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Development of ECMO training program for ICU nurses knowledge gain and self-efficacy outcomes assessment: quasi-experimental evaluation

ECMO training & nursing

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Abstract

Aim and objectives To develop an extracorporeal membrane oxygenation (ECMO) training program for intensive care unit (ICU) nurses and assessing the impact of the training on the knowledge and self-efficacy outcomes of the ICU nurses.

Backround The number of patients receiving ECMO support is increasing in Turkiye. However, ICU nurses providing care to ECMO patients lack of structured ECMO training programs.

Design A quasi-experimental study including a single group pretest and posttest.

Methods The study was conducted with 50 ICU nurses working in a public hospital in Ankara, Türkiye. ECMO training program was developed based on the ADDIE (A = Analyze, D = Design, D = Develop, I = Implement, E = Evaluation) model. Data were collected through with a "Knowledge Test', 'Self-Efficacy Perception Scale Regarding the Effectiveness of ICU Nurses in the Care of Patients with ECMO (ECMO- SEPS), 'Simulation checklist' and 'Evaluation form for the effectiveness of the training programme'.

Results In the pretest measurement of the nurses, the mean total score of the knowledge test was 12.0 ± 3.60, while it increased to 21.4 ± 3.57 after the training. In a retest one month after the training, the mean was found to be 20.2 ± 4.92 ($p < 0.05$). The effect size in the knowledge test (d = 2.62) confirms that the educational content was successful in transferring knowledge. It was found that the posttest and retest sub-dimension scores of the ECMO- SEPS increased in all three sub-dimensions compared to the pretest scores, and this increase was statistically significant ($p < 0.05$). The training significantly increased nurses' self-efficacy (η^2=0.702) at a statistically significant and practically important level. The strongest effect was in the cognitive domain (η^2=0.736). In the psychomotor domain (η^2=0.592), it significantly improved application skills. Affective (η^2=0.576): Education had a significant impact on motivation and self-confidence. After the training, an average of 15.0 ± 4.04 of the 22 items in the simulation checklist were fully implemented by the nurses.

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Conclusion In this study η^2 values and statistical significance ($p < 0.001$) prove that ECMO training program is clinically effective and sustainable for ICU nurses knowledge and self-efficacy. The lack of a control group in the study and the fact that all participants were from a single hospital limits the generalisability of the findings. Therefore, it is recommended that future studies implement the ECMO training programme nationwide and be randomised controlled trials.

Clinical trial number Not applicable.

Keywords Extracorporeal membrane oxygenation, Intensive care nursing, Education program, Simulation training, Self-efficacy

Introduction

Extracorporeal membrane oxygenation (ECMO), also known as artificial lung, is a mechanical support system designed to oxygenate blood and pump it through the circulation [1]. Due to its complexity, the effective management of various issues that arise during ECMO support requires multidisciplinary team approach and collaboration [2].In the ECMO team, perfusionists are responsible for setting up and operating the ECMO system, while intensive care unit (ICU) nurses play a critical role in the care of patients outside the operating room [3]. ICU nurses are an integral part of the ECMO process and take on many roles, such as coordinator, caregiver, educator, and consultant, from the beginning to the end of ECMO support [4]. Maintaining haemodynamic stability, preventing and managing complications, and balancing the complex relationship between the patient and the ECMO circuit are the main factors that complicate the care of ECMO patients [5]. In order to manage this process effectively and provide high-quality care, nurses need to continuously improve their knowledge and skills related to ECMO [6, 7]. Accordingly, ICU nurses should receive comprehensive and practical training that will enables them to evaluate the ECMO circuit and the patient's condition simultaneously [8, 9]. The aim of ECMO training is to improve nurses' clinical decision-making processes and ensure that patient care is standardised in accordance with current evidence-based quidelines. It is also aims to increase nurse's confidence, proficiency and skills in ECMO [10, 11].

ECMO training programmes in the literature are primarily multidisciplinary programmes focused on developing the technical skills of ECMO specialists and ECMO coordinators [12–15]. Studies have reported that ICU nurses who received ECMO training experienced reduced feelings of fear, anxiety and uncertainty, and increased expertise in ECMO [16–19]. ECMO trainings has mostly been simulation-based [20].

In recent years, active learning methods such as flipped classrooms, case discussions, and simulation-based practices have been incorporated into nursing education and practice [21–23]. Simulation-based training is an important training method that provides individuals with realistic visual, auditory and tactile cues in a potential or actual emergency scenario. This method effectively develops not only cognitive and technical skills, but also behavioural skills, using all three types of skills [23–25].

Integrating simulation practice into ECMO training programmes allows nurses to develop their decision-making skills under stress and strengthen interdisciplinary team communication [12, 13, 15]. Simulation-based ECMO training for ICU nurses is helps nurses acquire technical skills for patient care and manage complications [26, 27].

The use ECMO in Türkiye is increasing in parallel with the worldwide [28, 29]. However data on patients receiving ECMO and evidence related to nursing care remain limited. ECMO training has been restricted to physicians and perfusionists. Currently, there is no nationwide structured ECMO training program for intensive care nurses that includes practical training and/or simulation [30]. In conclusion, existing evidence highlights the critical importance of developing a comprehensive training programme to enable ICU nurses in Türkiye to cope with the challenges they face when caring for patients supported ECMO by and to provide high-quality care to patients.

Methods

Aim

The study had two objectives. The primary objective was to develop an ECMO training programme for intensive care nurses and to assess its effectiveness. The secondary objective was to assess the nurses' practical skills.

Research hypotheses

Hypothesis 1

$\mathbf{H_{1-0}}$ There is no significant difference between the ICU nurses' pretest and posttest knowledge scores after the ECMO training program.

$\mathbf{H_{1-1}}$ There is a significant difference between ICU nurses' pretest and posttest knowledge scores after the ECMO training program.

Hypothesis 2

$\mathbf{H_{2-0}}$ There is no significant difference between the ICU nurses' self-efficacy perception scores after the ECMO training program.

$\mathbf{H_{2-1}}$ There is a significant difference between the ICU nurses' self-efficacy perception scores after the ECMO training program.

Design

The research was designed as a quasi-experimental research design based on a one-group, pretest, posttest. Quasi-experimental designs are cost-effective ways to explore whether a potential intervention is worthy of further investigation. They can be helpful when conditions are not favorable for actual experimental designs. One-group pretest-posttest design is mostly used when it is possible for researchers to work with a single group [31]. In this study, since the sample was selected from a single center (the institution with the highest number of ECMO applications), training was given in a single group, considering confounding factors and interaction. The lack of a control group should be considered a factor that may limit causal inferences.

