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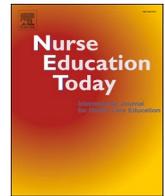
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Research article

Systematic education has a positive impact on nurses' evidence-based practice: Intervention study results

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ABSTRACT

Aims: To evaluate how an education program on evidence-based practice (EBP) affected nurses' knowledge, practices, and attitudes related to EBPs in patient care.

Methods: Nurses of one Finnish university hospital participated in two separate EBP education programs in 2016–2017 and 2018–2019. Data was collected by a questionnaire given before and after each program. Reliable instruments for measuring EBP were used: The Evidence-Based Practice Questionnaire (24 items) and the Attitudes to Evidence-Based Practice Questionnaire (17 items). Means and frequencies were evaluated with the Mann-Whitney *U* test and linear regression.

Results: Nurses reported that their EBP practice, skills and the Work based on EBPs improved substantially after the education program. We found that scores on the Work based on EBPs and the attitudes towards EBP could predict the nurses' overall self-evaluations of practices, attitudes, and skills.

Discussion: EBP education affects positively on implementation of nurses' practices and skills. There is still a need to change attitudes towards evidence based practice.

Implications for practice, research, policy, management, and education: Organizations need to maintain and develop efficient, attractive EBP educational programs to promote lifelong learning.

Conclusions: When designing EBP educational content, it is crucial to teach participants to develop evidence-based methods and consider how to implement them in practice.

1. Background

According to Melnyk et al. (2014) “Evidence-based practice (EBP) is a problem-solving approach to the delivery of healthcare that incorporates the best available evidence, clinician's expertise, and patient values and preferences.” Studies have shown that nurses are quite familiar with EBP. They have positive attitudes towards it, and they believe in the importance of evidence-based nursing in the care of patients (Lunden et al., 2021; Saunders and Vehviläinen-Julkunen, 2016). In addition, an understanding of current research-based evidence gives nurses confidence in changing their practices and working methods. (Häggman-Laitila et al., 2017; Mudderman et al., 2020)

After years of development and education, nurses and other healthcare clinicians have come to understand the importance and value of EBP. It improves the quality of patient care, patient outcomes, and

patient safety. Moreover, EBP is patient-centered, timely, efficient, and equitable. Nevertheless, many nurses do not currently employ EBP systematically, or they are not committed to implementing EBP (Koota et al., 2021; Lunden et al., 2021).

Researchers have found individual and organizational factors that act as barriers or facilitators in promoting EBP. At the individual level, the barriers most often mentioned are the lack of time and scarce resources, inadequate knowledge, and a lack of skills for implementing EBP. Organizational obstacles to EBP implementation include the lack of a fostering culture, with appropriate values and management support. Factors that facilitate EBP include education, leadership, time, and a culture that encourages improvements in the quality of care. (Berthelsen and Holge-Hazelton, 2021; Clavijo-Chamorro et al., 2020).

However, nurses have also identified gaps in their expertise in performing the scientific research required to implement EBP. For example,

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they might have difficulty in formulating a research question that addresses a practical problem or they might be deficient in their ability to conduct literature searches and critically evaluate research findings. (Hines et al., 2018; Mudderman et al., 2020). Moreover, they might feel inept or weak in the skills needed to implement EBPs or protocols in practice (Lunden et al., 2021).

Infrastructural support for educational interventions has played an important role in promoting the adoption, implementation, and maintenance of EBPs. Several studies have assessed the effects of educational activities on nurses' attitudes, knowledge, and skills (Sapri et al., 2022). After receiving an education on EBPs, nurses felt that their ways of thinking had changed. Participation in an educational intervention was perceived as valuable, and it enhanced the value of nursing (Connor et al., 2016). For example, nurses questioned their previous ways of working, and they made changes in the way they worked (Black et al., 2015). A systematic review of educational interventions on evidence-based nursing in clinical practice by Häggman-Laitila et al. (2017) shows positive outcomes. Nurses showed improvements in their understanding of research designs and in their abilities to interpret research results, to search for and evaluate evidence, and to plan a project for implementing changes in practice. In particular, educational interventions should emphasize the evidence that supports changes in patient care (Wu et al., 2018).

