Literature Review

The Effect of Pressure Injury Training for Nurses: A Systematic Review and Meta-analysis

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ABSTRACT

OBJECTIVE: To conduct a meta-analysis of the literature on training programs that aimed to improve nurses' pressure injury management skills.

METHODS: Literature searches were conducted using Ovid-MEDLINE, Cochrane Library, CINAHL, and Korean databases. The search terms used were: (nurse* AND ((pressure OR decubitus) AND (ulcer* OR injur*)) OR bed sore OR bedsore OR decubitus) AND (program* OR training)). Random-effects models were used to calculate the standardized mean difference and odds ratios, with 95% confidence intervals (CIs) to analyze the effects.

MAIN RESULTS: Initial searches yielded 1,067 studies. Of these, 23 met the selection criteria. Nurses' knowledge (standard mean difference, 1.23; 95% CI, 0.50-1.96; $P < .001$), visual discrimination ability (standard mean difference, 1.13; 95% CI, 0.88-1.38; $P < .001$), and clinical judgment (odds ratio, 1.52; 95% CI, 1.46-1.57; $P < .001$) improved after the programs.

CONCLUSIONS: Pressure injury training programs can improve nurses' competency. The results from this study indicate that such programs may help improve nurses' knowledge, visual discrimination ability, and clinical judgment and can be considered continuing education programs. However, large-scale studies are needed to confirm this conclusion.

KEYWORDS: competency, education, meta-analysis, nurses, PI, pressure injury, systematic review, training

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INTRODUCTION

Pressure injuries (PIs) have negative impacts not only on patients but also on the nurses and medical institutions involved.[1] Nurses taking care of patients with PIs work longer hours and thus feel overburdened.[2] In addition, they may experience guilt about the development of a PI or slow patient recovery.[3] Further, there has been an increase in the number of legal cases related to alleged nursing negligence after PI occurrence.[4–8]

Pressure injuries are one of the most important management issues for medical institutions. In the US, for instance, PI was added to the list of "never events," which ended reimbursement for the extra cost of care for stages 3 and 4 PIs documented during a patient's hospital stay when no PI of any stage or severity was present on admission.[9,10] In South Korea, there have been cases in which hospitals have had to compensate patients for PIs that occurred after hospitalization. In addition, PIs are one of the indicators to assess facility quality, and early detection allows for faster recovery and reductions in unnecessary hospitalization.[11]

Ultimately, the prevention, early detection, and proper treatment of PI are important issues for patients, nurses, and medical institutions.[12–14] However, although professional knowledge and management skills regarding PI are necessary for nursing staff, previous research has shown that nurses' overall level of knowledge in this area is low.[15,16] Critically, because PI-related education is mainly conducted at university-affiliated hospitals, nearly 40% of nurses at small- and medium-sized hospitals do not have adequate education or experience related to PI care.[16] Moreover, distinguishing PI is difficult; there are various stages that indicate tissue damage, and patients with PIs generally have multiple comorbidities. Therefore, a thorough understanding of the different stages of PI, clinical decision-making skills, and visual discrimination ability are particularly important in the care of patients with PIs.[17]

Most studies on PI training programs have been geared toward patients.[18–20] Only a few have examined the effectiveness of PI training on nurses,[3,21,22] and the

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results have varied, making it even more difficult to draw an integrated conclusion. Therefore, this study aimed to build a foundation for PI training for nurses by comprehensively reviewing how education affects their ability to care for patients with PIs.

METHODS

This systematic review and meta-analysis was conducted in February 2018 according to the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Group statement.[23,24] Studies were selected in accordance with the PICO (participants, interventions, comparisons, outcomes) framework.

Any study regarding nursing PI education with knowledge, visual discrimination ability, or clinical judgment as an outcome variable was included. No specific time limitations were set. Study designs were limited to randomized controlled trials (RCTs), non-randomized controlled trials (non-RCTs), and observational studies. Studies published in Korean and English were included.

The exclusion criteria were: studies that did not target nurses, inappropriate research design, outcome variables not included in the final report, inappropriate publication type (eg, dissertation, conference proceedings), or articles not written in English or Korean.

Search Strategy

Data retrieval and collection took place in August 2018 after obtaining review exemption approval (40525-201605-HR-62-01) from the authors' university's bioethics review committee. The literature search included MEDLINE, Cochrane Library CENTRAL, CINAHL, an academic research information service, the electronic library of the National Assembly, and Korean medical research data.

Search keywords combined MeSH terms and natural language. For international research, the team used (nurse* AND ((pressure OR decubitus) AND (ulcer* OR injur*)) OR bed sore OR bedsore OR decubitus) AND (program* OR training)), and for domestic research, the team used (nurse AND (bedsore OR pressure OR ulcer) AND (program OR education OR training)). Studies included in the final analysis were selected by two researchers based on selective exclusion, and conflicting opinions were mediated through discussion.