Setting and participants

The study was conducted in the city hospital in Ankara, Türkiye, between 25 December 2023 and 29 February 2024. The sample of the research was calculated as a result of the power analysis applied with the G* power 3.1.9.7 program; for the determination of the difference between the pretest and posttest measurements, the sample size was found to be 43 participants according to the type 1 error: 0.05, type 2 error: 0.05 and effect size 0.250 (df = 84; F = 3.105) Considering the high power of the test and possible losses, the study was finalized with 50 people [32]. Nurses who had worked as ICU nurses for at least one year, had experience in caring for patients receiving ECMO, and had provided written informed consent to participate in the study were included. ECMO is used in the hospital's cardiovascular surgery, coronary, heart-lung transplant, and internal ICUs. Nurses working in four different ICUs were included in the sample. However, the fact that data were collected on a voluntary basis should be considered a factor that may limit the representativeness of the sample. Those who had previously received training or a course related to ECMO, those who could not participate in any stage of the training program (theoretical or practical), and/or those who did not complete all stages of the program were excluded from the study. After analyzing the data, a power analysis was repeated at the end of the study based on the pretest and posttest scores of nurses on the ECMO Self-Efficacy Perception Scale (ECMO-SEPS) and the knowledge test, as presented in Table 1. As a result of the power analysis, the eta squared value was found to be 0.681 for the change in knowledge test scores across pretest, posttest, and retest; 0.702 for the change in self-efficacy perception scores across test, posttest, and retest; and the power of the test was determined to be 97%.

Data collection tools

Identifying information form

This form was developed by the researchers based on their own experiences and current literature [2, 3, 5, 7]. It consists of nine questions regarding the sociodemographic characteristics of the nurses (age, gender, educational status), duration of work in the ICU, experience in caring for the patient with ECMO (in years), participation in scientific meetings, follow-up of scientific publications, ICU certification, and the nurses' self-assessed adequacy in caring for patients with ECMO.

Knowledge test

The knowledge test was developed by researchers for this study, based on the literatüre, to assess nurses' knowledge

Table 1 Distribution of total and sub-dimension scores of ECMO self-efficacy perception levels of ICU nurses before and after training and mean scores of knowledge test

Dependent variables		Pre-test (T_0)		Post-test (T_1)		Re-test (T_2)		Statistical Analysis			
		$\bar{X} \pm SS$	Min-Max	$\bar{X} \pm SS$	Min-Max	$\bar{X} \pm SS$	Min-Max	F[b]	*p*	Etakare	Bonferroni (T)
Knowledge Test		12.0 ± 3.60	2–18	21.4 ± 3.57	14–27	20.2 ± 4.92	6–27	104.39	< 0.001	0.681	1 < 2,3
ECMO Self-Efficacy Perception Scale	Cognitive sub-dimension	37.8 ± 10,98	20–63	56.1 ± 9.93	28–70	59.7 ± 6.76	48–70	136.73	< 0.001	0.736	1 < 2,3; 2 < 3
	Affective sub-dimension	12.1 ± 3.23	6–19	16.2 ± 2.77	11–20	17.1 ± 2.73	10–20	66.60	< 0.001	0.576	1 < 2,3; 2 < 3
	Psychomotor sub-dimension	65.5 ± 16.09	38–95	82.5 ± 11.52	57–95	86.9 ± 8.121	74–95	71.11	< 0.001	0.592	1 < 2,3; 2 < 3
	Total	115.3 ± 28.04	70–177	154.8 ± 22.98	96–185	163.6 ± 16.02	137–185	115.34	< 0.001	0.702	1 < 2,3; 2 < 3

X̄: Arithmetic mean, SD: Standard deviation, F: Repeated measures analysis of variance, $p < 0.05$, TO: Total score before training, T1: Total score immediately after training, T2: Total score one month after training

level of ECMO [4, 9, 19, 33]. Learning objectives have been written according to Bloom's Taxonomy (knowledge, comprehension, application, analysis, synthesis, and evaluation) to measure the cognitive domain in education. These levels range from simple to complex, concrete to abstract, and build upon each other. Multiple-choice questions were prepared to measure each specified learning objective. The content validity of the knowledge test items was established based on the opinions of seven experts. Experts were asked to provide recommendations for each item as 'not appropriate,' 'appropriate but changes are necessary,' or 'appropriate,' and their opinions were analyzed using the Lawshe technique. According to Lawshe, for each item with a positive content validity ratio, the ratios should be examined at a significance level of α = 0.05. Following expert review, the content validity ratio of the items in the information evaluation form was found to be 0.98 [34]. In the pilot study, the questions were administered to 25 ICU nurses with experience in caring for patients receiving ECMO support, using snowball sampling. These nurses were from a different institution than the one where the main study was conducted. Item difficulty, discrimination, and response time were analyzed using the independent groups t-test. Questions with scores below 0.5 were excluded, while those with scores of 0.5 or above were included. As a result of the knowledge test, the lowest score was 0, and the highest score was 30. In summary, knowledge test scores are directly proportional to knowledge levels. In our study, the Cronbach's alpha value of the knowledge test was found to be 0.797 after analysis (Supplementary 1).

Self-efficacy perception scale regarding the effectiveness of ICU nurses in the care of patients under ECMO (ECMO- SEPS)

The ECMO-SEPS was developed by Güler, Savaş, Bulut, and Karakaya in 2021 [35]. The scale is a 5-point Likert-type instrument consisting of 37 items and three factors, designed to evaluate ICU nurses' self-efficacy perceptions in the cognitive, affective, and psychomotor domains related to ECMO care. The lowest score obtainable from the scale is 37, and the highest score is 185. The cognitive sub-dimension consists of 14 items (score range: 14–70), the affective sub-dimension consists of 4 items (score range: 4–20), and the psychomotor sub-dimension consists of 19 items (score range: 19–95).

Validity was examined using the Content Validity Index (CVI), while construct validity was evaluated through both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The CFA indicates that the items and subscales have good internal consistency. Additionally, the items demonstrated a high Content Validity Ratio (CVR) value of 0.94, reflecting strong content validity.

The cognitive, affective and psychomotor subscales explain %27.126, %9.594, and %33.771 of the total variance respectively. The self-efficacy perception scale explains %70.491 of the total variance. CFA indicated good fit values for the scale ($\chi^2/sd = 2.89$, GFI = 0.75, CFI = 0.91, RMSEA = 0.07, and SRMR = 0.04). Test-retest analysis to evaluate the scale's reliability showed a good fit between the responses over time (ICC: 0.932; $p < 0.001$). The total scale Cronbach's alpha was 0.97 and the cognitive, affective," and psychomotor subscales Cronbach's alpha was 0.97, 0.81, and 0.96, respectively. Higher scores indicate better self-efficacy perception. In our study, Cronbach's alpha value of the scale was found to be 0.985 (Supplementary 2). It complied with the COSMIN (Consensus-based standards for the selection of health status measurement instruments) checklist for health status measurement instruments.

Simulation checklist

It was developed by researchers in accordance with the literature [11, 15, 26, 36, 37]. This checklist consists of 22 items that evaluate targeted nursing interventions—such as monitoring, recognition of bleeding signs and symptoms, necessary management interventions, and documentation—and assess whether these interventions were implemented in accordance with the simulation scenario developed by the researchers (including bleeding complication and cardiac arrest scenarios in patients receiving ECMO). According to the implementation status of the items in the form, options of fully implemented, incompletely implemented, or not implemented were marked. The content validity of the form was established by obtaining the opinions of five faculty members specializing in surgical nursing and simulation training. Expert opinions were analyzed using the Lawshe technique, and the results showed that the content validity ratio of the items on the simulation checklist was 0.83.