The duration of educational interventions have varied from few weeks (Connor et al., 2016) to one (Savvas et al., 2014), and two years (Black et al., 2015). Educational interventions have covered specific topics that describe the individual steps that lead from learning about EBPs to implementing EBPs. Thus, nurses learned to formulate a research question from a practical problem, perform a literature search, critically evaluate study results, evaluate the degree of evidence, synthesize the research knowledge, write a research report, and translate their knowledge into practice (Black et al., 2015; Connor et al., 2016; D'Souza et al., 2021).

2. Aims

This study aims to evaluate the effects of an EBP education program on nurses' knowledge, practices, and attitudes related to EBPs for patient care.

This study addresses the following questions:

1. How did nurses evaluate their practices, attitudes, and skills, and their attitudes towards EBP before and after the EBP education program?
2. How did the nurses' attitudes towards EBP, percentage of Work based on EBP, graduation year, and education, explain their pre- and post-intervention practices, attitudes, and skills?

3. Methods

3.1. Study design

This study administered questionnaires to assess nurses' self-rated practices before and after an educational intervention in two groups of nurses that participated in one of two EBP educational programs conducted in 2016–2017 and 2018–2019.

3.2. Setting and participants

In 2016, the hospital employed about 1900 nursing staff members, and of these, 1226 were registered nurses (RNs). In 2018, among the 1920 nursing staff members, 1325 were RNs. In both years, the study aimed to recruit for participation in the educational intervention. The study participants (2016: $n = 28$ and 2018: $n = 33$) included individuals of the nursing staff with different types of profession (e.g., RNs, midwives, physiotherapists, nurse managers, and vice-nurse managers) that

had attended the EBP education program.

3.3. Instruments

Study participants completed two questionnaires: the Evidence Based Practice Questionnaire for nurses (EBPQ) (Upton and Upton, 2006) and the Evidence-Based Practice in Primary Care questionnaire (McKenna et al., 2004).

The EBPQ was developed and validated in 2006 (Upton and Upton, 2006). Later, the EBPQ was implemented in >40 countries and translated into >18 different languages, including Finnish (see EBPQ, 2017, <https://ebpq.co.uk/>). The EBPQ included 24 items, and each item was rated on a scale of 1–7, where 1 = poor and 7 = best. The EBPQ included three subscales, including the Practice subscale (six items), the Attitudes subscale (four items), and the Skills subscale (14 items). In addition, the questionnaire included six background questions (Upton and Upton, 2006). The Finnish Nursing Research Foundation translated the EBPQ questionnaire into Finnish, with permission from the developers.

The Attitudes to Evidence-Based Practice Questionnaire was based on a previous literature review and previously described measurement tools. It was developed and refined by testing in focus groups (McKenna et al., 2004). The Attitudes to Evidence-Based Practice questionnaire contained 26 items and 8 background questions. The items were rated on a scale of 1 = Strongly disagree to 5 = Strongly agree. The aim of this questionnaire was to address barriers to the use of EBPs, including demographic variables and skills in using research and information resources (McKenna et al., 2004). In this study, we used 17 of the original 26 items on the questionnaire by McKenna et al. (2004) to estimate each participant's use of EBPs. Also, we removed irrelevant questions (old-fashioned or culturally unsuitable) and questions that were duplicated in the EBPQ. The Attitudes to Evidence-Based Practice Questionnaire was translated into Finnish by the University of Eastern Finland, Department of Nursing Science, with permission from the developers.

In this study, we included seven background questions: age, professional education, year that the last professional degree was completed, professional position, nursing specialty, experience (i.e., time spent) in the current occupation, and an estimate of the percentage of work based on EBP (Work based on EBP).