Risk of Bias

The authors used Cochrane's Risk of Bias tool for RCTs. For non-RCTs and observational studies, the team used the Risk of Bias assessment tool for nonrandomized studies. The risk of bias for each item was marked as low, uncertain, or high. Two independent researchers evaluated the included studies, and any conflicting opinions were mediated through discussion.

Data Collection and Analysis

Researchers extracted the year of publication, country, research design, target selection and inclusion criteria, number of samples, dropout rates, contents and methods of intervention, intervention provider, hours and terms of intervention, number of interventions, measurement tool, outcome variables, and postevaluation for each study. The effect of the PI training program was analyzed using RevMan 5.3.3 (Cochrane, London, United Kingdom) and Comprehensive Meta-Analysis software (Biostat, Englewood, New Jersey). The homogeneity of studies was identified through Higgins' I^2 statistic, forest plots, and the Q statistic.

In analyzing data, the pooling of effect size was analyzed with a fixed-effects model, which assumes that the effect sizes of populations are the same and that the differences in effect size are attributable to sampling error. Any heterogeneity found was analyzed by the random-effects model. To identify publication bias, the team used a funnel plot and Egger's linear regression asymmetry test. All tests used a 95% confidence interval (CI) with a statistical significance level of .05.

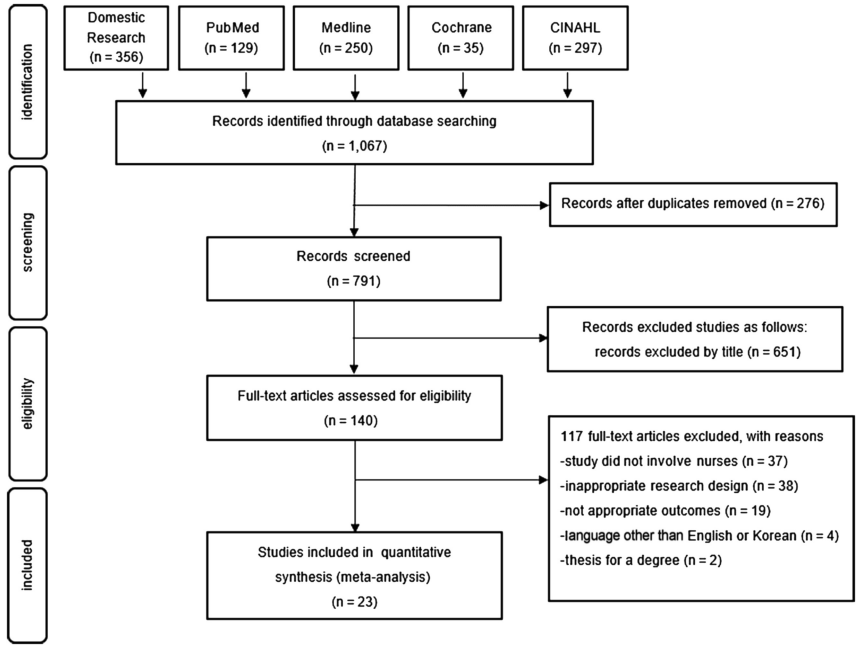
RESULTS

A total of 1,067 studies were retrieved, and after removing duplicate literature, 791 studies remained. After browsing the abstracts, 140 studies remained. After excluding 117 studies, a total of 23 studies[1,3,21,22,25–43] (n = 4,326) were included in the analysis (Figure 1).

The general characteristics of the final selections are as follows (Supplemental Table). Three RCTs and 20 observational studies were included. Five of the studies were in Korean, and 18 were published in English. Ten studies were published before 2010 and 13 after. Ten studies had fewer than 50 participants, 6 studies had between 50 and 100 participants, and 7 studies had more than 100 participants. There were 14 studies targeting secondary medical institutions (61%), 6 targeting convalescent wards (26%), and 3 targeting tertiary medical institutions (13%). Four studies targeted nurses in general hospitals and ICUs (23.5%), two targeted the ED (11.8%), one targeted a wound care unit (5.9%), and six did not identify a specific department (35.3%). Thirteen studies (56.5%) had no participant dropout, six (26.1%) had a wastage rate of 20% or lower, and four (17.4%) had a dropout rate greater than 20%.

Twenty-two studies included knowledge of PI prevention and management in the education program, seven studies included education on visual identification of the PI classification system and incontinence-related skin problems, eight studies involved PI risk assessment, and four involved back care (eg, bathing and massage). Evidence-based PI education stresses practice skills, interactive and longitudinal formats, linking education

Figure 1. FLOW DIAGRAM OF STUDY SELECTION PROCESS



to practice, and outcomes as the most important strategies for improving outcomes.[44] However, the education methodology used in these 23 studies included parallel training (a combination of practice and knowledge) and/or interactive methods; in some cases, only traditional lectures were used.

Nine of the education program providers were directly trained by researchers, six by wound care professionals, and four by professional nurses. One study involved a multidisciplinary team, and three studies did not provide detailed information regarding this aspect. The duration of education programs varied from 1 day to 12 months, with an average of 11.7 hours of training.