Evaluation form for the effectiveness of the training program

The form was created by the researchers and consists of two sections. The first section includes 15 statements with a 5-point Likert scale. These statements include evaluations of the training duration, content, methods, materials used, contribution of the training, and trainer competence [38, 39]. Participants rate the statements on a scale from 1 to 5 (1 = 'strongly disagree', 5 = 'strongly agree') according to their level of agreement. The second part of the form includes a SWOT analysis (strengths, weaknesses, opportunities, and threats), consisting of four open-ended questions about the training program's strengths and weaknesses, opportunities it offers, and perceived threats. The content validity of the form was established by obtaining the opinions of five faculty

members specializing in surgical nursing and nursing education.

Development of the ECMO training program for ICU nurses

In the study, a systematic process was followed in the development and evaluation of the ECMO training programme.

The study flow chart is outlined in Fig. 1. The steps of the ADDIE model (Analyze, Design, Develop, Implement, Evaluate) were followed to develop and evaluate the effectiveness of the training programme.

This process is illustrated in Fig. 2.

Analysing stage

A literature review on ECMO training was conducted using keywords searched in major databases (Pubmed, CINAHL, EBSCO, Scıence Dırect, Google Scholar), resulting in a content pool for the training program [40–48]. Additionally, a qualitative preliminary study identified nurses' needs for practical training on ECMO mechanics, console parameters, complication management, and related topics [30].

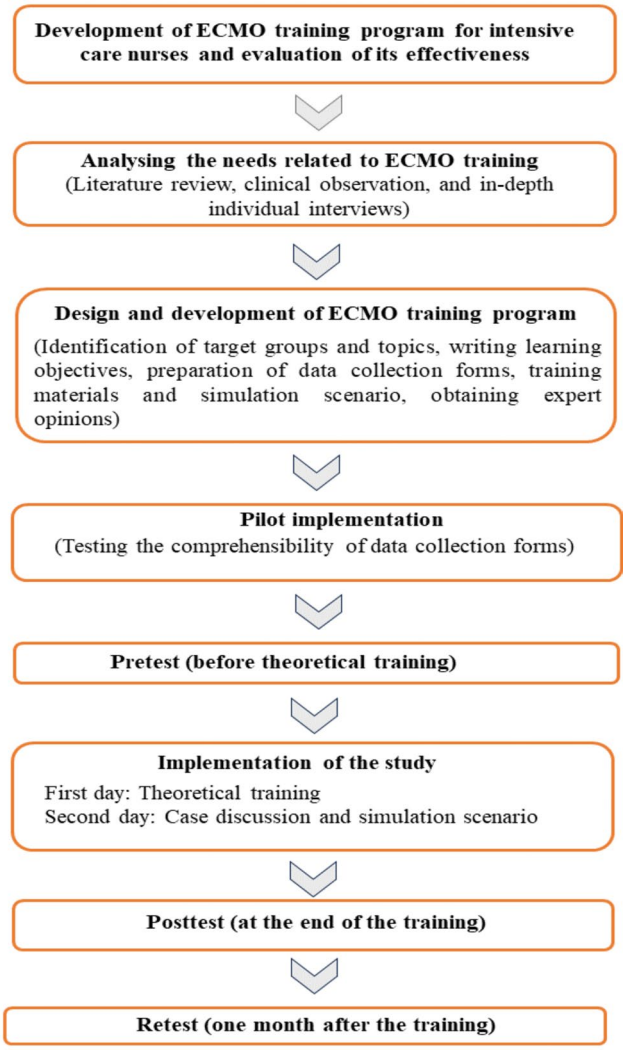


Fig. 1 Flow chart of the study

Design stage

At this stage, the content of the training program, including topics and teaching methods, was designed. The training is planned to include both theoretical and simulation-based learning. For the theoretical education, active learning approaches such as presentations, collaborative learning, and learning by discovery are planned. For case discussions, literature reviews were conducted on common clinical situations. The Hybrid Simulation method, frequently used in health-related case studies and simulation practice, was selected as the simulation-based teaching approach. The training period was set to three days: theoretical training on the first day, case discussions on the second day, and simulation practice on the third day. The city hospital was chosen as the training venue, and it was planned to supply ECMO circuits with the support of perfusionists at the institution.

Development stage

A draft of the training program was prepared, including topics for theoretical sessions and case studies. Presentations and training materials, along with an ECMO mind notes booklet, were developed for participants. Expert feedback was obtained from unit managers and cardiovascular specialists to create seven case examples covering common ECMO complications [49–52]. A simulation scenario was designed based on the International Nursing Association for Clinical Simulation and Learning (INACSL) model, and reviewed by experts for program content, scenario, and booklet [53, 54].

Collaboration was established with an experienced standardized patient from a university simulation center, matching scenario characteristics. A pre-training briefing explained session details and obtained participant consent. To accommodate nurses' schedules, training was arranged over two days twice a week for different groups. For ethical reasons, a demo ECMO set was used during simulation, with the actual device kept as a spare. The simulation session was recorded using Open Broadcaster Software (OBS) Studio installed beforehand on the researcher's computer.

Implementation stage

The implementation phase of the study consisted of two stages: theoretical and practical.

First day (Theoretical training process) Theoretical training spanned four weeks with two groups per week, each containing 6 to 8 nurses. Relevant materials were sent beforehand. On training day, the program was