3.4. The educational intervention

The first educational program was conducted in 2009–2010. And it was carried out altogether five times. Each educational program lasted approximately eight months, and altogether 160 nurses participated in years 2009–2018. For each EBP education program, we recruited nurses that had volunteered with their managers' support. The number of participants was limited to ensure that each participant received tutoring. The role of the tutor was to support in completing the development assignment. Tutors were recruited from the organization and had to have minimum a master's degree qualifications. At the beginning of the education, uniform practices were agreed with the tutors. The participant and tutor met on contact days and at other times as needed as the development task progressed. This EBP education program was based on the principles of problem-based, experimental, and collaborative learning. Participants learned through interactive and transformative approaches that fostered thinking skills; critical reflection, which aimed to engage learners; and information sharing to enhance understanding (Gallagher et al., 2020).

EBP education programs (4 ects, European Credit Transfer and Accumulation System) were carried out in the Kuopio University Hospital as a multimodal education program, in collaboration with the University of Eastern Finland, Department of Nursing Science. The main aim was to improve evidence-based skills among the nursing staff. The program consisted of contact teaching (44 h), online teaching (6 h) and independent studying (58 h). The EBP education program included seven steps that were completed in the following order (Fig. 1): 1) develop

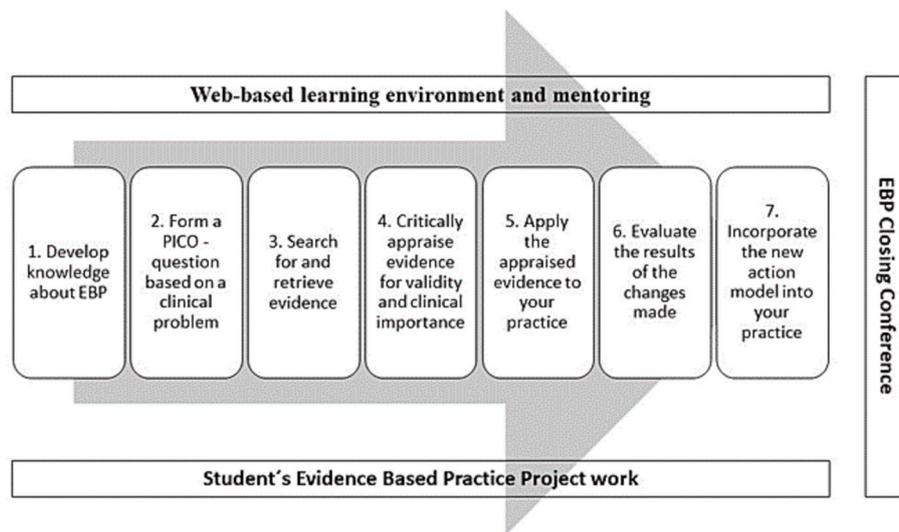


Fig. 1. EBP education seven steps program (according to Melnyk et al., 2014).

knowledge about EBP, 2) form a PICO (Patient, Intervention, Comparison, Outcome)-question based on a clinical problem, 3) search for and retrieve evidence, 4) critically appraise evidence for validity and clinical importance, 5) apply the appraised evidence (regarding research, clinical expertise, patient/client perspectives, values, or resources) to your practice, 6) evaluate the results of the changes made, and 7) incorporate the new action model into your practice (Melnyk et al., 2014).

After completing these seven steps, every participant wrote their own EBP project, based on a recognised clinical problem (PICO) in their own unit. At the end of the educational program, the projects were presented in a closing conference. During the entire education program, the participants worked in a web-based learning environment, attended lectures, received mentoring, and participated in discussions.

3.5. Data collection

The fact sheet and a cover letter were included with the questionnaires to provide information on confidentiality and the rights of study volunteers. The participants had the right to prohibit the use of their answers in the study. Data was collected before (October 2016 and 2018) and after (April 2017 and 2019) the educational programs. However, consecutive queries were not linked to an individual. The 2016–2017 EBP education program included 28 participants at the start, and 23 participants completed it. The 2018–2019 EBP education program included 33 participants at the start, and 28 participants completed it. These two cohorts (2016 and 2018) were the most similar compared to previous education programs, and the measurements were performed in the same way.