Risk of Bias

For RCTs (n = 3), the risk of bias from randomized assignment and concealed sequence was low for two studies (66.7%) and uncertain for one (33.3%). The risk of bias from blindness was uncertain for two studies (66.7%) and high for one (33.3%). Otherwise, the risk of bias was generally low.

For the observational studies (n = 20), the risk of bias from target group selection and reporting was low in all 20 studies (100%). The risk of bias from confounding variable was low in 15 studies (75%) and high in five (25%). The risk of bias from intervention (exposure) and incomplete data was evaluated as low in 19 studies (95%) and uncertain in one (5%). Generally, the risk of bias in the selected literature was judged to be low enough that it did not have a significant impact on the research outcome.

Effect of Training by Outcome

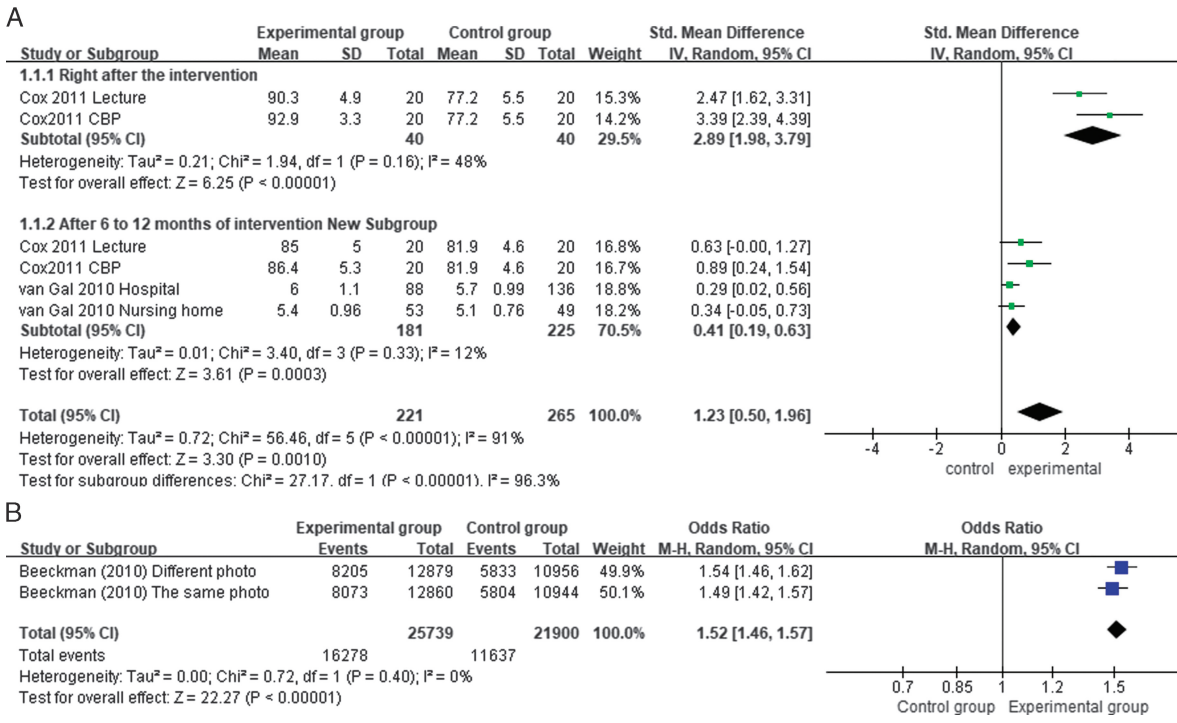
Seventeen studies (58.8%) analyzed the change in nursing staff knowledge as an outcome variable, five (20.6%) examined visual discrimination ability, and ten (17.7%) studied clinical judgment.

Knowledge. Nursing PI knowledge was measured by a questionnaire or measurement tool for related knowledge.[45–55] The higher the score, the higher the knowledge of PI nursing. Combined analysis of the knowledge scores showed an overall improvement with training (standard mean difference [SMD], 1.23; 95% CI, 0.50-1.96) but with considerable heterogeneity (I^2 = 91%). Authors performed subgroup analysis according to follow-up duration to analyze the cause of heterogeneity. The improvement in knowledge scores for PIs was not only statistically significant immediately after applying the program (SMD, 2.89; 95% CI, 1.89-3.79; $P < .001$; I^2 = 48%), but it also improved after 6 to 12 months (SMD, 0.41; 95% CI, 0.19-0.63; $P < .001$; I^2 = 12%), and the heterogeneity was resolved (Figure 2A).

For the observational studies, there was a significant increase in knowledge immediately after the intervention (SMD, 1.78; 95% CI, 1.13-2.42; $P < .0001$; Supplemental Figure), although the effect no longer existed 1 to 6 months after the intervention (SMD, 0.83; 95% CI, -0.48 to 12.14; $P = .210$). However, the nurses' correction rate for PI knowledge showed a significant increase after

Figure 2. FOREST PLOT OF EFFECT SIZE BY TRAINING PROGRAM (RANDOMIZED CONTROLLED TRIALS)

A, Changes in knowledge (score); B, changes in clinical judgment (percent correct answers).



the intervention, with an odds ratio (OR) of 7.80 (95% CI, 2.90-20.96; $P < .0001$; Supplemental Figure).