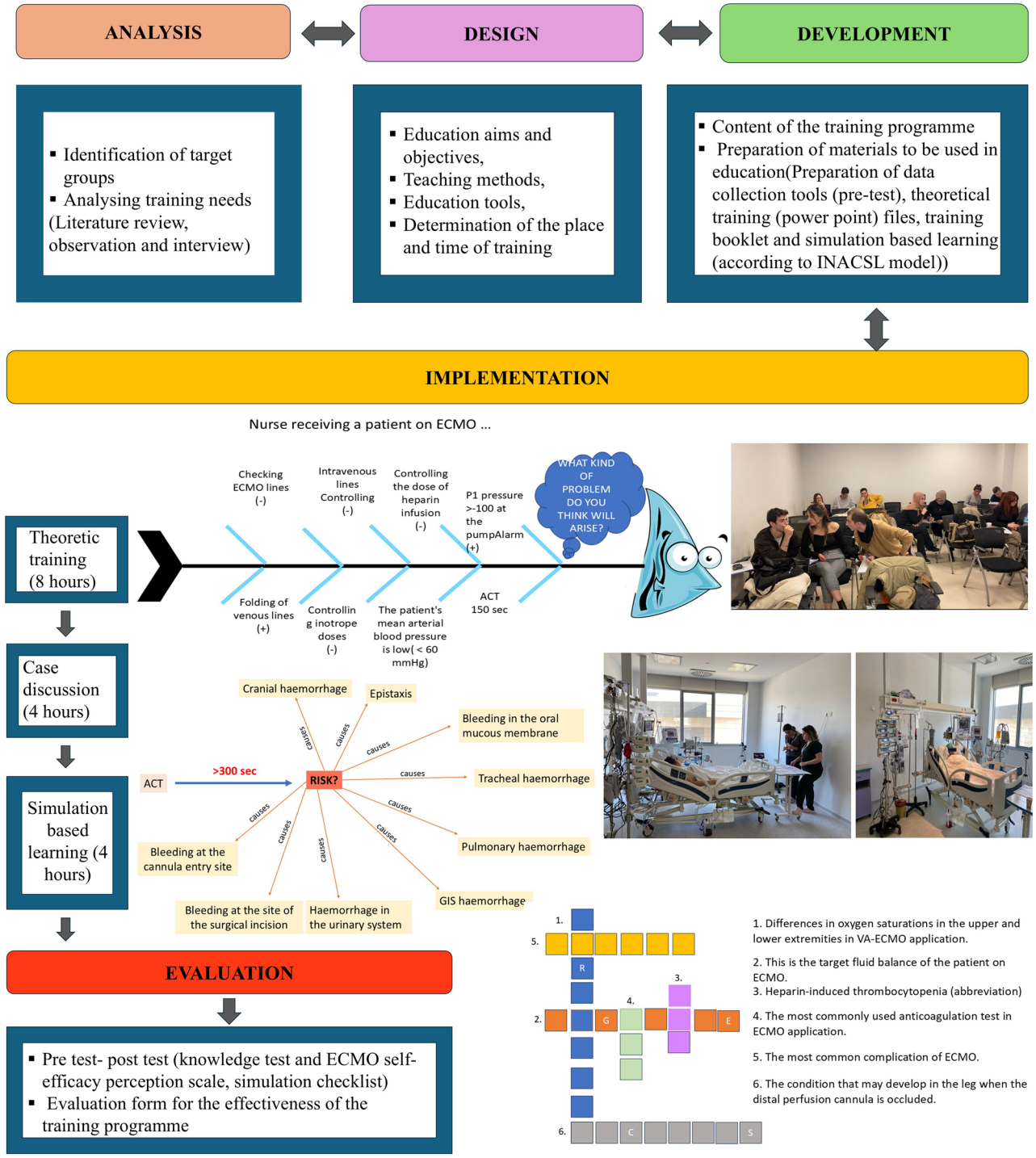


Fig. 2 Development process of the ECMO training programme for ICU nurses and evaluation of its effectiveness using the ADDIE model

introduced, consent forms were signed, and a pretest was administered, which included an introductory form, the ECMO-SEPS scale, and a knowledge test (40 min allotted). This was followed by 8 h of theoretical sessions using varied teaching methods such as lectures, discussions, group work, and case studies. Interactive techniques like True-False, Fishbone, Buzz 44, Concept Map, and "What Would You Do If You Were Me?" supported learning.

Second day (case discussion & simulation-based learning) During the first four hours in the morning, brainstorming, question-and-answer sessions, and case studies were conducted. The case studies were done in groups of

four using the Buzz 44 method, with each group assigned a nickname for addressing questions. The responses were then collected and discussed with the trainers. In the afternoon, the four-hour simulation consisted of three parts: preliminary information, scenario implementation, and debriefing. During the preliminary information phase, participants were informed about the purpose, objectives, simulation room, materials, characteristics of the standardized patient, and roles in the scenario. This briefing was given in groups of four and lasted about 7 min on average (range 3–10 min).

After that, each nurse individually performed the scenario tasks, with no repetitions. Each simulation lasted approximately 12 to 15 min. Two observers—the researcher and a hospital training nurse with an MSc in surgical nursing—monitored the sessions. A checklist was used to record whether expected tasks were completed, marked with plus or minus (+/-) signs. Inter-rater reliability was ensured through consensus coding.

Following the scenarios, an analysis session was held where participants viewed recordings of their performance. A debriefing session based on the PEARLS model (Promoting Excellence and Reflective Learning in Simulation) was conducted, lasting about 40 min [55].

After debriefing, the knowledge test and ECMO-SEPS were reapplied as posttests. Since participants knew they were being videotaped and performed the simulation at their own institutions, there was a possible Hawthorne effect [56].

Evaluation stage

In our study, we followed the steps of the model developed by Kirkpatrick for evaluating training programs. The model consists of four consecutive stages [57, 58].

Stage 1 – Reaction process Feedback was collected through the simulation analysis sessions and the training program evaluation form.

Stage 2- learning process Evaluation was conducted using pretest and posttest results.

Stage 3- behavioural process At this stage, the knowledge test and ECMO-SEPS were repeated one month after the completion of the training to assess the retained information.

Stage 4- results process The results of the training program need to be implemented by institutions according to their own policies. Since this process requires time, determining the exact outcomes may be difficult. Therefore, this stage could not be evaluated.

Statistical analyses

The data obtained in the study were analyzed using IBM SPSS Statistics for Windows, Version 22.0 (SPSS INC., Chicago, IL, USA). Frequency and percentage statistics were used to analyze descriptive characteristics, simulation checklist application steps, and the evaluation of the training program. Mean and standard deviation were applied to analyze the self-efficacy perception scale results.

It was determined that all variables followed a normal distribution (|skewness| < 1, |kurtosis| < 2). Therefore, parametric tests were preferred. Differences in knowledge test scores and self-efficacy perception levels according to participants' characteristics were examined using independent samples t-tests and one-way ANOVA; a Tukey post hoc test was applied to determine the source of significant differences. Changes over time were analyzed using repeated measures ANOVA. Effect sizes were reported using η^2 coefficients.

Results

Descriptive characteristics of participants

Table 2 presents the descriptive characteristics of ICU nurses, including their unit of work, age, gender, education level, and experience related to ICU and ECMO care. According to the data, %36 of the nurses worked in cardiovascular surgery ICUs, %24 in heart-lung transplant units, %22 in internal medicine ICUs, and %18 in coronary ICUs. The mean age of the participants was 26.7 ± 3.34 years, and 66% were female. The majority held a bachelor's degree (%82). The average ICU experience was 3.5 years, while %74 did not have an ICU nursing certificate. Nurses had an average of 2.7 ± 2.04 years of experience caring for patients receiving ECMO. Notably, %94 had never attended any scientific meetings related to ECMO, and none reported regularly following periodicals on ECMO patient care. In the correlation analysis of descriptive characteristics and dependent variables, the relationship between ICU experiences and post-tests was positive, but a weak correlation was found. The findings suggest that the effects of age and ICU experience on learning are limited, while the active and simulation-based training methods used play an important role in the learning process (Supplementary 3).

Comparison of pre-and post-training knowledge test and ECMO self-efficacy scale scores

Table 1 summarizes the mean total knowledge test scores of nurses. The mean pretest score was 12.0 ± 3.60, which increased significantly to 21.4 ± 3.57 following the training ($p < 0.05$). In the follow-up assessment conducted one month later, the mean score slightly decreased to 20.2 ± 4.92; however, this decrease was not statistically significant. While the significant improvement in

Table 2 Descriptive characteristics of ICU nurses ($n=50$)

Descriptive Characteristics	*n*	%
Gender		
Female	33	66
Male	17	34
Education Situation		
High school	9	18
Bachelor's degree	41	82
Having a certificate of intensive care nursing		
Yes	13	26
No	37	74
Participation in scientific meetings(webinars, conferences, etc.) related to ECMO and patient care		
Yes	3	6
No	47	94
The following periodicals (journals, articles, etc.) related to ECMO patient care		
Yes	0	0
No	50	100
	$\bar{X} \pm SS$	Min-Max
Age	26.7 ± 3.34	23–40
Year of working	3.6 ± 3.04	1–16
Experience in caring for a patient on ECMO (years)	2.7 ± 2.04	1–10
Department (ICU)	**n**	**%**
Cardiovascular surgery	18	36
Heart-lung transplant	12	24
Coronary	9	18
Internal	11	22
Level of feeling competent in the care of the patient in ECMO	5.26 ± 1.64	2–8

posttest scores indicates the immediate effectiveness of the training, the slight decline at follow-up may suggest a gradual loss of knowledge over time. It is noteworthy that no further long-term follow-up assessments (e.g., at 3 or 6 months) were conducted.