3.6. Data analysis

The data collected from both education programs were combined for data analysis. Participant characteristics are expressed as the frequency and percentage, and each EBPQ subscale result is expressed as the mean score. The items on the Attitudes to EBP questionnaire that were worded in negative terms were reversed to positive terms to facilitate the analyses. Reliability was evaluated by Chronbach alpha values. Two subscales (Practise and Skills) had good Chronbach alpha values and also two other (Attitudes and Attitudes towards EBP) acceptable, around 0.6. So, it was appropriate to calculate subscale scores (Grove et al., 2013, p. 544). The Mann-Whitney *U* test was performed to assess differences between responses given before and after the educational program. Linear regression analyses were performed to assess relationships

between outcome variables (Practice, Attitudes, and Skills) and explanatory variables (profession, attitudes towards EBP, work based on EBP, year of graduation, education, and whether data was collected before or after the educational program). Statistical analyses were performed with SPSS version 27.0 for Windows (SPSS Inc., Chicago, IL, USA) and The R Project for Statistical Computing (R, version 4.1.0).

4. Results

4.1. Characteristics of participants in the educational program

The questionnaires were completed by 60 participants before the education program and 50 participants after the education program. Participants' characteristics are presented in Table 1. Over half of participants were RNs, and 1/3 were aged 40–49 years (Table 1).

4.2. Self-evaluations of practices, attitudes, and skills, and attitudes towards EBP before and after the EBP education program

The participants' self-evaluations performed before and after the educational program showed significant changes in their Skills subscale ($p < 0.0001$; before mean = 4.27, SD = 0.63; after mean = 4.94, SD =

Table 1
Characteristics of the participants before and after education.

Background variable	Before (N = 60) n (%)	After (N = 50) n (%)
Age (years)		
20–29	15 (25.4)	10 (20.0)
30–39	16 (27.1)	17 (34.0)
40–49	20 (33.9)	17 (34.0)
50–59	8 (13.6)	6 (12.0)
Graduation year		
Before 2000	18 (31.6)	16 (32.6)
2001–2010	16 (28.1)	12 (24.5)
After 2011	23 (40.3)	21 (42.9)
Profession		
Registered Nurse	43 (71.7)	35 (70.0)
Others ^a	16 (28.3)	15 (30.0)
Education		
RN	15 (25.9)	15 (30.6)
Bachelor degree	39 (67.2)	31 (63.3)
Master degree ^b	4 (6.9)	3 (6.1)

^a Physiotherapist, occupational therapist.

^b Master degree from University of Applied Sciences or University.

0.59) and Practices subscale ($p = 0.014$; before: mean = 4.24, SD = 1.31; after: mean = 4.91, SD = 0.85; Table 2.) The Work based on EBP was higher after (69 %, $n = 50$) than before (60 %, $n = 60$) the educational program ($p = 0.012$) (Table 2).

4.3. Relationships associated with attitudes towards EBP

Three different linear regression models (Table 3) were fit to assess the relationships between the participants' Attitudes towards EBP, the Work based on EBP, the graduation year, and education variables and the changes observed in the participants' Practices, Attitudes, and Skills subscales. In each of the models, the explanatory variables are: professional specialty, Attitudes towards EBP, Work based on EBP, year of graduation, education, and the time period of the measurement. The variable Work based on EBP was centered around the mean value (64 %, $N = 110$). The time period of the measurement was dichotomized to 0 = before and 1 = after the educational program. The professional specialty was dichotomized to 0 = RN and 1 = other. The education and the year of graduation are considered categorical variables: the reference for education is "RN" and the reference for the year of graduation is "before 2000".