Owing to the high heterogeneity of the studies, subgroups had to be analyzed by participant characteristics. The results of subgroup analysis according to intervention time, number of trainees, type of hospital service, mean age of participants, dropout rate, service department, and arbitration provider are as follows. In the analysis of the time of intervention, the SMD of the experimental group that received an intervention of 2 hours or more was 1.79 (95% CI, 0.65-2.93; $P = .002$), higher than those 2 hours or less (SMD, 1.00; 95% CI, 0.59-1.41; $P < .001$). The analysis by number of participants indicated that the increase in knowledge was significant when the trainees were 100 or fewer (SMD, 2.50; 95% CI, 1.32-3.67; $P < .001$), but not when the number exceeded 100 (SMD, 0.99; 95% CI, -0.07 to 2.06; $P = .070$). Regarding hospital type, nurses from general hospitals demonstrated a significant difference in knowledge (SMD, 2.26; 95% CI, 1.43-3.10; $P < .001$), whereas there was no difference in nurses at advanced general hospitals (SMD, 0.40; 95% CI, -0.02 to 0.83; $P = .060$; $I^2 = 98\%$). Interventions were more effective for participants aged between 20 and 29 years (SMD, 1.30; 95% CI, 0.03-2.58; $P = .040$) than those between 30 and 39 years (SMD, 0.67; 95% CI, 0.54-0.79; $P < .001$; $I^2 = 99\%$). Further, studies with no dropout rate showed a significant increase in participant knowledge (SMD, 2.47; 95% CI, 1.31-3.64; $P < .001$), whereas those with high dropout rates indicated no difference (SMD, 1.02; 95% CI, -0.26 to 2.29; $P = .120$).

Based on the departments, no meaningful knowledge changes were shown for general ward nurses (SMD, 1.52; 95% CI, -1.11 to 4.15; $P = .260$), but a significant difference was identified for intensive care nurses (SMD, 1.78; 95% CI, 0.60-2.96; $P = .003$). In analysis by intervention provider, interventions conducted by advanced practice nurses (SMD, 2.38; 95% CI, 0.69-4.06; $P = .006$) and researchers (SMD, 0.68; 95% CI, 0.56-0.80; $P < .001$) both resulted in significant increases in knowledge, but staff educated by advanced practice nurses performed better. Finally, for training methods, theoretical lectures combined with practice were more effective (OR, 7.66; 95% CI, 3.60-16.30; $P < .001$) than traditional teaching (OR, 6.95; 95% CI, 3.00-16.07; $P < .001$; $I^2 = 64\%$).

Visual Discrimination Ability. This outcome referred to nurses' ability to discriminate among PI classifications, determine the presence of a PI, and distinguish it from other dermatitis (eg, incontinence-associated dermatitis).[3,11,49,56] Higher scores represent better discrimination ability.

Visual discrimination ability was 1.13 (95% CI, 0.88-1.38; $P < .001$) in SMD for intervention groups, which showed a significant increase in this outcome (Supplemental Figure).

The correction rate for visual perception was also higher after the training (OR, 2.96; 95% CI, 2.76-3.16; $P < .001$). There was no heterogeneity among these articles ($I^2 = 0\%$; Supplemental Figure).

Clinical Judgment. Clinical judgment is the nurse's ability to make decisions promptly by considering the patient's health problems or needs and the differentiated ability to perform appropriate nursing care.[41,45,47,48,51,57,58]

The clinical judgment of the experimental groups that received the training showed a statistically significant increase (OR, 1.52; 95% CI, 1.46-1.57; $P < .001$; Figure 2B). Changes in clinical judgment resulting from the intervention in observational studies were demonstrated by an increase in SMD (1.69; 95% CI, 1.28-2.09; $P < .0001$; Supplemental Figure), and the correction rate for clinical judgment also increased significantly (OR, 5.78; 95% CI, 5.23-6.38; $P < .001$; Supplemental Figure).