According to the Bonferroni test results, the mean scores of the posttest and follow-up measurements were similar and both were significantly higher than the pretest scores. The eta squared value indicated that the ECMO training accounted for % 68.1 of the total variance in knowledge test scores.

The total and sub-dimension scores of the ECMO-SEPS in both the posttest and retest showed a significant increase compared to those in the pretest ($p<0.05$).

In the pretest sub-dimension scores of the ECMO-SEPS, nurses perceived themselves as sufficiently competent, particularly in the affective domain and to a lesser extent in the psychomotor domain, prior to the training. Analyses of the posttest and retest scores showed statistically significant increases in all three sub-dimensions compared to the pretest ($p<0.05$). Notably, the highest score increase in the retest was observed in the cognitive sub-dimension, which was also statistically significant ($p<0.05$).

A positive and significant relationship ($p<0.05$) was found between ICU nurses' duration of work experience and the total as well as sub-dimension scores of the ECMO-SEPS in the pretest, posttest, and retest. Similarly, the duration of professional experience with ECMO was positively and significantly correlated ($p<0.05$) with perceived competence in ECMO patient care, as well as with the total and sub-dimension scores—specifically the cognitive and affective sub-dimensions—in the pretest, posttest, and retest.

Implementation rates of simulation checklist

Table 3 summarizes nurses' performance in completing each stage of the ECMO simulation checklist. After the theoretical training, each nurse participated in one simulation practice section. On average, they fully completed 15.0 ± 4.04 of the 22 checklist items. Performance was particularly strong in the stages involving the monitoring and evaluation of hemodynamic parameters, which were completed with high accuracy.

However, nurses did not perform an average of seven specific items. These included checking the distal perfusion cannula, monitoring kidney function tests, assessing peripheral pulses, evaluating incision sites for wound healing, preparing for CPR in case of cardiac arrest, conducting neurological assessments, and ensuring patient safety.

Table 3 Implementation rates of simulation checklist steps

Sequence	Simulation checklist steps	Status of steps	*n*	%
1.	The patient was received in accordance with the SBAR method (status, history, assessment, recommendations).	Completely	50	100
2.	Vital parameters of the patient were evaluated and recorded.	Completely	50	100
3.	Infusions, drains and urine output of the patient were evaluated and recorded.	Completely	46	92
		Inadequate	4	8
4.	Mechanical ventilator parameters of the patient were evaluated and recorded	Completely	37	74
		Inadequate	12	24
		Never	1	2
5.	ECMO parameters were evaluated and recorded	Completely	24	48
		Inadequate	18	36
		Never.	8	16
6.	Patient safety was assessed (checking that the bed lock and bed cable were attached; checking the power connections of the mechanical ventilator and ECMO device)	Completely	7	14
		Inadequate	23	46
		Never	20	40
7.	Neurological evaluation was performed (Glasgow coma scale, orientation, agitation status)	Completely	19	38
		Inadequate	28	56
		Never	3	6
8.	Fluid intake and output were monitored/evaluated	Completely	31	62
		Inadequate	16	32
		Never	3	6
9.	Renal function tests (urea, creatinine, etc.) were checked	Completely	7	14
		Inadequate	13	26
		Never	30	60
10.	Signs and symptoms of bleeding were monitored (haemoglobin, haematocrit, INR, plt, ptz, ACT)	Completely	25	50
		Inadequate	23	46
		Never	2	4
11.	ACT control was performed and the result was evaluated	Completely	44	88
		Inadequate	4	8
		Never	2	4
12.	Peripheral pulses, temperature, colour and oedema in the extremities were evaluated	Completely	22	44
		Inadequate	11	22
		Never	17	34
13.	Distal perfusion cannula was checked	Completely	12	24
		Inadequate	1	2
		Never	37	74
14	Incision sites were evaluated in terms of wound healing	Completely	26	52
		Inadequate	13	26
		Never	11	22
15.	Blood gas was controled and results were evaluated	Completely	50	100
16.	Medical treatments were administered and recorded	Completely	50	100
17.	Hypovolemia was noticed in the patient	Completely	46	92
		Inadequate	4	8
18.	Signs and symptoms of bleeding were recognised	Completely	46	92
		Inadequate	4	8
19.	Bleeding and hypovolaemia were reported to the team	Completely	47	94
		Inadequate	3	6
20.	Physician orders were implemented (doses of inotropic drugs were increased, blood gas control was performed, heparin infusion was terminated, drug and environment preparations were checked for emergency)	Completely	37	74
		Inadequate	12	24
		Never	1	2
21.	The patient was placed in supine position	Completely	31	62
		Inadequate	5	10
		Never	14	28

Table 3 (continued)

Sequence	Simulation checklist steps	Status of steps	*n*	%
22.	The environment and patient were prepared for CPR (ambu, overhead lamp, cautery, defibrillator, blood preparations were made)	Completely	33	66
		Inadequate	11	22
		Never	6	12
Total number of applications (N)		$\bar{X} \pm SS$	Min -Max	
50		15 ± 4.04	7–22	

Table 4 Evaluation form the effectiveness of training programme

Statements about evaluation	Respond status					
	Never		Partly		Completely	
	n	%	*n*	%	*n*	%
The time of the training programme was sufficient.	-	-	5	10	45	90
The theoretical hours of the training programme was sufficient.	-	-	2	4	48	96
The practical hours of the training programme was sufficient	-	-	3	6	47	94
The content of the training programme was adequate.	-	-	-	-	50	100
The training programme met my expectations	-	-	-	-	50	100
The trainer was knowledgeable and experienced on the subject.	-	-	-	-	50	100
The trainer provided a comfortable and effective learning environment.	-	-	-	-	50	100
The time management of the trainer was good.	-	-	-	-	50	100
The teaching methods increased my interest in the training and my level of knowledge about the topics.	-	-	-	-	50	100
Interactive methods encouraged my critical thinking and self-learning.	-	-	1	2	49	98
The materials used in the training increased the permanence of the training.	-	-	1	2	49	98
The size, lighting and technological adequacy of the classroom where the theoretical training was given were appropriate.	1	2.0	-	-	49	98
The simulation based learning improved my clinical skills.	-	-	2	4	48	96
The simulation based learning provided a professional learning environment.	-	-	2	4	48	96
Case examples helped me to reinforce care management in the patient with ECMO.	-	-	1	2	49	98

Evaluation of the effectiveness of the training program

Table 4 presents nurses' evaluations of the ECMO training program. All participants (%100) reported that the training content was sufficient and met their expectations. They rated the trainer as knowledgeable and experienced, and described the training environment as comfortable and conducive to learning. Additionally, time management was evaluated positively, and the teaching methods were found to enhance both their interest and knowledge in the subject matter.

