



Original research

Development and evaluation of a web-based acute pain management education program for Korean registered nurses: A randomized controlled trial



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ABSTRACT

The aim of this randomized controlled trial was to develop a web-based acute pain management education program for nurses and to evaluate its effectiveness. The developed program consisted of a total duration of 400 min with eight modules and 29 topics in pain management. Fifty nurses from the post-anesthesia care unit in two university-affiliated hospitals in Seoul, Korea were randomly assigned to either the experimental group (n = 25) or the control group (n = 25) and a total of 46 nurses, 23 for each group, completed the pre and post-tests. The pre and post-tests were performed to evaluate the changes of the nurses' knowledge, attitude, and self-efficacy regarding acute pain management. The experimental group showed a significant increase in knowledge and in self-efficacy about pain management compared to the control group (u = 389.0, p = .006; u = 360.0, p = .030, respectively). The results support the effective use of these web-based modules as part of a continuing education program on pain management for nurses working in an acute care setting. The findings of this study can be the basis for the development of evidence-based guidelines and training tailored to the Korean culture and similar settings.

More than 313 million people undergo surgical procedures globally each year and the number is increasing annually (Meara et al., 2015). Despite an improved understanding of pain mechanisms and new approaches to advanced pain management, effective acute pain management still remains a global challenge (Gan, 2017), particularly in the effective management of postoperative pain. For example, 75–80% of patients experience moderate/extreme pain during the immediate postoperative period, and 74% still have these levels of pain after discharge in Western countries (Gan, 2017; Meissner et al., 2015). Poor management of acute pain may lead to serious medical complications (e.g., pneumonia, infection, and deep vein thrombosis), and progress to chronic pain; it may delay discharge, which also causes a higher social burden, such as health care costs and absenteeism (Joshi et al., 2014; Meissner et al., 2015).

As nurses provide 24-h nursing care to hospitalized patients, they play a pivotal role in acute pain management by monitoring and assessing the pain, medicating and educating patients, and communicating with other medical staff about the patient's pain (Han et al.,

2016; Kaasalainen et al., 2015). Although nurses also contribute as a specialist in a multidisciplinary team for acute pain management, their knowledge about pain management is rather low in Korea (Han et al., 2016). However, lack of knowledge has been reported as a major barrier to providing optimal pain management in a clinical setting (Latchman, 2014; Medrzycka-Dabrowska et al., 2015). One of the main reasons for this knowledge gap is that the typical nursing curriculum includes only a minimal amount of content covering very basic pain management principles (Allred and Gerardi, 2017; Voshall et al., 2013). In Korea, pain management is not usually taught as a distinct subject, but is scattered amongst various courses on other topics. Also, there is no minimum requirement for teaching or testing regarding pain management in Korean nursing curriculums. Although Korean registered nurses have the requirement for mandatory continuing education (8 h yearly) (Jho, 2013), the education programs focus mostly on specific diseases and few focus on pain management.

Lack of such knowledge is associated with a poor attitude regarding pain management (Angeletti et al., 2018; Chiang et al., 2006;

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Gerbershagen et al., 2013). For example, nurses often depend on their own judgment in assessing a patient's pain while disregarding the patient's self-report that is the most reliable indicator of pain (Gerbershagen et al., 2013). Knowledge enhancement improves the level of self-efficacy or self-confidence in one's ability to perform a certain task successfully (Angeletti et al., 2018; Chiang et al., 2006). Several studies that analyzed the importance of education have demonstrated that education can enhance a nurse's level of knowledge, self-efficacy, and attitude regarding pain, which also can improve their pain management performance and patient outcomes (Angeletti et al., 2018; Chiang et al., 2006).

Education for health professionals can be provided in a variety of ways depending on the characteristics of the participant and the educational environment. Web-based education has received attention recently from practicing healthcare professionals (Du et al., 2013). It is an efficient medium for transmitting knowledge and improving the quality of care (Davies et al., 2017). This platform allows learners to learn at their own pace and at a location of their choice in a cost-efficient way (Rouleau et al., 2017). Additionally, content can be presented thru a variety of multimedia components (Romero-Hall, 2015). Due to these positive findings, web-based education is usually undertaken to provide information for healthcare professionals in Korea. For example Korean nurses attend a continuing education program via either online or offline. Those web-based pain management education programs that have been proposed for health professionals mainly target topics on general pain (Al Qadire and Al Khalailah, 2014; Lax et al., 2011) or pain assessment (Phillips et al., 2014) in Western countries. However, few have targeted acute pain management, which is a topic often embedded into general pain management education programs. Moreover, few studies have been conducted in Asian countries, including South Korea. Cross-country comparisons reveal large differences in terms of healthcare systems, as well as cultural aspects that affect perceptions and attitudes regarding pain (Kim et al., 2017).