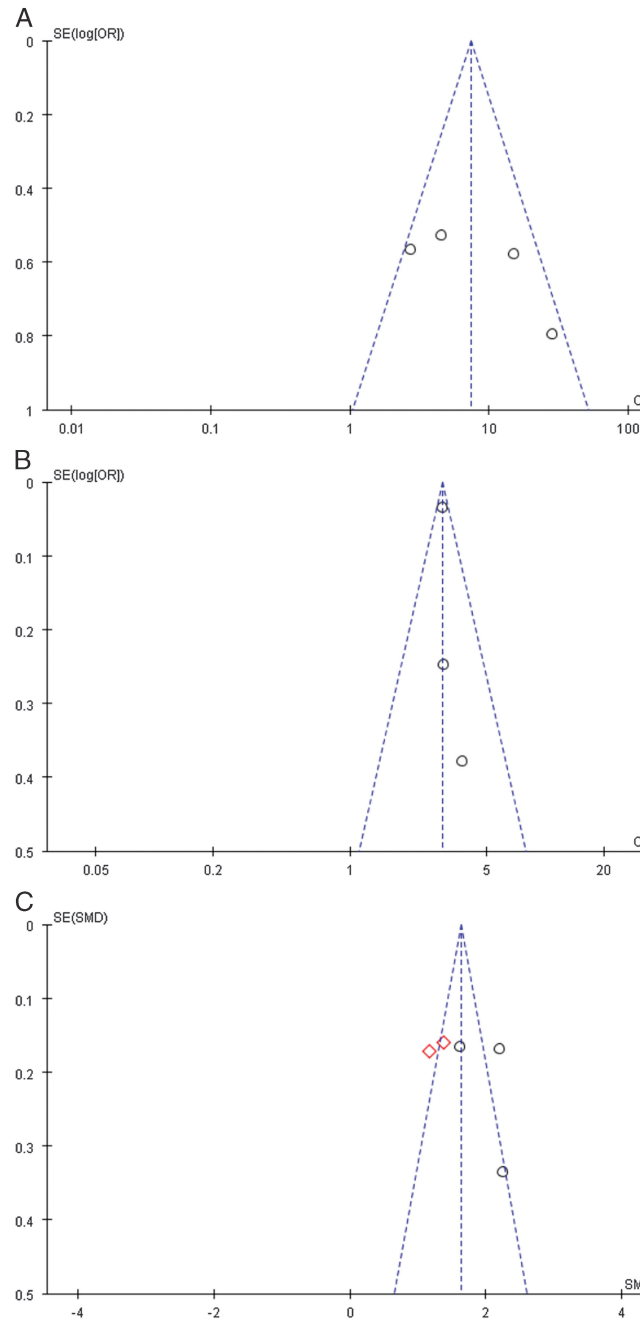
According to subgroup analysis, effectiveness was highest immediately after the intervention (OR, 7.95; 95% CI, 7.10-8.90; $P < .001$), and there was no significant difference 1 to 3 months after the intervention (OR, 1.01; 95% CI, 0.79-1.30; $P = .930$). For hospital type, nurses from both advanced general hospitals (OR, 29.40; 95% CI, 24.01-36.01; $P < .001$) and general hospitals (OR, 1.08; 95% CI, 0.90-1.31; $P < .001$) showed a significant increase in clinical judgment. Interventions were effective regardless of size (<100 trainees: OR, 1.93; 95% CI, 1.59-2.34; $P < .001$; >100 trainees: OR, 1.89; 95% CI, 1.83-1.96; $P < .001$). Any program involving clinical judgment education seemed more effective (SMD, 1.86; 95% CI, 1.32-2.39; $P < .001$) than when only knowledge regarding PI prevention and management was imparted (SMD, 0.83; 95% CI, 0.54-1.12; $P < .001$).

Publication Bias

The publication bias of the studies included in the analysis was identified by a funnel plot, provided in Figure 3. No asymmetrical distribution was shown, and, because the figure showed an even distribution within the triangle, the risk of publishing bias was considered low.

Figure 3. FUNNEL PLOT BY TRAINING PROGRAM

A, Knowledge; B, visual discrimination ability; C, clinical judgment.



DISCUSSION

Pressure injury recognition (knowledge, visual discrimination ability, and clinical judgment) is an important patient safety factor in Korean hospitals.[59] From this perspective, PIs are no longer a matter to be overlooked, and the responsibilities and roles of nurses in this context should be emphasized, especially during the present expansion of integrated nursing care.

However, PI-related education is conducted mainly for nurses or advanced practice nurses in advanced general hospitals. Most nurses in general hospitals or nursing homes, who tend to care for older adults or patients with chronic conditions, lack such opportunities. For this and other reasons, studies examining the effectiveness of PI training among nurses are not adequate; most single-group studies have weak foundations and may provide conflicting views. The need for a consensus is urgent; it is essential for evidence-based practice and effective nursing activities.

The results of this systematic review indicate that a standardized PI training program for nurses can significantly enhance knowledge. In addition, this study found

that PI training programs increase the visual discrimination ability of caregivers significantly. This result aligns with previous studies that reported an increase in visual discrimination ability after PI training,[41,42] but conflicts with another study that reported no significant difference in the ability to distinguish between PI, moisture-related lesions, incontinence-related dermatitis, and burns.[60] This seems to be because even though education on PI classification and incontinence-related dermatitis improves visual identification, distinction between PI and incontinence-related dermatitis remains difficult. A strategy to strengthen this differentiation is necessary. Finally, the PI training programs have been found to increase clinical judgment significantly, which is expected to increase nurses' core competence as well.

