated by the same researchers throughout the study. Prior to data collection, calibration meetings were conducted to standardize scenario delivery, student guidance, and feedback procedures, thereby minimizing inter-session variability. The Pain Management Self-Efficacy Scale and the Knowledge and Attitudes Survey Regarding Pain were administered one week after completion of the respective educational interventions in both groups, ensuring consistency in the time interval between intervention exposure and outcome assessment.

Data Analysis

Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics included means, standard deviations, frequencies, percentages, medians, and minimum and maximum values. The normality of data distribution was assessed using histogram visualizations and the Kolmogorov-Smirnov test. Between-group differences were examined using the independent samples t-test and the Mann-Whitney U test, depending on the normality assumption. Within-group changes for continuous variables were evaluated using the Wilcoxon signed-rank test. Statistical significance was set at $p<0.05$ for all analyses.

Ethical Considerations

Ethical approval for the study was obtained from Kastamonu University Non-interventional Ethics Committee (Approval Number: 2024-KAEK-47, Date: 06.03.2024), along with administrative permission from the faculty dean's office. Participation was voluntary, and students were assured that their involvement would not affect their academic evaluations or examination outcomes. Prior to participation, written informed consent was obtained from all participants, who were informed of their right to withdraw from the study at any time without penalty or academic disadvantage. The study was conducted in accordance with the Declaration of Helsinki.

Results

The mean age of participants in both groups was 21 years. In the experimental group, 66.7% of participants were female, while 65.4% of the control group were female. In response to the item "Participants' Opinions on the Effectiveness Level of Nurses in Pain Management," 68.6% of the experimental group and 71.2% of the control group rated nurses as "Effective." Statistical analysis revealed no significant differences between the groups in this perception or in other descriptive variables ($p>0.05$) (Table 2).

The mean pre-test PMSEQ scores were 78.98 (11.77) in the simulation (experimental) group and 77.13 (13.54) in the traditional education (control) group. Post-test mean PMSEQ scores were 84.90 (14.09) for the experimental group and 83.55 (11.26) for the control group. Between-group analysis did not demonstrate a statistically significant difference in PMSEQ scores. The difference in post-test PMSEQ scores between groups was negligible (Cohen's $d=0.11$, 95% confidence interval (CI) [−0.28, 0.50]). Regarding NKASRP scores, students in the simulation group achieved higher mean scores than those in the traditional education group (23.25 (3.09) vs. 21.63 (4.36), respectively). This difference was statistically significant ($p=0.032$) and corresponded to a moderate effect size (Cohen's $d=0.34$, 95% CI [−0.05, 0.73]) (Table 3).

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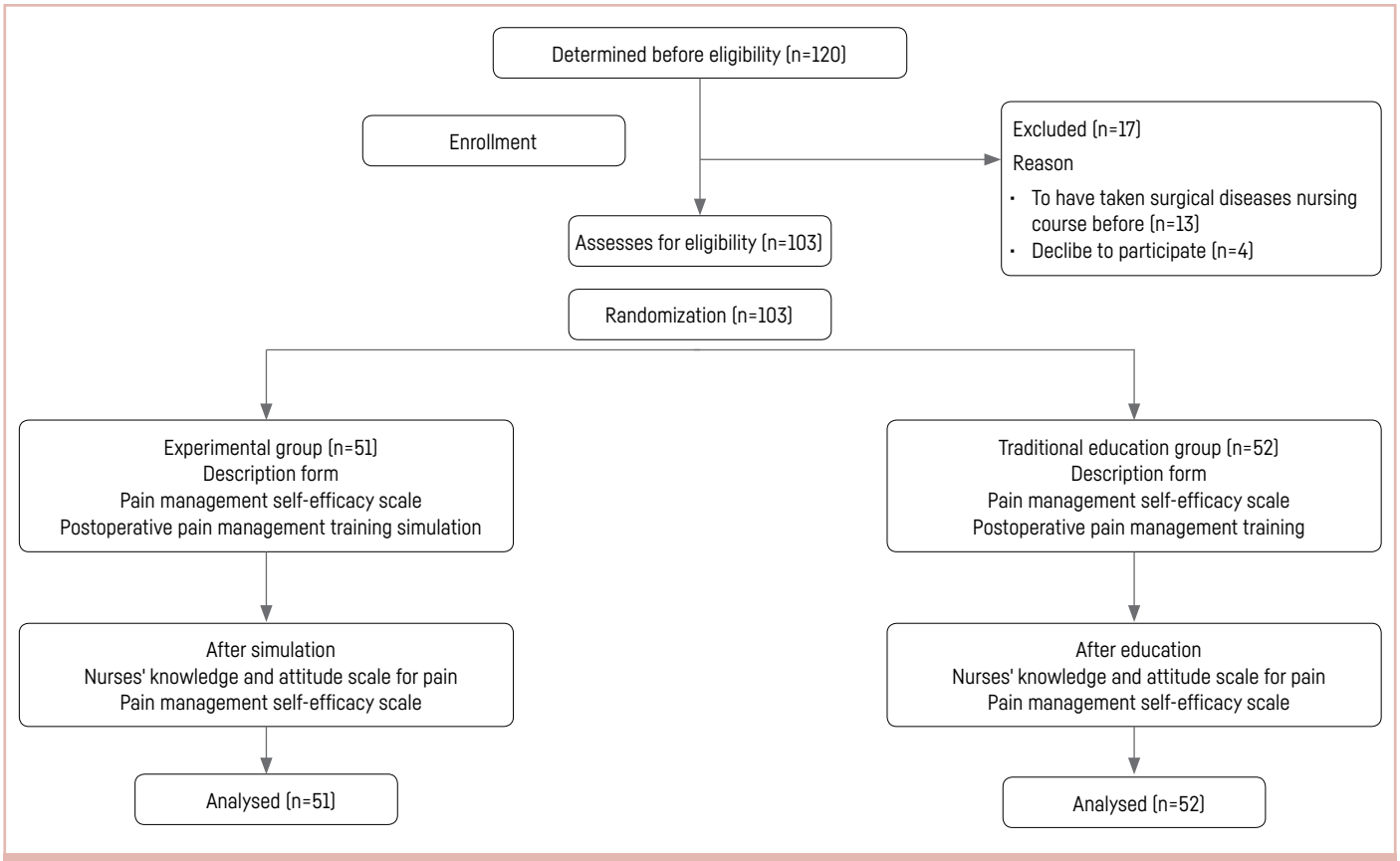