1. Objectives

We developed a web-based acute pain management program for Korean registered nurses and evaluated the effectiveness of the program by examining their knowledge, attitude, and self-efficacy. The trial was conducted among nurses working in a post-anesthesia care unit (PACU), where patients span the transition from surgery room to wards, often experiencing postoperative acute pain (Luo and Min, 2017). The research hypotheses of this study were as follows: there will be significant differences between the experimental group and control group in changes of: (1) knowledge about pain management, (2) attitude regarding pain management, and (3) self-efficacy for pain management before and after the education program.

2. Design

A randomized controlled trial with pre-vs. post-intervention and random assignment design aimed to examine the effects of the education program. The education program development and evaluation was guided by the analysis, design, development, implementation, and evaluation (ADDIE) model (Schlegel, 1995).

3. Methods

3.1. Step 1: Analysis

A program development team was assembled, including one nursing professor with experience in pain management, one anesthesiologist, and two PACU nurse managers. The team examined learning needs and preferences by conducting a needs-assessment questionnaire to identify knowledge gaps and training needs. Nurses with at least one year of experience were recruited from the PACU and two surgical wards in a

Table 1
Modules and topic of the web-based acute pain management education program.

Modules (time)	Topics
Pain theory (50 min)	<ul style="list-style-type: none"> ● Necessity of pain management ● Principles & pathophysiology of pain ● Classification of pain
Pain assessment (50 min)	<ul style="list-style-type: none"> ● Principles of pain management ● Pain assessment tool ● Pain measurement ● Pain disorder
Pharmacotherapy for pain management (50 min)	<ul style="list-style-type: none"> ● Different classes of drugs for pain management ● Analgesics side effects
Complementary methods for pain management (50 min)	<ul style="list-style-type: none"> ● Types of complementary therapies ● Evidence and application for complementary therapies for pain management ● Indications & contraindications for pain patients' chief complaints
Intervention procedures of pain management (50 min)	<ul style="list-style-type: none"> ● The role of a pain clinic ● Types of nerve block & nerve block methods ● Nursing management after nerve block
Patient-controlled analgesia (PCA) (50 min)	<ul style="list-style-type: none"> ● Types of PCA ● Nursing education of PCA patient ● PCA management
Recent advances for pain management (50 min)	<ul style="list-style-type: none"> ● Recent data for pharmacotherapy for pain management ● Recent data for non-pharmacotherapy for pain management ● Pain management in multidisciplinary approach
Pain management for special groups (50 min)	<ul style="list-style-type: none"> ● Pain management for children ● Pain management for geriatric patients ● Pain management and recognition of patients who abuse opioids ● Therapeutic communication with a patient

university-affiliated hospital in Seoul, Korea.

3.2. Step 2: Design

Learning content and objectives were set for the education program. An online teaching-learning design with the use of multimedia such as videos, audios, photos, and slide shows was chosen based on the needs-assessment analysis. Each topic included lectures, post-learning tests, and a summary. To stimulate critical thinking, a variety of case questions were included regarding situations learners are likely to face in their practice settings (Chiang et al., 2006).

3.3. Step 3: Development of education program

The modules and topics of the preliminary program were established as shown in Table 1. These were based on learner educational needs, textbooks (American Society of Pain Management Nurses, 2002; Holland and Adams, 2015; The Korean Society of Anesthesiologists, 2014), a literature review, and several pain control theories (i.e., specificity, pattern, gate control, neuromatrix, central biasing, and endogenous opiates) (Mann and Carr, 2018). The education program covered pain theories, pain assessment, and a diverse presentation of pain management methods including pharmacotherapy and non-pharmacotherapy methods. Complementary therapies for pain management (e. g, massage, acupuncture, music therapy, relaxation therapy, taping therapy, and cooling/hot packs) were also presented. This content was aimed at helping nurses proactively and confidently perform non-pharmaceutical modalities in addition to pharmaceutical interventions. For example, music therapy was suggested as an intervention for the acute postoperative period to promote patient comfort and a more tolerable perception of pain (Sfakianakis et al., 2017; Sin and Chow,

2015). Lastly, the education program included acute pain management for special and diverse clinical situations to facilitate effective pain nursing for patients with different clinical characteristics.

After content topics were organized, lectures were recorded and animations were added that matched voice recordings or texts on the slides to increase the interest of learners. A pop-up message function was utilized to prohibit learners from skipping lectures without finishing the previous one. Sending text messages or email alerts was planned to encourage learners to finish the course. The final education program encompassed eight 50-min-long classes with a total duration of 400 min, with 8 modules and 29 topics.

The content validity of the developed education content was reviewed and evaluated by an advisory panel made up of five experts who were different from the members of the education development team (two professors of anesthesia, a professor of nursing, a professor of education, and a professor of online education). The panel members used Kuo et al.'s assessment tool (2014), comprising six components: suitability of the instructional design (1 item), ease of use for the interface (3 items), interactivity (1 item), diversity of evaluation items (1 item), and appropriateness of learning materials (1 item). Each part was evaluated with a 3-point scale (A: excellent, B: acceptable, and C: unacceptable). The expert panel results provided a content validity of 0.97.