The regression results indicate that the Work based on EBP significantly predicted a change in Practice subscale. A 10-percentage point change in Work based on EBP variable predicted an expected 0.15-point change in Practice subscale. The professional specialty of participants also had a significant effect. The mean score for a change in Practice subscale was 0.60 points higher among participants in professional specialties other than a RN, compared to the RNs. Moreover, the measurement performed after the educational intervention was 0.55 points higher than the measurement performed before the intervention, which was also a significant difference. The Practice model predicted 27 % ($N = 110$) of the variation in the changes in Practice subscale (Table 3). In contrast, Attitudes towards EBP subscale, education, and the year of graduation did not significantly predict a change in Practice subscale.

The work based on EBP variable significantly predicted the participants' Attitudes subscale. A 10-percentage point change in Work based on EBP variable was associated with a 0.09-point change in Attitude subscale. Additionally, the Attitudes towards EBP variable had a positive effect on the participants' Attitudes subscale and the effect was significant. A one-point increase in the Attitude towards EBP variable predicted a 0.83-point increase in the participants' Attitudes subscale. Compared to participants that graduated (before 1992) from nursing school as a RNs, those that graduated from a university of applied sciences with a bachelor's or master's degree had, respectively -0.42 and -1.07 lower Attitude subscale scores, but only the master's degree scores were significantly different from the nursing school scores. It should be noted that RNs who graduated before 1992 did not have a university of applied sciences degree at that time, and the corresponding education before -92 is described here as a Nursing school. In addition, compared to participants that graduated before 2000, Attitude subscale scores were approximately 0.5 points higher among participants that graduated in 2001–2010 and 0.78 points higher among those that graduated after 2011. Both differences were statistically significant. The

Table 2
Evidence-based practice (EBP) before and after the educational program.

Time	Practice	Attitudes	Skills	Attitudes towards EBP	Work based on EBP (%)
Chronbach α	0.904	0.618	0.931	0.598	–
Before	4.24 (1.31)	5.42 (0.89)	4.27 (0.63)	3.16 (0.34)	59.60 (19.84)
After	4.91 (0.85)	5.38 (0.88)	4.94 (0.59)	3.15 (0.41)	69.05 (17.79)
p-value	0.014	0.816	<0.0001	0.500	0.012

(Chronbach α , Mean, SD, Mann-Whitney, p-value)

Attitude subscale scores for participants with professional specialties other than RNs were 0.33 points higher than the Attitude subscale scores for RNs. This effect was also statistically significant. The Attitudes model predicted 40 % ($N = 110$) of the variation in participants' Attitudes subscale (Table 3).

The Work based on EBP variable could significantly predict participant Skills subscale. A 10-percentage point change in Work based on EBP variable indicated a 0.01-point change in Skills subscale. However, the effects of Work based on EBP variable were quite small for both Skills and Attitudes subscales, compared to its effect on Practice subscale. In contrast, the Attitudes towards EBP variable had a significant effect on participant Skills subscale, with a slope of 0.31. Moreover, participants that graduated after year 2011 had significantly higher Skills subscale scores compared to participants that graduated before 2000. Additionally, participants with professional specialties other than RNs had significantly higher Skills subscale scores than RNs. The measurements performed before and after the educational intervention showed that participant Skills subscale had improved significantly; the Skills subscale score improved, on average, by 0.53 points. The skills model predicted 43 % ($N = 110$) of the variation in participant Skills subscale (Table 3).

4.4. Study limitations and strengths

This study has some limitations. First, the small cohort in Finland, in one organization limited the global adoption of the findings; therefore, the results are only indicative. The results of the linear regression models predicted quite strong effects, but it is important to note that the data was based on small groups, and there were quite a few explanatory variables. This should be taken into account when critically examining the results. Nevertheless, the models predicted the variations in the outcome variables quite well.