Figure 1. Study flowchart.

Table 2. Participants' characteristics

Characteristics	Experimental group (n=51)	Control group (n=52)	p
Age (mean (SD))	21.02 (1.46)	20.79 (1.47)	0.80*
	n (%)	n (%)	
Sex			0.89**
Male	17 (33.3)	18 (34.60)	
Female	34 (66.7)	34 (65.40)	
Participants' opinions on the effectiveness of nurses in pain management			0.11**
Less effective	2 (3.9)	7 (13.5)	
Effective	35 (68.6)	37 (71.2)	
Very effective	14 (27.5)	8 (15.4)	

*: Pearson's chi square test, **: Independent samples t-test. n: Frequency, %: Percentage, SD: Standard deviation.

Table 3. Comparison of pain management self-efficacy and knowledge-attitude mean scores between groups

Scale	Experimental group (n=51)		Control group (n=52)		Z	p
	Mean (SD)	Median (Min-Max)	Mean (SD)	Median (Min-Max)		
Pain management self-efficacy scale pre-test	78.98 (11.77)	80 (54–103)	77.13 (13.5)	76 (42–101)	-0.825*	0.41
Pain management self-efficacy scale post-test	84.90 (14.09)	85 (51–104)	83.55 (11.26)	83 (55–102)	-0.888*	0.37
Mean difference (% change)	+5.92 (+7.5%)		+6.42 (+8.3%)			
Knowledge and attitudes regarding pain scale	23.25 (3.09)	23 (18–31)	21.63 (4.36)	22 (22–31)	2.176**	**0.032**

*: Mann–Whitney U test, **: Independent samples t-test. SD: Standard deviation.

Table 4. Within-group comparison of pre-test and post-test mean scores on the pain management self-efficacy Scale in the experimental and control groups

Scale	Experimental group (n=51)		Control group (n=52)	
	Z	p	Z	p
Pain management self-efficacy scale pre-test vs. post-test	-3.086*	**0.002**	-3.916*	**<0.001**

*: Wilcoxon test.

Although no significant difference was found between the groups in terms of PMSEQ scores, both the experimental (p=0.002) and control (p<0.001) groups demonstrated significant within-group improvements from pre-test to post-test (Table 4).

Discussion

This study aimed to evaluate the comparative effectiveness of different educational modalities on nursing students' pain management self-efficacy and clinical knowledge and attitude. The parity observed between the groups in self-efficacy improvements suggests that any structured educational intervention can enhance a student's perceived capability. However, the distinct advantage of the simulation group in knowledge and attitudes underscores a potential gap between 'feeling confident' and 'being clinically informed.' These results imply that while traditional methods may suffice for building self-assurance, simulation-based training is a more robust catalyst for rectifying misconceptions and internalizing evidence-based pain management principles.