3.4. Step 4: Implementation

The developed program was placed online through a professional web-hosting company. A minimum of 25 per group were required to achieve a large effect size of 0.80 with a power of 80%, a 5% level of significance and a 20% dropout rate, based on the estimation using GPower version 3.1. The inclusion criteria for the study were nurses (1) who had at least 1 year of working experience in PACU as a registered nurse and (2) who agreed to participate in this study; the exclusion criteria were nurses who had completed education courses related to pain in the last 6 months. Nurses were recruited from the PACU in two university-affiliated hospitals (staffed by approximately 50 and 90 nurses, respectively) in Seoul, from April to June 2016. After nursing managers in the PACUs identified potentially eligible participants (44 and 80 nurses), the principal investigator of this research study (JY) contacted the eligible nurses one by one, until 25 nurses were recruited from each PACU. When the enrollment process was finished, we randomly divided the participants into the experimental and control groups, by assigning 0 or 1 of computer-generated random numbers, using the RANDBETWEEN function in Excel software. The experimental group took the education course during their paid educational leave (one day). No experimental procedure was conducted in the control group (blank control).

3.5. Step 5: Evaluation

A preliminary survey of demographic characteristics, knowledge, attitude, and self-efficacy in pain management investigation was administered to both the experimental and the control groups before offering the web-based acute pain management education program. The experimental group was asked to complete the same three questionnaires two weeks after completing their education program, based on a previous study (Kang, 2017). The control group was also re-examined two weeks after the preliminary survey questionnaire.

3.6. Measurements

Knowledge of pain management was assessed using the modified Watt-Watson and Donovan questionnaire (1992), which was modified for the Korean context and used in Cho's study (2013). The questionnaire consisted of 65 items with six sub-domains to measure general knowledge of pain (e.g., patients may sleep in spite of severe pain) (20

items), knowledge of pain medication use (e.g., Morphine has a dose ceiling) (19 items), knowledge of pain scales (e.g., Face pain rating scale) (8 items), knowledge of pain interventions (e.g., music therapy) (8 items), and knowledge of analgesia classification (e.g., Ibuprofen, Opioid/Non-opioid) (10 items). Each item was either a yes/no or multiple-choice question and a correct item was worth 1 point. Total scores ranged from 0 to 53; the higher the score, the higher the knowledge level. KR-20 reliability in this study was .654 (pre-test) and .770 (post-test).

Attitude toward pain management was assessed using the modified Watt-Watson and Donovan questionnaire (1992), which was modified for the Korean context and used in Cho's study (2013). A total of 9 questions measured attitudes toward pain management, and each item was answered either a yes/no (e.g., patient's self-report is the most reliable indicator of pain), with yes being scored 1 and no being scored 0. The highest possible total score was 9; the higher the score, the more pain intervention behaviors. Cronbach's α in this study was .790 (pre-test) and .799 (post-test).

Self-efficacy in pain management was measured by a questionnaire used in Yoo's study (2015), which modified Chiang, Chen, and Huang's (2006) questionnaire. Six items (e.g., How confident are you about your ability to provide nonpharmacologic management of your patients?) were presented on a 5-point scale (1: not at all, 2: not confident, 3: neutral, 4: confident, and 5: very confident). Higher scores indicate higher self-efficacy, with the total score ranging from 6 to 30. Cronbach's α in this study was .906 (pre-test) and .946 (post-test).

3.7. Ethical considerations

The study protocol was approved by the Institutional Review Board of the Korean National Institute for Bioethics Policy (Approval No.: P01-201604-22-003). Permission was also obtained from the nursing department of the university hospital where the data were collected. The principal investigator of this research study (JY) explained to the participants the purpose and content, duration, and process of the study; confidentiality and potential risks involved with participation; and criteria for selecting participants and suspending this study. When participants agreed to participate voluntarily, signed consent forms were obtained and data were collected. To ensure confidentiality, all collected data were de-identified and stored in a password-protected spreadsheet in a personal USB. Control group participants were given the opportunity to receive the education after the post-test.

3.8. Data analysis

The collected data were statistically analyzed using SAS 9.4 (SAS, Cary, NC, USA). The significance level was set at .05. The preliminary homogeneity test between the two groups to measure participants' general characteristics and pre-test outcomes was conducted using the chi-square test, Fisher's exact test, and the Mann-Whitney U test (Table 2). To test the effectiveness of the education program, differences between the two groups regarding knowledge of pain management, attitudes toward pain management, and self-efficacy in pain management were tested using the Mann-Whitney U test because the variables did not have normal distributions.

4. Results

Of the 50 nurses recruited in this study, two participants failed to complete the education program in the experimental group and another two in the control group could not take the post-test for personal reasons. Therefore, a total of 46 nurses, 23 in each group, were analyzed for the effectiveness of the web-based acute pain education program (Fig. 1). Table 2 present the homogeneity of participants' general characteristics and the outcome variables – knowledge of pain management, attitudes toward pain management, and self-efficacy in pain

Table 2
Summary of general characteristics.