Almost all nurses considered the total duration (%90.0), theoretical duration (%96.0), and practical duration (%94.0) of the training sufficient. Furthermore, nearly all participants indicated that the interactive methods encouraged critical thinking and self-learning. They reported that the training materials enhanced knowledge retention, the simulation practice improved clinical skills and provided a professional learning environment, and the case examples reinforced ECMO patient care management.

Table 5 presents the results of the nurses' SWOT analysis of the ECMO training program. Based on their open-ended responses, nurses identified several strengths of the program, including the trainers' expertise, the quality of the theoretical content, the use of case discussions and simulations, and the effectiveness of the training materials. The weaknesses were generally related to environmental factors, such as the training duration and training environment. Most participants ($n = 28$) reported that the short duration of the theoretical training was a particular weakness. The nurses reported that the ventilation in the theoretical training room was inadequate. Fourteen participants ($n = 14$) suggested that the theoretical training should be longer and the classrooms should be larger and more spacious. Participants reported issues related to certain physical conditions (ventilation, classroom size, duration of theoretical lessons, etc.) that may have adversely affected their concentration and learning performance during the training process. This situation may have had a limiting effect on the effectiveness of the training environment.

Statements such as video recording during the simulation practice and anxiety about being compared with peers are included in the threats section of the SWOT analysis. Therefore, it should be acknowledged that video recording may have negatively affected the performance of some nurses. Although our study did not develop a specific strategy to address this issue, future research is recommended to implement methods to minimize participant anxiety, such as improving pre-briefing

Table 5 SWOT analysis regarding the evaluation of the training program

Strengths	Weaknesses
• "Combining theory with practice provided permanent knowledge' (n:44) • "Practical training" (n:37) • "Implementation in a real environment" (n:35) • "To have simulation application" (n:28) • "Trainers' mastery of the subject" (n:26) • "Receiving training from someone who has developed himself very well in ECMO was a very productive training both theoretically and practically." (n:22) • "Training booklet" (n:20) • "Training materials, case presentations, practice" (n:19) • "It was good that it was instructive, comprehensive and practical. The trainer being knowledgeable and being able to convey what he knows, motivation" (n:18) • "Providing practical training, supporting theory with visuals, teaching by experts, and providing course content with subject explanations." (n:15) • "Group work in case discussion provides an exchange of ideas" (n:13) • "Having ECMO application enabled us to consolidate the knowledge" (n:13) • "It was efficient in terms of evidence-based, the trainer was knowledgeable about the subject" (n:12) • "Providing realistic practice in a clinical environment, and ensuring that trainers have sufficient knowledge and explanation skills." (n:11) • "Reinforcing theoretical training with practice enabled us to become more active, thus providing a more effective training." (n:10) • "Providing theoretical training in sufficient time, using informative booklets, providing practical training, making the simulation realistic, and providing one-on-one practical training." (n:6) • "Providing both verbal and practical training was very good in terms of understanding and reinforcement." (n:5) • "High level of knowledge in education" (n:4) • "The environmental arrangements were realistic and what was explained theoretically was reinforced during the simulation." (n:3) • "Question-answer format, educational activities, sufficient materials" (n:2) • "The simulation training was the best and most lively training I have ever received, as the narrator was experienced and had taken care of patients with ECMO." (n:1)	• "Limited time" (n:28) • "Theoretical training period is short" (n:24) • "The durations could have been longer" (n:23) • "Short duration of training" (n:18) • "The implementation could have been kept a little more wider" (n:7) • "Keep short to implementatıon durations, the used of the ECMO device and its termination are not mentioned in the implementation" (n:6) • "The theoretical training hall was stuffy" (n:5) • Theoretical training hall is crowded" (n:3) "When I first entered the simulation, I couldn't master it; it could have been explained through a video beforehand." (n:1) **Proposals** • "It would be better if theoretical training was spread over a wide range of days rather than just one day." (n:27) • "The duration for theoretical training could have been longer, the classroom area could have been wider and more spacious." (n: 14) • "The implementation could have been more explanatory, I couldn't figure out what to do at first." (n:7) • "As a nurse, I would feel safer working as a team rather than being alone at the patient's bedside, the time could be longer." (n:5) • "Theoretical information could be enriched with more videos and visuals." (n:3) • "Visuals can be increased with video" (n:2) • "The fluid used in ECMO could be more realistic" (n:1)

Table 5 (continued)

Opportunity	Threats
• "It gave us a better understanding of ECMO." (n:40) • "Increasing courage and confidence." (n:39) • "After receiving the training, realising/consciousness of lack of knowledge on the subject." (n:38) • "Listening to someone who knows ECMO one-to-one helped me to approach ECMO without fear." (n:34) • "I was able to learn what I lacked in terms of theoretical knowledge." (n:29) • "We have learnt that patients with ECMO that we have cared for before are actually not scary. We have learnt what kind of complications are waiting for us. We have learnt what we should pay attention to when caring for a patient with ECMO." (n:25) • "Repeating many interventions applied in practice with their reasons increased my awareness." (n:24) • "It will enable me to provide better care for the ECMO patient." (n:23) • "I became more aware of ECMO." (n:20) • "Theoretical knowledge has become more permanent with practice. I learnt what and when and how to intervene when I encounter in the field." (n:19) • "The combination of theory with practice allowed us to get to know the ECMO system and the patient better." (n:17) • "Increasing professional satisfaction and knowledge." (n:16) • "To be able to examine the ECMO device, to comprehend the logic of ECMO." (n:14) • "I believe it will add professionalism on ECMO." (n:10) • "To be able to take care of the patient with ECMO in a stronger way." (n:6) • "The training was actually guiding about the areas that should be known, observed and taken role." (n:5)	• "Being recorded on camera is threatening." (n:3) • "Knowing that the cameras are actively recording." (n:2) • "Having the simulation in intensive care." (n:1)

procedures, fostering psychological safety in the environment, and carefully managing video recording and evaluation processes when necessary.

The opportunities provided by the training were perceived as increasing awareness about patient care with ECMO, alleviating nurses' fears, and enhancing their knowledge and confidence in caring for ECMO patients. The recording with a camera during the simulation practice was perceived as a negative aspect by some nurses. Suggestions for improving the training program included extending the theoretical training period and conducting simulation training as a team activity rather than as individual practice.

However, it should not be forgotten that all the results in the study need to be interpreted within the limitations of the quasi-experimental design, and that definitive conclusions about the effectiveness of the training program are limited due to the absence of a control group.

Discussion

In parallel with the widespread use of ECMO, the competencies of nurses in this field are increasing with ECMO training [6, 16, 17]. However, ECMO training in the literature is mostly multidisciplinary and aimed at ECMO specialists and ECMO coordinators [11, 13, 14, 59]. This study aimed to develop an ECMO training program specifically for ICU nurses and to evaluate the effect of the training on nurses' knowledge and self-efficacy perception levels related to the care of patients receiving ECMO. In the study, it was concluded that ECMO training was effective in increasing the knowledge and self-efficacy of nurses.

The development process and content of our ECMO training program include both theoretical and practical training, similar to most studies in the literature [58, 60, 61]. In the study, the steps of the ADDIE model were followed to determine a systematic road map for the development of the ECMO training program. The ADDIE model, which offers a comprehensive design process allowing transitions between stages and opportunities for error correction, was used, and the steps were completed sequentially [61–63].