Direct comparisons of traditional and simulation-based education in relation to PMSEQ outcomes are scarce. Nevertheless, the present findings should be interpreted in light of previous studies examining self-efficacy outcomes in nursing education.[22,23] For instance, Mohamed and Fashafsheh[22] reported a marked increase in nursing students' self-efficacy following simulation-based training. Similarly, Kim[23] found that simulation-based practical education enhanced nursing students' self-efficacy levels. Simulation provides students with opportunities to engage in realistic clinical scenarios, thereby strengthening problem-solving and clinical decision-making skills; as these competencies develop, corresponding increases in perceived self-efficacy may occur.[24] As these skills improve, an increase in perceived self-efficacy may be observed.[11] In this study, although both the experimental and control groups demonstrated significant increases in PMSEQ mean scores, between-group comparisons revealed no statistically significant difference in PMSEQ scores, indicating comparable effects across the two educational approaches. This finding suggests that simulation-based training may not confer a distinct short-term advantage over traditional instruction in terms of pain management self-efficacy. According to Bandura,[11] sustained improvements in self-efficacy require repeated mastery experiences, opportunities for autonomous performance, and continuous reinforcement over time. In the present study, simulation was delivered as a time-limited educational component, which may have been sufficient to enhance knowledge and attitudes but insufficient to produce a distinct advantage in self-efficacy beyond that achieved through theoretical instruction alone. Thus, the absence of a between-group difference in self-efficacy should not be interpreted as a contradiction of Bandura's theory;[11] rather, it may indicate that the development of self-efficacy requires more prolonged and repeated experiential learning opportunities than those provided within the scope of this intervention. Indeed, previous studies in the literature suggest that repeated simulation experiences can enhance students' self-efficacy levels over the long term.[25,26] Shin et al.[27] reported that students initially experienced difficulties when exposed to active learning and simulation-based approaches; however, as they became more familiar with these methods, improvements in skill performance and learning engagement were observed.

In contrast to the self-efficacy findings, the present study demonstrated a clear advantage of simulation-based education over traditional instruction in terms of pain-related knowledge and attitudes, as reflected by significantly higher NKAS-RP scores. Although limited, existing literature comparing traditional and simulation-based education in relation to nursing students' pain-related knowledge and attitudes supports these findings. For example, in evaluating the effects of simulation training on knowledge and attitudes related to pain, Tawalbeh[14] found that integrating simulation into both theoretical and clinical curricula had a more pronounced impact on nursing students' competence and confidence in performing critical tasks than traditional education alone. Similarly, Salameh et al.[28] demonstrated that high-fidelity simulation significantly outperformed traditional methods in enhancing students' clinical knowledge, critical thinking, and decision-making skills in a cohort of 151 nursing students. Simulation-based learning has also been shown to influence learners' affective orientations and attitudes toward clinical practice. The observed improvement in attitudes toward pain management in the simulation group may be attributed to the experiential and affective components of simulation-based learning. Unlike traditional instruction, simulation requires active engagement in realistic clinical scenarios, thereby promoting emotional involvement, reflection, and perspective-taking. Previous research has shown that immersive and virtual simulation environments enhance learning presence and self-directed learning, both of which are closely associated with more positive learning attitudes and greater affective engagement among nursing students.[29]

In pain management education, simulated clinical encounters may help students internalize patients' pain experiences, foster empathy, and reconsider preconceived beliefs about pain assessment and control.[30] Consequently, simulation-based education may facilitate attitudinal change by bridging cognitive understanding with emotional experience, which may explain the higher attitude-related outcomes observed in the simulation group. Although empirical studies specifically examining attitudes toward pain in the context of simulation-based learning are few in number, the literature generally emphasizes the potential of high-quality simulation to promote positive attitudinal change among students.[31,32] The findings of the present study are consistent with the existing literature.

Limitations

This study has several limitations. First, the sample consisted solely of nursing students from a single university, which may limit the generalizability of the findings to other educational settings and student populations. Second, outcomes were assessed only in the short term following the educational interventions; therefore, the sustainability of changes in self-efficacy, knowledge, and attitudes toward pain management could not be evaluated.

Conclusion and Recommendations

The differential effects observed across outcome domains highlight the distinct ways in which simulation-enhanced education may contribute to the development of nursing competence. While simulation appears particularly effective in strengthening knowledge and attitudinal aspects of pain management, self-efficacy may represent a more stable construct that requires sustained experiential exposure to change meaningfully. These findings suggest that simulation-supported learning may primarily facilitate knowledge integration and attitudinal refinement in the short term, whereas perceptions of self-efficacy may evolve more gradually through repeated and prolonged clinical engagement.

Importantly, the implications of these findings extend beyond undergraduate nursing education. Given the complexity and dynamic nature of pain management in clinical practice, simulation-based education offers a valuable platform not only for students but also for practicing nurses. By providing opportunities for experiential learning, reflective practice, and clinical decision-making within a controlled and low-risk environment, simulation may support the ongoing development of professional competence and confidence in pain management across different career stages.

To advance understanding of the durability and progression of learning outcomes associated with simulation-enhanced education, future research should employ longitudinal designs that assess changes over extended periods. Investigating the long-term impact of repeated and sustained simulation exposure may provide important insights into its role in promoting enduring knowledge retention, skill maintenance, and effective transfer of competencies to real-world clinical settings. Larger, randomized, and multi-site studies comparing diverse educational strategies would further strengthen the evidence base and inform the optimization of undergraduate nursing curricula as well as continuing professional development programs.

Ethics Committee Approval: The study was approved by the Kastamonu University Non-interventional Ethics Committee (Approval Number: 2024-KAEK-47, Date: 06.03.2024).

Informed Consent: Written informed consent was obtained from all the participants.

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