Variables	Categories	n (%) or <i>M(SD)</i>		χ^2/U	<i>p</i>
		Experimental Group (<i>n</i> = 23)	Control Group (<i>n</i> = 23)		
Age (years)		33.09 (5.92)	33.57 (6.45)	257.00	.869
Total years of service		9.35 (6.13)	9.48 (7.2)	269.00	.920
Present years of service		7.83 (5.59)	8.7 (6.9)	256.00	.849
Position	Charge nurse	10 (21.7)	7 (15.2)	0.84	.360 [‡]
	Staff nurse	13 (28.3)	16 (34.8)		
Educational background	Associate's	1 (2.2)	1 (2.2)	3.22	.200 [§]
	Bachelor's	22 (47.8)	19 (41.3)		
	Master's	0 (0.0)	3 (6.5)		
Religion	Christian	8 (17.4)	5 (10.9)	3.49	.174 [§]
	Catholic	1 (2.2)	5 (10.9)		
	Buddhist	0 (0.0)	0 (0.0)		
	No religion	14 (30.4)	13 (28.3)		
Marital status	Unmarried	12 (26.1)	8 (17.4)	1.42	.234 [‡]
	Married	11 (23.9)	15 (32.6)		
Pain education experience	Yes	16 (34.8)	17 (37.0)	0.11	.743 [‡]
	No	7 (15.2)	6 (13.0)		
Knowledge	General	21.17 ± 1.23	21.00 ± 1.62	294.5	.501
	Knowledge of analgesics	11.78 ± 2.37	11.04 ± 2.18	312.5	.291
	Pain measures	2.39 ± 0.89	2.43 ± 0.99	269.0	.919
	Intervention	8.13 ± 3.76	7.57 ± 3.51	277.5	.780
	Criteria for analgesics	7.30 ± 0.82	7.52 ± 0.67	211.0	.214
Attitudes		5.17 ± 1.53	4.48 ± 1.41	325.5	.173
Self-efficacy		22.48 ± 2.61	21.57 ± 3.38	314.5	.271

Note. Mean (*M*); Standard deviation (*SD*); Mann-Whitney *U* Test (*U*); [‡]chi-square test; [§] Fisher's exact test.

management – of the pretest.

There was a significant difference in the changed scores of pain management knowledge (Exp. 5.13 ± 4.85 , Cont. 1.30 ± 3.13 , $p = .012$) between the two groups, which supported the first hypothesis. Specifically, the results showed a significant difference in knowledge of analgesics ($p = .048$), knowledge of pain scales ($p = .004$), and knowledge of pain intervention methods ($p = .031$). There was no significant difference between the two groups in general knowledge about pain ($p = .629$) or knowledge about analgesics classification ($p = .924$).

The second hypothesis was that participants who attended the education program would have higher changes in their scores for attitude toward pain management than those who did not take the program. The second hypothesis was rejected as there was no significant difference between the two groups (Exp. 1.39 ± 1.67 , Cont. 0.13 ± 0.97 , $p = .164$).

The third hypothesis was that participants who attended the program would have higher changes in self-efficacy for pain management than those who did not take the classes. The self-efficacy of the experimental group increased significantly compared to the control group (Exp. 1.91 ± 1.88 , Cont. $.70 \pm 1.79$, $p = .030$); therefore, the third hypothesis was supported (Table 3).

5. Discussion

Pain management is an important skill for health professionals in an acute clinical setting. In this study, we developed a web-based acute pain management education program for nurses according to the ADDIE model and evaluated its effects on knowledge, attitude, and self-efficacy. Significant differences were found in the experimental and control groups in changes between pre and post scores, which demonstrated effectiveness in improving nurses' knowledge and self-efficacy regarding pain management. These results are consistent with several previous studies in which an educational intervention improved nurses' knowledge of pain management (Y. M. Cho, 2013; Machira et al., 2013; van Dijk et al., 2017). This study was novel as the education was offered online for Korean PACU nurses. This program also provided a more in-depth education, as the scope was focused on pain

management for acute pain such as postoperative pain.

Differences in the pre and post scores were higher in the experimental group than in the control group in several subdomains: knowledge of analgesics, pain measurements, and interventions. However, scores of knowledge of general pain and criteria for analgesics did not change significantly after intervention, and all scores were relatively high. These results are probably because the participants were working in a PACU, and care for most patients included complaints of acute pain. A previous study has reported that nurses' pain knowledge is significantly associated with their current working area (Yaakup et al., 2014).

Nurses' attitude toward pain management is important, as it might negatively affect their pain management practices (H. Cho and Kwon, 2016). In this study, nurses' attitude scores were relatively low and did not show a significant change after the intervention, which was contrary to the findings in Cho's study (2013). Al Qadire and Al Khalailah (2014) found a significant difference in nurses' attitudes depending on whether they had been previously educated in pain management and suggested continuous and repetitive education from college onward. Furthermore, Jarrett et al. (2013) examined nurses' knowledge of and attitude toward pain management in acute care settings including medical and surgical nursing units and surgery and postsurgical units, etc. They measured nurses' knowledge and attitude immediately before and after receiving education, and six months after education. They found a significant effect on knowledge and attitude six months after education, but not right before or directly after. The lack of difference in attitude toward pain management in our study could be partially explained by the fact that the education program was provided only once and the evaluation was conducted in a relatively short time. It is possible that subsequent experiences with patients may change their attitude after they see the benefits of the education they received.