All that said, readers should interpret these results with caution; most of the studies included in the analysis were observational, and the heterogeneity of the articles was relatively high. To investigate the causes of heterogeneity, researchers broke down results by the following variables: patients with significant occupational healthcare, study department, mean age of participants, number of participants, education methods, and training time.

These training programs had a significant effect among nurses aged 20 to 29 years from general hospitals, especially for staff working in ICUs. Programs involving theoretical teaching and clinical practice for more than 2 hours in a class fewer than 100 people were particularly effective. This is consistent with a study[30,32,33,61] suggesting the need for a combination of theory and practice. Programs that last for at least 2 hours and focus on developing problem-solving and practical application skills, rather than traditional lectures, appear to increase efficiency in practice.

Further, the educational effects on nurses at tertiary medical institutions were more significant than those at secondary institutions or nursing homes. This could be because nursing staff at tertiary medical institutions tend to be more experienced and thus have a greater ability to predict and manage potential problems. However, the discrepancy could have been caused by varying measurements of clinical judgment. Therefore, a precise and accepted tool to measure specific characteristics of nursing judgment is needed.

In addition, the posteducation knowledge level of participants significantly improved right after intervention, but effects significantly decreased or disappeared as time passed. This is similar to findings from Park et al[43] and Cox et al[21] suggesting that the longer the time interval after intervention, the more likely participants are to revert to their pre-education baseline. Regular educational programs, continuous feedback after education, and follow-up are necessary. Considering the limitations of one-time education, strategies for enhancing long-term educational effectiveness are also needed.

Regarding program content, those that included not only knowledge provision but also practical content such as visual identification were most effective. However, most of the PI training programs carried out so far only assessed knowledge on the prevention and management of PIs, and most studies have measured changes in knowledge accordingly. Therefore, it seems appropriate to include information that can improve nurses' clinical judgment in future education programs.

Limitations

As previously mentioned, most of the studies included in the analysis were observational, and the heterogeneity of the articles was relatively high. More RCTs studying this issue are needed. Further, this review included only English and Korean studies, so language bias may have influenced the results.

CONCLUSIONS

This systematic review and meta-analysis included a total of 23 studies to identify the effects of PI training programs on nurses. These studies show that these programs are effective in improving nurses' knowledge, visual discrimination ability, and clinical judgment. Training sessions longer than 2 hours at general hospitals targeting ICU nurses aged 20 to 29 years with a mixed method of theory education and clinical practice were most effective. This study could serve as a foundation for the development of PI prevention education for nurses. However, because most of the studies included in this meta-analysis were observational, more experimental RCTs with a high level of evidence are required to validate these findings. ●

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Supplemental Table. CHARACTERISTICS OF INCLUDED STUDIES

Author, Year, Country	Study Design	Participant Type, n	Mean Age, y Mean ± SD or Range	Intervention Contents	Method	Intervention Duration	Outcome Variable	Measurement Tool
Beeckman et al, 2010, UK[3]	RCT	NHN, 1217	20-44	Classification system	Lecture	EXP: 60 min/1 time CONT: 15 min/1 time	Clinical judgment	Classification system: EPUAP,[47] 2005
Cox et al, 2011, US[21]	RCT	GHN (ICU), 60	21-61	Causes and symptoms, classification system, prevention and management	EXP 1: Computer-based program EXP 2: Lecture	1 time/2 wk, 60 min/1 time	Knowledge	Knowledge: Pieper and Mott,[53] 1995
van Gaal et al, 2010, the Netherlands[22]	RCT	GHN (GW), 224 and NHN, 102	EXP: 36.90 ± 10.00 CONT: 39.00 ± 10.30 EXP: 38.10 ± 11.50 CONT: 39.00 ± 10.30	Causes and symptoms, classification system, prevention and management Causes and symptoms, classification system, prevention and management	EXP: Computer-based program CONT: Lecture EXP: Computer-based program CONT: Lecture	2 times/6 mo, 150 min/1 time × 2 2 times/6 mo, 150 min/1 time × 2	Knowledge	Knowledge: EPUAP; Defloor et al, 2005 Visual discrimination: Lee et al,[11] 2011
Altun et al, 2011, Turkey[25]	OBS	GHN, 28	NR	Causes and symptoms, prevention and management, wound care	Lecture	180 min/1 time × 1	Knowledge	Knowledge: multiple-choice questions
Beeckman et al, 2008, Belgium[26]	OBS	NHN, 212	25-44	Classification system, visual discrimination	Computer-based program, Lecture	3 times/3 mo, 60 min/1 time × 3	Clinical judgment	Classification system: EPUAP,[47] 2005
Bredesen et al, 2016, Norway[27]	OBS	NHN (GW), 50	NR	Risk assessment	NR	45 min/1 time × 1	Clinical judgment	Classification system: NPUAP, 2014
Briggs et al, 2006, UK[28]	OBS	GHN (GW), 57	NR	Classification system	Theory and practice	NR	Clinical judgment	Classification system: EPUAP, 2002
Esche et al, 2015, US[29]	OBS	GHN (ER), 141	21-69	Causes and symptoms, prevention and management	Computer-based program, lecture	180 min/1 time × 1	Knowledge	Knowledge: Pieper and Mott,[53] 1995
Gunningberg, 2004, Sweden[30]	OBS	NHN (GW), 20	38.50 ± 9.70	Risk assessment prevention and management, wound care, documentation	Theory and practice	40 h/1 time × 1	Knowledge, clinical judgment	Knowledge: Ek and Bjurulf,[46] 1987 Documentation: Ehnofors and Smedby's five-level scale, 1993