In the study, a simulation-based training program was applied, and its effect on nurses' knowledge and self-efficacy levels was evaluated. Hybrid Simulation is an integrated method where the trainer (e.g., urinary catheter model) is realistically combined with a simulated/standardized/standard patient or a high-fidelity simulator, and a simulated/standardized/standard patient is used at consecutive times within a scenario [64]. Standard patient emotional state, body language, physical findings, and personal characteristics observed in real patients can be visualized. Simulation practice with a standardized patient develops learners' critical thinking and self-efficacy skills [65].To achieve a high level of realism, it is recommended that the simulation-based experience be conducted in the actual patient care area/environment [64]. For this reason, in our study, a hybrid simulation training was designed using InSitu (in situ) / (intensive care environment) as the simulation environment and the standard patient as the application. One of the main advantages of on-site simulation is increased realism, both physically and functionally. The authenticity of the environment provides such a high degree of realism that the learning objectives are more effectively realized than when using a less realistic mannequin. Especially considering the work intensity and time constraints of nurses, it may be costly and impractical for them to leave their

working environment, so on-site simulation also provides us with cost savings in the area of use [64]. Our study is the first example in the literature in terms of simulation training in an InSitu environment and its application with a standard patient.

In studies involving simulation-based ECMO training, it was reported that nurses' knowledge and skill levels about ECMO increased in tests repeated immediately after the training and 3–6 months after the training [6, 66].In the study in France, an increase in knowledge test scores was reported after ECMO training [12]. In the study in the USA, it was determined that simulation training for ECMO increased the level of knowledge in the tests repeated immediately after the training and 6 months after the training [11]. In this context, the results of our study are similar to the literature and can be interpreted as a result of the creation of the content of the training program in line with the needs of the nurses, interactive methods used in theoretical education, case discussions before the simulation and a simulation scenario in which frequently encountered situations are discussed and reinforced with theoretical knowledge. Although the knowledge test total score mean increased after training, it decreased in the knowledge test repeated one month after the post-test (not statistically significant). This indicates that knowledge has decreased and renewal training may be necessary. In fact, the responses given by nurses in the SWOT analysis for the evaluation of their education confirm this result.In line with the results of our study, hypothesis H_{1-0} is rejected, and hypothesis H_{1-1} is accepted.

The ECMO training program developed in this study was found to significantly increase the total ECMO-SEPS scores of ICU nurses both immediately after the training and one month later. This increase can be attributed to the program's design, including theoretical education, case discussions, and simulation activities. The rise in scores one month post-training suggests that nurses endeavored to apply the information gained to clinical practice. This is consistent with Galos's report of a 27% increase in self-efficacy among ICU nurses in a heart transplantation unit following ECMO training [6]. The results indicate that ECMO training enhances nurses' self-efficacy perception, with a more pronounced effect among nurses who have experience in ECMO patient care, especially after increased awareness from pretesting and simulation.

It was found that the cognitive sub-dimension scores of ECMO-SEPS increased significantly immediately after the training and one month later. There is no specific tool in the literature that evaluates the self-efficacy of intensive care nurses in ECMO. Melnikov et al. developed a checklist evaluating nurses' interventions for three emergencies that may occur in the ECMO circuit (venous air, arterial air, and oxygenator failure) [67]. In our study, the greatest increase in ECMO-SEPS mean scores after training occurred in the cognitive sub-dimension, which supports nurses' statement in the SWOT analysis that "the combination of theory and practice provided lasting knowledge" (n = 44).

In our study, it was found that ECMO-SEPS affective sub-dimension scores increased significantly immediately after the training and one month after the training. In the affective sub-dimension, individuals are expected to have attitudes, especially self-confidence, and reflect them to practice [68]. In a study in London, it was reported that after simulation-based ECMO training, participants (64% of whom were ICU nurses) improved their technical skills by 57% in their self-assessment and increased their confidence in ECMO device (pump and circulation) and patient management [15]. In this context, the results of our study are similar to those of the literature.

In our study, the psychomotor sub-dimension scores of ECMO-SEPS increased significantly immediately after and one month post-training. Psychomotor self-efficacy refers to individuals' perceived competence in skills and behaviors [69]. While Chan et al. reported a decrease in skill scores after ECMO training among a heterogeneous pediatric ICU team, attributed to group diversity and scenario complexity, Brum et al. found technical skills improved following simulation-based ECMO training [11, 15]. Başak et al. showed that students trained with standardized patients scored higher in hygiene care, satisfaction, and self-confidence, experienced less stress, and transferred skills to clinical practice more effectively compared to those trained on low-fidelity mannequins [69]. Our findings align with the literature, suggesting that the psychomotor improvement is mainly due to simulation involving standardized patients. All study hypotheses on ECMO-SEPS sub-dimensions were supported, with H2-0 rejected and H2-1 accepted.

According to the simulation checklist findings, most nurses completed the necessary steps in recognizing and managing patient complications. In the SWOT analysis, nurses supported the training's effectiveness, describing it as "a simulation with real patients in a practical/clinical environment." However, some gaps were observed during the simulation in patient safety interventions (such as bed lock and power connections of equipment), neurological and renal assessments, and distal perfusion cannula checks. During debriefing, nurses explained these deficiencies by noting they skipped routine procedures, but their awareness of these errors increased. Psychological safety concerns related to camera recording may have affected performance. Hunter et al. reported that in simulation training for health professionals working outside the hospital, such as emergency medical technicians and paramedics, participants focused on the environment

rather than the patient at the scene [70]. Campbell et al. reported that the awareness, knowledge, and sensitivity perceptions of nurses toward the care of dementia patients increased with the simulated virtual reality application [71]. In our study, the effects of simulation training on nurses are similar to those of the literature.

In the results of the evaluation of the effectiveness of the training program, the training program was found to be adequate in terms of the content of the training, the materials used in the training, and the learning environment. In addition, it was determined that the training improved the knowledge, skills, and professionalism of the nurses. Our results are similar to the results of many studies in the literature in which simulation-based ECMO training was given [9, 12, 66, 69].

In the SWOT analysis, the training's strengths were identified as its theoretical and practical approach, evidence-based content, support from field experts, interactive methods, and training materials.This situation confirms the effectiveness of interactive methods and simulation implementation in education. The training increased nurses' ECMO knowledge and awareness, reduced fears and anxieties, and enhanced professional satisfaction and growth.

These results are similar to the literature in that satisfaction, and self-confidence increased in simulation-implemented training in the target group who had not received any ECMO training before. Regarding the weaknesses of the training, the nurses gave feedback, especially in terms of the training period being limited to two days. In Chan et al.'s study, the ECMO course lasted a total of three weeks, with nine hours of training per day [11].

In the study reported by Fouilloux et al., a two-day ECMO training course was provided, with the first day consisting of five hours of didactic training followed by two hours of practical training on the practical use of ECMO components, and the second day devoted entirely to simulation [12]. Di Nardo et al. reported that the ECMO course consisted of 16 h of didactic lectures, 16 h of high-quality simulations, and 32 h of bedside supervision [13]. Said et al. reported that ELSO and ELSO-approved ECMO courses have a standard structure of 25 h over 3.5 days and include 14.5 h of simulation [24]. The duration of ECMO courses reported in most studies in the literature is similar to the duration in our study. However, the fact that the 8-hour theoretical training in our study was limited to one day, simulation practice were performed only once, and the training was not repeated are among the limitations of the study. It is also considered that the extensive of information provided in the 8-hour theoretical training negatively affected the motivation and concentration of the participants.