In this study, self-efficacy for pain management in the experimental group improved significantly compared to the control group after the education program. This was consistent with the findings of Du et al.'s systematic review (2013) on a web-based program for nursing education, which showed that the program had encouraging effects on improving both participants' knowledge and self-efficacy in performing nursing skills. These results can be explained by the close relationship



CONSORT 2010 Flow Diagram

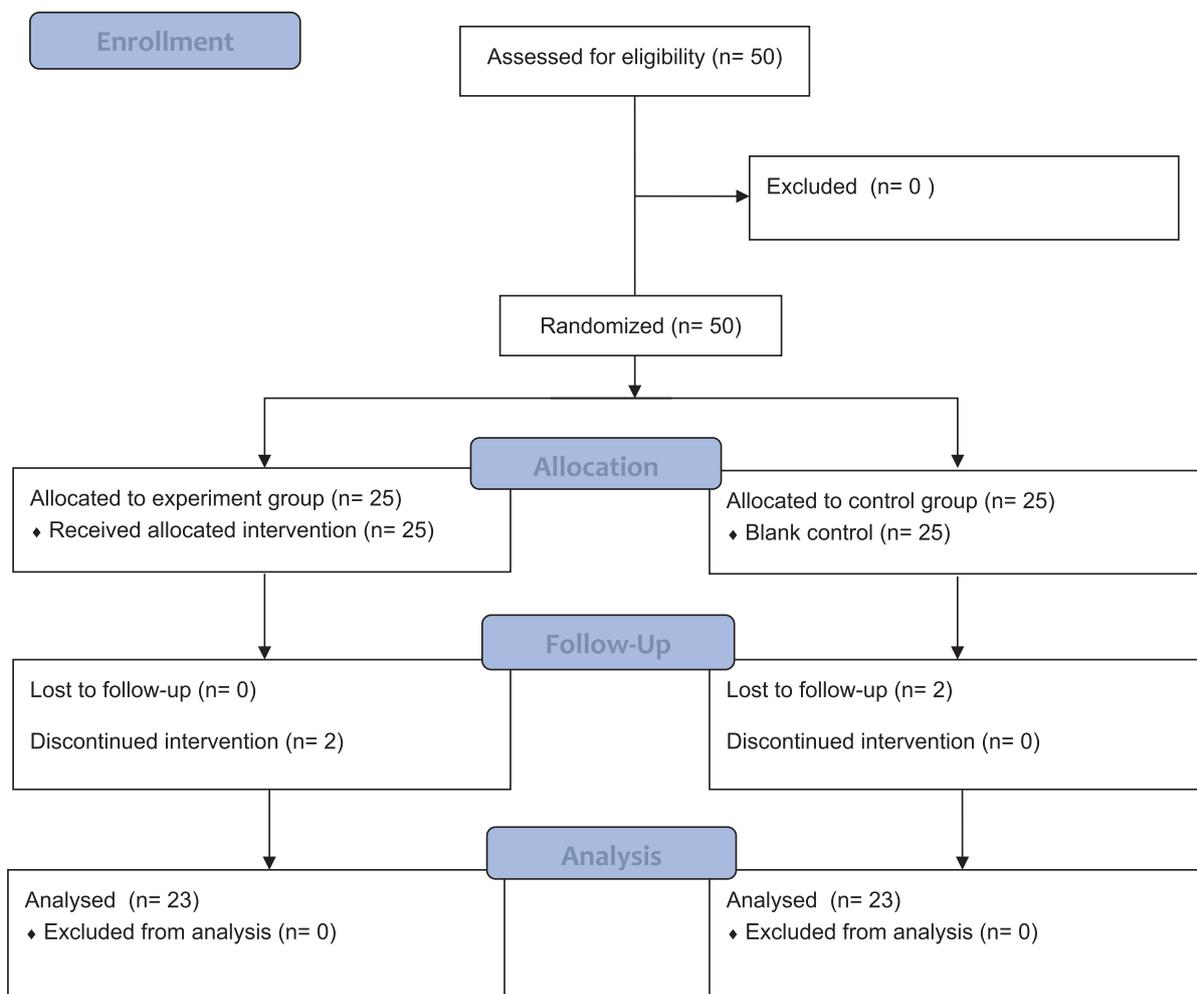


Fig. 1. Flow diagram of the study.

between knowledge of pain management and self-efficacy (Heo et al., 2016). Stanley and Pollard (2013) emphasized the importance of self-efficacy in managing children's pain and showed that an increase in self-efficacy had a significant impact on nurses' performance of managing children's pain. Heo et al. (2016) reported that pediatric nurses' pain management performance for children was affected by not only their current department, but also their self-efficacy for pain management, emphasizing that self-efficacy can change through interventions. In this study, an enhanced level of knowledge and self-efficacy in pain management through the education program could probably improve nursing outcomes, which should be examined in future studies.