(continues)

Supplemental Table. CHARACTERISTICS OF INCLUDED STUDIES, CONTINUED

Author, Year, Country	Study Design	Participant Type, n	Mean Age, y Mean ± SD or Range	Intervention Contents	Method	Intervention Duration	Outcome Variable	Measurement Tool
Ham et al, 2015, the Netherlands[31]	OBS	AGHN (ER), 54	NR	Classification system, visual discrimination	Lecture	20 min/1 time × 1	Clinical judgment, visual discrimination ability	Classification system: EPUAP, 2014 Visual discrimination: PUCLAS2, 2014, photographs
Jones et al, 2003, US[32]	OBS	GHN (GW), 49	NR	Causes and symptoms, prevention and management, wound care	Theory and practice	3 times/15 d 24 h/1 time	Knowledge	Knowledge: NICE,[54] 2001; RCN,[55] 2000
Law, 2003, UK[33]	OBS	NHN (GW), 40	NR	Prevention and management, wound care	Theory and practice	1 time/1 wk, 8 h/1 time × 5	Knowledge	Knowledge: NICE,[54] 2001
Lee and Park, 2014, Korea[42]	OBS	GHN, 107	30.60 ± 7.75	Prevention and management, classification system, visual discrimination	Lecture	50 min/1 time × 1	Knowledge, visual discrimination ability	Knowledge: Lee et al,[49] 2013 Visual discrimination: Lee et al,[11] 2011, photographs
Lee and Kim, 2016, Korea[34]	OBS	GHN, 407	30.31 ± 6.53	Causes and symptoms, prevention and management, visual discrimination	Lecture	50 min/1 time × 1	Knowledge, visual discrimination ability	Knowledge: Lee et al,[49] 2013 Visual discrimination: Lee et al,[11] 2011, photographs
Lissa et al, 2014, India[35]	OBS	GHN, 60	20-60	Prevention and management	Lecture	NR	Knowledge	NR
Mohamed and Weheida, 2014, Egypt[1]	OBS	AGHN (GW), 40	24.50 ± 3.50	Prevention and management, risk assessment	Lecture	4 h/1 wk 2 h/1 d × 2	Knowledge, clinical judgment	Knowledge: Maylor and Torrance,[50] 1999; Halfens and Eggink,[48] 1995; 22-item checklist
Nayak, 2014, India[36]	OBS	GHN (GW), 30	22-28	Prevention and management, back care	Lecture	NR	Knowledge, clinical judgment	Knowledge: 24-item questionnaire
Park et al, 2013, Korea[37]	OBS	AGHN (GW + ICU), 242	24.10 ± 2.40 24.10± 2.50	Causes and symptoms, prevention and management, risk assessment	Lecture	60 min/1 time × 1	Knowledge, clinical judgment	Knowledge: Park,[45] 2005 Braden scale risk: Bergstrom et al, 1987
Park et al, 2015, Korea[41]	OBS	GHN (ICU), 12	<25: n = 6 ≥26: n = 6	Risk assessment	Lecture	60 min/1 time × 2	Clinical judgment	Neonatal/infant Braden Q scale Risk: McLane et al,[57] 2004