Despite these limitations, the following strengths are worth pointing out. First, the EBPO questionnaire was previously validated by Upton and Upton (2006). Second, the content of the EBP education programs were designed in collaboration with the university and based on international experiences, which remained largely the same over the study period. However, based on participant feedback, the order and emphasis of the content varied. Nevertheless, the individuals in charge of the educational interventions were the same during the study period. In addition, the expert lecturers on EBP and the information specialist were from the University of Eastern Finland, Nursing Research Foundation, and the doctors of health sciences were from Kuopio University Hospital. The individual in charge of the coordination and accountability was a Clinical Nurse Consultant, PhD, from Kuopio University Hospital.

4.5. Recommendations of education and management

The aim of EBP education has changed from providing knowledge to teaching EBP implementation in practice. It is crucial to develop evidence-based methods for implementing EBPs in practice, and this point should be considered when designing educational content. Nevertheless, education alone does not reinforce nurses' practices, skills, or attitudes towards evidence-based actions and decision-making in nursing. It is paramount for the organization to build the structures and culture necessary to foster EBP. Nurses need time, resources (e.g., educational interventions, mentorship), and support from nurse leaders. It is also necessary for nursing staff members to commit to evidence-based actions and ongoing evaluations. Nurses must learn to utilize research information in their work. At a time when there is a shortage of nurses, consistent evidence-based approaches are of paramount importance. EBP education must focus more on the implementation of evidence-based activities in the clinical setting. Interactive learning methods and tutor support should receive more consideration in designing future educational interventions.

Table 3

Three models show the abilities of background variables to predict changes in participants' Practice, Attitudes, and Skills subscales.

Dependent variable	Practice		Attitudes		Skills	
	F-value = 5.224 (DF = 83, p < 0.000) Adj. R ² = 0.2708		F-value = 8.377 (DF = 80, p < 0.000) Adj. R ² = 0.4014		F-value = 9.654 (DF = 83, p < 0.000) Adj. R ² = 0.4321	
Variable	Estimate	p-value	Estimate	p-value	Estimate	p-value
(Intercept)	2.14	0.022	2.68	<0.000	3.17	<0.000
Work based on EBP (centered)	0.02	0.014	0.01	0.014	0.01	0.012
Attitudes towards EBP	0.55	0.061	0.83	<0.000	0.31	0.045
Profession (others than RN)	0.60	0.019	0.33	0.024	0.40	0.004
Education RN (reference)						
Education (bachelor)	-0.08	0.836	-0.42	0.079	-0.29	0.165
Education (master)	-0.12	0.860	-1.07	0.010	0.15	0.696
Year of graduation, before 2000 (reference)						
Year of graduation 2001–2010	0.06	0.888	0.55	0.035	0.21	0.362
Year of graduation after 2011	0.66	0.093	0.78	0.002	0.56	0.008
Time of measurement (after)	0.55	0.014	-0.10	0.365	0.53	<0.000

5. Discussion

The main result of this study is that, after the educational intervention, nurses reported improvements in their practices, skills, and percentages of work based on EBP. Previous studies (D'Souza et al., 2021; Alghatani et al., 2019) have shown similar results. EBP education is important, when the organization aims to implement EBP in the clinical setting.

In this study, a later graduation predicted improvements in participant practices, attitudes, and skills. Moreover, a Master's degree education played a significant role in the attitudes towards EBP. This might be explained by assuming that participants that graduated before 2000 might not have had evidence-based content in their nursing education curriculum; moreover, a systematic education in evidence-based nursing was not available in the organization at that time. The results of this study confirm the importance of a systematic education in EBPs. This educational intervention also had a positive effect on participant attitudes towards evidence-based actions and decision-making.

An interesting result of this study was that the skills and practice scores were higher among participants in specialties other than RNs than among RNs. The other specialties included physiotherapy and occupational therapy, and those individuals worked at outpatient clinics. This finding is consistent with a study by Rudman et al., 2020, which shows that nurses with specialist education that worked in outpatient clinics performed EBPs more often than nurses without specialist education.