This study is limited by the fact that nurses' knowledge, attitudes, and self-efficacy were measured only once after the education program and the study sample was restricted to PACU Korean nurses from two university-affiliated hospitals. We recruited the participants by

convenience sampling; thus, some selection bias may have affected results. For example, subjects with higher motivation in learning could have participated, which might overestimate the education effects. Moreover, this study could not provide long-term effects (e.g., 6-month effects) of the education and the comparative effects with traditional education (e.g., web-based education versus face-to-face education). However, despite such limitations, the high penetration rate of the Internet in Korea can provide several advantages in similar web-based education programs. Most of all, this access minimizes time away from the clinic and provides a more flexible schedule compared to offline classes (Davies et al., 2017).

6. Conclusion

Nurses who spend a considerable part of the day managing patients'

Table 3
Knowledge, attitudes, and self-efficacy regarding acute pain management for the experimental (n = 23) and control (n = 23) groups.

Variables	Group	Pretest	Posttest	Difference (post-pre)	U	p	
		Mean ± SD	Mean ± SD	Mean ± SD			
Knowledge	Total	Exp.	50.91 ± 5.14	56.04 ± 6.47	5.13 ± 4.85	389.0	.012
		Cont.	49.57 ± 5.29	50.87 ± 4.99	1.30 ± 3.13		
	General	Exp.	21.17 ± 1.23	21.44 ± 1.24	0.26 ± 1.45	243.0	.629
		Cont.	21.00 ± 1.62	21.61 ± 1.20	0.61 ± 1.59		
	Knowledge of analgesics	Exp.	11.78 ± 2.37	13.17 ± 1.62	1.17 ± 2.39	353.3	.048
		Cont.	11.04 ± 2.18	11.17 ± 2.61	0.22 ± 2.19		
	Pain measures	Exp.	2.39 ± 0.89	3.78 ± 1.62	1.39 ± 1.67	389.0	.004
		Cont.	2.43 ± 0.99	2.57 ± 0.90	0.13 ± 0.97		
	Intervention	Exp.	8.13 ± 3.76	10.57 ± 4.44	2.43 ± 3.56	362.0	.031
		Cont.	7.57 ± 3.51	8.13 ± 3.45	0.57 ± 2.19		
Criteria for Analgesics	Exp.	7.3 ± 0.82	7.09 ± 0.9	0.22 ± 1.00	268.5	.924	
	Cont.	7.52 ± 0.67	7.35 ± 0.78	0.17 ± 0.58			
Attitudes	Exp.	5.17 ± 1.53	5.22 ± 1.2	0.04 ± 0.98	203.0	.164	
	Cont.	4.48 ± 1.41	5.04 ± 1.22	0.57 ± 1.41			
Self-efficacy	Exp.	22.48 ± 2.61	24.39 ± 1.83	1.91 ± 1.88	360.0	.030	
	Cont.	21.57 ± 3.38	22.26 ± 3.86	0.70 ± 1.79			

Note. Standard deviation (SD); Mann-Whitney U Test (U); Experimental (Exp.); Control (Cont.).

acute pain, such as nurses working in the PACU, surgical wards, intensive care unit, and emergency room, could enhance their knowledge of pain and how to provide effective pain management services in their clinical practice by taking a targeted education program. Our program would be of benefit to nursing students as pain management education should be taught not only in classroom settings, but also in clinical practicums. The results of the present study can be used as the basis for future studies with a larger sample from multiple centers. Additional studies should attempt to follow up on this study's results to determine if nurses' improved knowledge and attitude due to pain management education can be continuously maintained after education. Also, future studies should examine patient outcomes (e.g., postoperative pulmonary complications rate, duration of hospital stay after surgery, satisfaction level, etc.) as well as outcomes at a nurse level. In the future, a comparative study on the effects of this web-based education versus traditional face-to-face education would provide more significance in practice. Lastly, this study can be the basis for the development of evidence-based guidelines, through multidisciplinary collaboration, for safe and effective pain management tailored to the Korean culture and individual patient characteristics and preferences.

Conflicts of interest

The authors have disclosed no potential conflicts of interest, financial, or otherwise.

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Ethical approval

The study protocol was approved by the Institutional Review Board of the Korean National Institute for Bioethics Policy (Approval No.: P01-201604-22-003).

References

Al Qadire, M., Al Khalailah, M., 2014. Jordanian nurses knowledge and attitude regarding pain management. *Pain Manag. Nurs.* 15 (1), 220–228. <https://doi.org/10.1016/j.pmn.2012.08.006>.
 Allred, K., Gerardi, N., 2017. Computer simulation for pain management education: a pilot study. *Pain Manag. Nurs.* 18 (5), 278–287. <https://doi.org/10.1016/j.pmn.2017.05.004>.
 American Society of Pain Management Nurses, 2002. *Core Curriculum for Pain Management Nursing*. Saunders, Philadelphia.