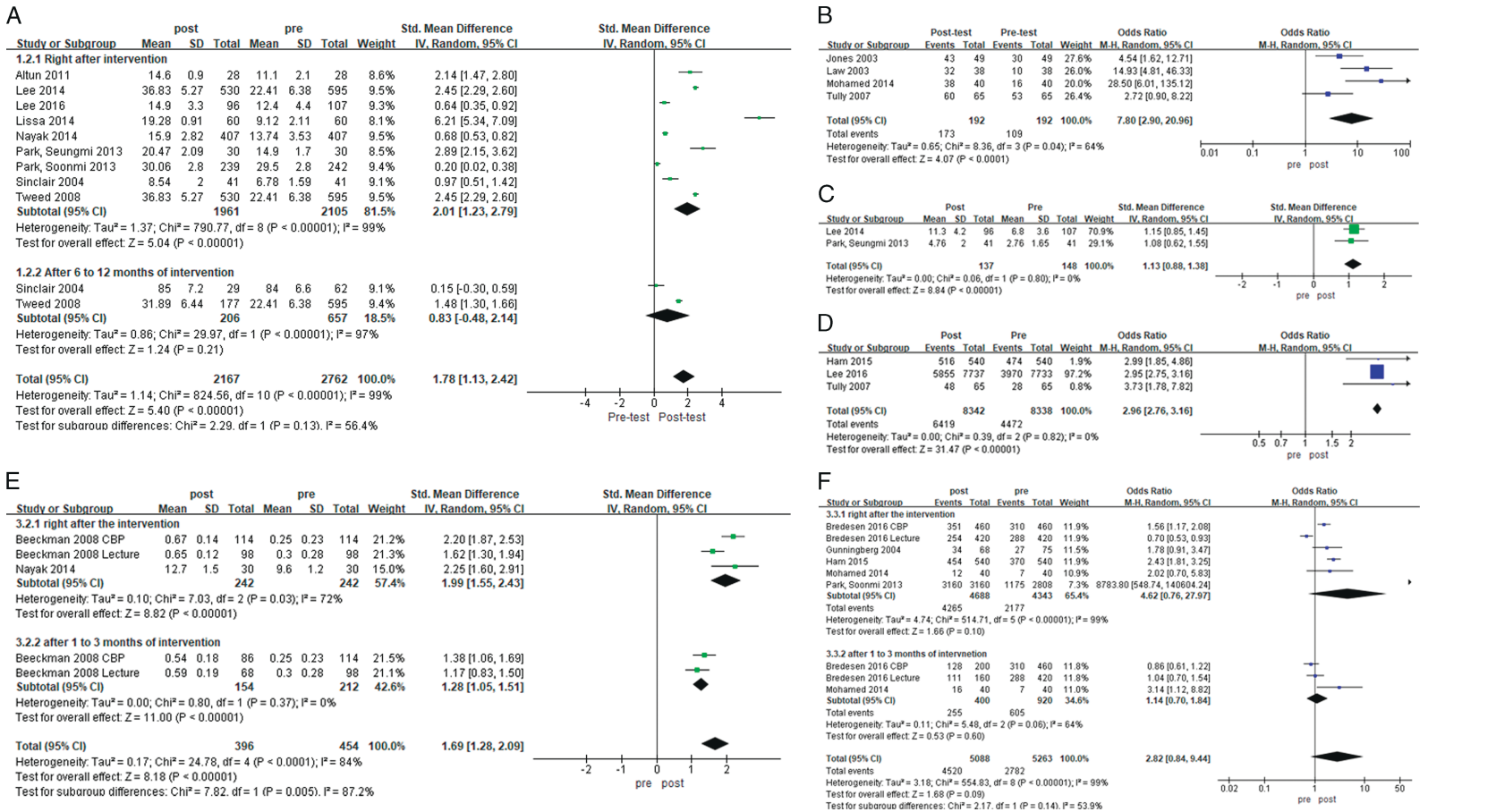
(continues)

Supplemental Table. CHARACTERISTICS OF INCLUDED STUDIES, CONTINUED

Author, Year, Country	Study Design	Participant Type, n	Mean Age, y Mean ± SD or Range	Intervention Contents	Method	Intervention Duration	Outcome Variable	Measurement Tool
Park et al, 2013, Korea[43]	OBS	GHN, 41	28.90 ± 6.00	Causes and symptoms, prevention and management, visual discrimination	Lecture	90 min/1 time × 1	Knowledge, visual discrimination ability	Knowledge: NPUAP, 2007 Visual discrimination: Lee et al,[11] 2011, photographs
Sinclair et al, 2004, US[38]	OBS	GHN (GW), 595	20-51	Prevention and management, wound care	Lecture	3.5 h/1 time × 1	Knowledge	Knowledge: Pieper and Mott,[53] 1995
Tully et al, 2007, Canada[39]	OBS	GHN (WCN), 65	NR	Prevention and management, wound care, visual discrimination	Lecture	2 h/1 time × 4	Knowledge, visual discrimination ability	Knowledge: 27 true/false questions Visual discrimination: 30-picture test
Tweed and Tweed, 2008, New Zealand[40]	OBS	GHN (ICU), 62	NR	Causes and symptoms, prevention and management	Lecture	3 h/1 time × 1	Knowledge	Knowledge: Halfe and Eggink,[48] 1995; Panagiotopoulou and Kerr,[52] 2002; Maylor and Torrance,[50] 1999

Abbreviations: AGHN, advanced general hospital nurse; CONT, control group; EPUAP, European Pressure Ulcer Advisory Panel; EXP, experimental group; GHN, general hospital nurse; GW, general ward; NHN, nursing home nurse; OBS, observational study; NR, not reported; NPUAP, National Pressure Ulcer Advisory Panel; RCT, randomized controlled trial; WCN, wound care nurse.

Supplemental Figure. FOREST PLOT OF EFFECT SIZE BY TRAINING PROGRAM (OBSERVATIONAL STUDIES)



A, changes in knowledge (score); B, changes in knowledge (percent correct answers); C, changes in visual discrimination ability (score); D, changes in visual discrimination ability (percent correct answers); E, changes in clinical judgment (score); F, changes in clinical judgment (percent correct answers)