EBP skills reflect the ability to apply knowledge to nursing practices and clinical decision-making. Our findings suggest that, after the EBP educational interventions, the work based on EBP, and the attitudes towards EBPs could predict improvements in participant skills. These results support previous findings that EBP education significantly improves skills and the use of EBP (D'Souza et al., 2021), which improves the efficiency of nurses. Thus, EBP educational interventions reinforce EBPs in nursing.

EBP-related nursing practices reflect the nurses' confidence and ability to formulate a question about a practical problem, to retrieve relevant evidence, and to share it with colleagues. In the present study, the work time based on EBP increased significantly after the educational intervention, and participant practices improved. This result might be due to a heightened awareness in participants after the educational intervention, which led to increased attention to evidence-based activities. Moreover, the intervention included a development task that had to be completed according to an evidence-based process. Nurses reported that formulating a question about a practical problem and retrieving information on the topic was perceived as challenging. This perception might be due to differences in educational backgrounds and work experiences among participants and a lack of research skills.

Research literacy is essential for evidence-based action (Hines et al., 2018).

The nurses' attitudes reflect how much importance the individual places on evidence-based actions in nursing and clinical decision-making. In this study, before the educational intervention, the nurses' attitudes were at a moderate level, but they did not improve after the educational intervention. This result contrast with the results from a study by Koota et al. (2021), where nurses' attitudes improved immediately after an educational intervention. Moreover, in a study by Alghatani et al. (2019), nurses' ratings on attitudes were higher than their ratings on knowledge and implementation. Furthermore, Alghatani et al. (2019) shows that attitudes influenced the implementation of EBPs. However, in the present study, self-evaluations of the work based on EBP did not affect the participants' attitudes towards EBP.

The EBP educational intervention included lectures and discussions, tutor support, database search support, and self-directed learning methods. Although the durations of previous EBP educational interventions have varied, an 8-month duration was shown to be appropriate. In this study, it was conducted in a single period without summer holiday breaks, and it engaged participants in the subject. The educational content was evidence-based, and the course followed an evidence-based structure. The education course was intensive and demanding. It was conducted alongside work; thus, participants had to complete the assigned tasks during their free time. Each participant had a tutor for support and guidance for the tasks. About 10–20 % of participants dropped out of the intervention, due to the demands of the assignments, the doubt in their own skills, and difficulties in coping with current life situations. Nevertheless, the interactive learning method was shown to be effective for promoting EBP knowledge and skills. This conclusion is consistent with the conclusions of Koota et al. (2021), who found that contact learning and teaching produced good results. A similar conclusion was reached in a systematic review conducted at the Joanna Briggs Institute on interventions for improving nurses' research literacy (Hines et al., 2018).

6. Conclusions

Regular, well planned and organized evidence-based practice education, as in study hospital, improves practices, skills, and percentages of work based on EBP. Systematic education programs solving practical problems according to an evidence-based protocol are required for Registered Nurses to make them more prepared for evidence-based practices. Due to this, the preparedness to use EBP is higher than years ago. Successful experiences increase RNs' confidence in evidence-based practice. However, there is still a need for practical education and support for nurses to identify clinical problems and transfer evidence

into daily patient care.

6.1. Ethical considerations

XX Hospital granted a research permit for the study (TAJ No 24/2018 23.10.2018). According to Finnish law, this type of research did not require approval from an official research ethics committee. Anonymity and confidentiality were protected by assigning numerical codes to each participant, and all personal data and information that might identify participants were removed (Finnish National Board on Research Integrity, TENK, 2019). Permission to use both Evidence-Based Questionnaires was obtained from their developers by email. At the beginning of the educational program, all participants of the study were informed about the study, the rights of the volunteers, and the measures to maintain confidentiality.

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CRediT authorship contribution statement

Anne Vaajoki: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Tarja Kvist:** Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Markus Kulmala:** Formal analysis, Software, Writing – original draft. **Tarja Tervo-Heikkinen:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing, Visualization.

Declaration of competing interest

None.

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