Angeletti, C., Guetti, C., Paesani, M., Colavincenzo, S., Ciccozzi, A., Angeletti, P.M., 2018. An analysis of Italian nurses' approach to patients' pain: a nationwide online survey. *Pain Res. Manag.* <https://doi.org/10.1155/2018/5165262>. 2018, 5165262.
 Chiang, L.C., Chen, H.J., Huang, L., 2006. Student nurses' knowledge, attitudes, and self-efficacy of children's pain management: evaluation of an education program in taiwan. *J. Pain Symptom Manag.* 32 (1), 82–89. <https://doi.org/10.1016/j.jpainsymman.2006.01.011>.
 Cho, H., Kwon, S.-H., 2016. Pain management knowledge, attitudes, and performance of nurses in long-term care hospitals. *Korean J. Hospice Pall. Care* 19 (4), 322–330.
 Cho, Y.M., 2013. Impact of Pain Management Education on Knowledge and Attitude in One University Hospital's Nurses. Konyang University, Nonsan (Unpublished master's thesis). <http://www.riss.kr/link?id=T13214722>.
 Davies, S., Lorello, G.R., Downey, K., Friedman, Z., 2017. Effective learning environments - the process of creating and maintaining an online continuing education tool. *Adv. Med. Educ. Pract.* 8, 447–452. <https://doi.org/10.2147/amep.s136348>.
 Du, S., Liu, Z., Liu, S., Yin, H., Xu, G., Zhang, H., Wang, A., 2013. Web-based distance learning for nurse education: a systematic review. *Int. Nurs. Rev.* 60 (2), 167–177. <https://doi.org/10.1111/inr.12015>.
 Gan, T.J., 2017. Poorly controlled postoperative pain: prevalence, consequences, and prevention. *J. Pain Res.* 10, 2287–2298. <https://doi.org/10.2147/jpr.s144066>.
 Gerbershagen, H.J., Aduckathil, S., van Wijck, A.J., Peelen, L.M., Kalkman, C.J., Meissner, W., 2013. Pain intensity on the first day after surgery: a prospective cohort study comparing 179 surgical procedures. *Anesthesiology* 118 (4), 934–944. <https://doi.org/10.1097/ALN.0b013e31828866b3>.
 Han, J.-Y., Park, H.-S., Jin, M.-J., 2016. Nurses' knowledge and performance of pain management at a general hospital. *J. Korean Acad. Fund. Nurs.* 23 (1), 6–11.
 Heo, S.J., Kim, J.S., Kim, H., 2016. Factors influencing pain management practice in pediatric nurses. *Child Health Nurs. Res.* 22 (4), 279–288.
 Holland, L.N., Adams, M.P., 2015. *Core Concepts in Pharmacology*. Paju: Soomoonsa.
 Jarrett, A., Church, T., Fancher-Gonzalez, K., Shackelford, J., Lofton, A., 2013. Nurses' knowledge and attitudes about pain in hospitalized patients. *Clin. Nurse Spec.* 27 (2), 81–87. <https://doi.org/10.1097/NUR.0b013e3182819133>.
 Jho, M.Y., 2013. Nurses' perception of the importance of evaluating continuing education programs. *Korean J. Adult Nurs.* 25 (1), 1–12.
 Joshi, G.P., Schug, S.A., Kehlet, H., 2014. Procedure-specific pain management and outcome strategies. *Best Pract. Res. Clin. Anaesthesiol.* 28 (2), 191–201. <https://doi.org/10.1016/j.bpa.2014.03.005>.
 Kaasalainen, S., Ploeg, J., Donald, F., Coker, E., Brazil, K., Martin-Misener, R., ... Hadjistavropoulos, T., 2015. Positioning clinical nurse specialists and nurse practitioners as change champions to implement a pain protocol in long-term care. *Pain Manag. Nurs.* 16 (2), 78–88. <https://doi.org/10.1016/j.pmn.2014.04.002>.
 Kang, M.R., 2017. Effects of Pain Management Education on Nurses' Knowledge, Attitude, and Patients' Satisfaction : for the Patients with Liver Resection. Yonsei University, Seoul (Unpublished Master's thesis). <http://www.riss.kr/link?id=T14450959>.
 Kim, H.J., Yang, G.S., Greenspan, J.D., Downton, K.D., Griffith, K.A., Renn, C.L., ... Dorsey, S.G., 2017. Racial and ethnic differences in experimental pain sensitivity: systematic review and meta-analysis. *Pain* 158 (2), 194–211. <https://doi.org/10.1097/j.pain.0000000000000731>.
 Kuo, Y.-C., Walker, A.E., Schroder, K.E., Belland, B.R., 2014. Interaction, internet self-efficacy, and self-regulated learning as predictors of student satisfaction in online education courses. *Internet High Educ.* 20, 35–50.
 Latchman, J., 2014. Improving pain management at the nursing education level: evaluating knowledge and attitudes. *J. Adv. Pract. Oncol.* 5 (1), 10–16.
 Lax, L., Watt-Watson, J., Lui, M., Dubrowski, A., McGillion, M., Hunter, J., ... Lapeyre, J., 2011. Innovation and design of a web-based pain education interprofessional resource. *Pain Res. Manag.* 16 (6), 427–432.
 Luo, J., Min, S., 2017. Postoperative pain management in the postanesthesia care unit: an update. *J. Pain Res.* 10, 2687–2698. <https://doi.org/10.2147/jpr.s142889>.

- Machira, G., Kariuki, H., Martindale, L., 2013. Impact of an educational pain management programme on nurses pain knowledge and attitudes in Kenya. *Int. J. Palliat. Nurs.* 19 (7), 341–346. <https://doi.org/10.12968/ijpn.2013.19.7.341>.
- Mann, E., Carr, E., 2018. *Pain Management: Nursing Perspective*. Mosby, St Louis.
- Meara, J.G., Leather, A.J., Hagander, L., Alkire, B.C., Alonso, N., Ameh, E.A., ... Yip, W., 2015. Global surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet* 386 (9993), 569–624. [https://doi.org/10.1016/s0140-6736\(15\)60160-x](https://doi.org/10.1016/s0140-6736(15)60160-x).
- Medrzycka-Dabrowska, W., Dabrowski, S., Basinski, A., 2015. Problems and barriers in ensuring effective acute and post-operative pain management—an international perspective. *Adv. Clin. Exp. Med.* 24 (5), 905–910. <https://doi.org/10.17219/acem/26394>.
- Meissner, W., Coluzzi, F., Fletcher, D., Huygen, F., Morlion, B., Neugebauer, E., ... Pergolizzi, J., 2015. Improving the management of post-operative acute pain: priorities for change. *Curr. Med. Res. Opin.* 31 (11), 2131–2143. <https://doi.org/10.1185/03007995.2015.1092122>.
- Phillips, J.L., Heneka, N., Hickman, L., Lam, L., Shaw, T., 2014. Impact of a novel online learning module on specialist palliative care nurses' pain assessment competencies and patients' reports of pain: results from a quasi-experimental pilot study. *Palliat. Med.* 28 (6), 521–529. <https://doi.org/10.1177/0269216314527780>.
- Romero-Hall, E., 2015. Pain assessment and management in nursing education using computer-based simulations. *Pain Manag. Nurs.* 16 (4), 609–616. <https://doi.org/10.1016/j.pmn.2014.11.001>.
- Rouleau, G., Gagnon, M.P., Cote, J., Payne-Gagnon, J., Hudson, E., Bouix-Picasso, J., Dubois, C.A., 2017. Effects of e-learning in a continuing education context on nursing care: a review of systematic qualitative, quantitative and mixed studies reviews (protocol). *BMJ Open* 7 (10), e018441. <https://doi.org/10.1136/bmjopen-2017-018441>.
- Schlegel, M., 1995. A handbook of instructional and training program design. Retrieved from. <https://eric.ed.gov/?id=ED383281>.
- Sfakianakis, M.Z., Kareraki, M., Panayioti, K., Christaki, O., Chatzikou, V., 2017. Effect of music therapy intervention in acute postoperative pain among obese patients. *Int. J. Caring Sci.* 10 (2), 937.
- Sin, W.M., Chow, K.M., 2015. Effect of music therapy on postoperative pain management in gynecological patients: a literature review. *Pain Manag. Nurs.* 16 (6), 978–987. <https://doi.org/10.1016/j.pmn.2015.06.008>.
- Stanley, M., Pollard, D., 2013. Relationship between knowledge, attitudes, and self-efficacy of nurses in the management of pediatric pain. *Pediatr. Nurs.* 39 (4), 165–171.
- The Korean Society of Anesthesiologists, 2014. *Anesthesiology and Pain Medicine*. Ryo Moom Gak, Seoul.
- van Dijk, J.F., Schuurmans, M.J., Alblas, E.E., Kalkman, C.J., van Wijck, A.J., 2017. Postoperative pain: knowledge and beliefs of patients and nurses. *J. Clin. Nurs.* 26 (21–22), 3500–3510. <https://doi.org/10.1111/jocn.13714>.
- Voshall, B., Dunn, K.S., Shelestak, D., 2013. Knowledge and attitudes of pain management among nursing faculty. *Pain Manag. Nurs.* 14 (4), e226–e235. <https://doi.org/10.1016/j.pmn.2012.02.001>.
- Watt-Watson, J., 1992. Misbeliefs about Pain. *Pain Management: Nursing Perspective*. Mosby, St Louis, pp. 36–58.
- Yaakup, H., Eng, T.C., Shah, S.A., 2014. Does clinical experience help oncology nursing staff to deal with patient pain better than nurses from other disciplines? Knowledge and attitudes survey amongst nurses in a tertiary care in Malaysia. *Asian Pac. J. Cancer Prev. APJCP* 15 (12), 4885–4891.
- Yoo, H.R., 2015. Relationship Among the Knowledge, Self-Efficacy and Nursing Practices of Nurses in the Management of Pediatric Pain. Seoul National University, Seoul (Unpublished master's thesis). <http://www.riss.kr/link?id=T13925807>.