Some participants perceived the recording of the simulation as a threat. Experienced nurses especially felt uncomfortable being compared to younger or less experienced colleagues in terms of skills and competence, and they were worried about making mistakes. Yu et al. reported that medical students with prior simulation experience experienced less anxiety and greater confidence in their second simulation compared to those without such experience [72]. It was also emphasized that students need multiple simulation experiences to competently provide medical treatment in a clinical setting. Considering that nurses in our study experienced the simulation only once, their anxiety is regarded as normal.

Study limitations

The study has several limitations;

This study was designed as a single-group, single-center quasi-experimental pretest/posttest study, which restricts the ability to draw causal inferences. The absence of a control or comparison group limits attributing observed changes solely to the intervention. Furthermore, the relatively narrow and inexperienced sample, consisting of voluntary participants from a single hospital, limits the generalizability of the findings. The participants had an average ICU experience of 3.5 years, which may have positively influenced their motivation and engagement but reduces applicability to a broader population.

Due to staffing constraints, the short training period limited opportunities for in-depth and practical training, potentially affecting participants' acquisition of hands-on skills. The reliance on self-reported ECMO-SEPS data introduces risks of social desirability bias, which may have led nurses to overreport their scores on both the ECMO-SEPS and the simulation checklist. Similarly, positive feedback from the SWOT analysis may also reflect social desirability bias or the Hawthorne effect, potentially influencing the study outcomes.

The Hawthorne effect, particularly in studies assessing performance and competency, can manifest as behavioral changes in response to observation and evaluation. In our study, the voluntary participation of subjects and the self-report nature of the data collection instruments may have increased participants' susceptibility to the Hawthorne effect. However, the extent and impact of this effect were not measured. Future studies are recommended to include test-retest measurements and incorporate objective assessment tools, such as OSCE or expert observer evaluations, to enhance validity.

The simulation checklist was developed by the researchers. Although its content validity was assessed, key reliability metrics such as inter-rater agreement (e.g., intraclass correlation coefficient or kappa statistics) were not established. This limitation may have affected the accuracy and consistency of performance assessments.

Therefore, results related to the simulation checklist should be interpreted cautiously. Additionally, each nurse participated in the simulation training only once. Since repeated exposure is generally recommended to gain confidence and mastery, the absence of repeated simulation sessions in our study may have further limited the nurses' skill acquisition. In future studies, it is recommended to increase participants' simulation training experiences and to more comprehensively investigate the effects of repeated practice.

Follow-up data were collected only one month post-training, a duration insufficient to evaluate long-term knowledge retention or sustained changes in professional behavior. Evaluating institutional outcomes is a complex process requiring extensive synthesis and longer-term follow-up, which was beyond the scope of this study due to resource and time constraints. As such, caution is warranted when generalizing the findings.

Additionally, factors such as participants' varying clinical experience, differential access to external educational resources, and variability in workplace environments were not controlled or accounted for in the study design or analysis; these may have influenced the results.

Finally, the study did not address the fourth level of the Kirkpatrick model, which assesses institutional outcomes or impacts on patient care. This limits the comprehensiveness of evaluating the training program's effectiveness. Future research is recommended to include control groups, longer-term follow-up periods, and assessment of higher-level outcomes to derive more robust and generalizable evidence.

Conclusion

This study demonstrated that the developed ECMO training program effectively enhanced ICU nurses' knowledge levels and self-efficacy. The positive correlation observed between improvements in cognitive and psychomotor knowledge scores and performance in the simulation checklist provides statistical evidence for the training's effectiveness. Furthermore, SWOT analysis revealed significant qualitative benefits: enhanced professionalism, increased awareness of inadequate/incorrect ECMO care practices, reduced fears regarding ECMO practice and patient management, and bolstered confidence in evidence-based, up-to-date practices. The feedback obtained during the debriefing stage strongly supported these findings and demonstrated the perceived value of the program among the participants.

However, the absence of a control group limits definitive causal attribution of the observed improvements solely to the training intervention. Building directly on this specific limitation and our findings, we propose the following practical strategies for future research and program development:

1. *Mitigating the Control Group Limitation & Enhancing Rigor*: To address the control group gap identified in this study, future iterations should employ cluster randomization by ICU shift or unit (where feasible and ethical) to create comparable intervention and control groups. Where full randomization is impractical, a stepped-wedge design implementing the training sequentially across different units could provide stronger causal inference while allowing all nurses eventual access.
2. *Structuring Extended Training & Sustained Learning*: Based on nurses' needs to reinforce complex skills and reduce fears, the program duration should be extended by incorporating periodic repeated simulation sessions focused on high-risk and low-frequency ECMO complications. These sessions should be integrated into the hospital's existing competency assessment and continuing education framework to ensure sustainability and institutional support.
3. *Assessing Long-Term Impact & Implications for Patiens Care*: To evaluate the durability of knowledge/skill gains and their translation to practice (beyond the initial post-test and simulation), implement structured bedside assessments using standardized checklists at 3, 6, and 12 months post-training. These should focus on specific high-risk tasks identified in our SWOT analysis (e.g., circuit checks during emergencies, safe patient mobilization). Supplement these with electronic medical record audits for key evidence-based practices (e.g., anticoagulation monitoring documentation, specific complication screening).
4. *Reducing Bias & Linking to Outcomes*: To reduce observation bias (e.g., Hawthorne effect) and ensure objective measurement of the effect, the following measures should be taken: (1) self-report scales should be avoided and replaced with internationally validated and reliable instruments; (2) inter-rater reliability should be ensured; and (3) during follow-up periods, blinded expert reviews of video recordings should be conducted using the same checklist applied during training.

By implementing these specific, actionable strategies derived from our study's findings and limitations, future research can provide more robust evidence on ECMO training effectiveness.

Abbreviations

ADDIE model	Analyze, Design, Develop, Implement, Evaluate model
COSMİN	Consensus-based standards for the selection of health status measurement instruments
ECMO	Extracorporeal membrane oxygenation
ECMO-SEPS	Self-Efficacy Perception Scale Regarding the Effectiveness of ICU Nurses in the Care of Patients Under ECMO

ICU	Intensive care unit
INACSL	International Nursing Association for Clinical Simulation and Learning
PEARLS	Promoting Excellence and Reflective Learning in Simulation

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions

CrediT Authorship contribution statement: Hafize SAVAŞ: Writing – _review & editing, Writing – _original draft, Validation, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. Sevil GÜLER: Writing – _review & editing, Validation, Supervision, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. S. Sabit KOCABEYOGLU: Writing – _review & editing, Validation, Supervision, Methodology, Investigation, Formal analysis.

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Data availability

The datasets generated and analysed during the current study are not publicly available due to privacy and ethical restrictions of the participants, but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was conducted after obtaining ethical approvals and institutional permissions from the Gazi University Ethics Committee (Date/Number: 07.https://doi.org/10.2022/E-77082166-302.081-474144) and the Ethics Commission of Ankara Bilkent City Hospital (Date/Number: 09.12.2022/E-90739949-799-2799). The purpose and content of this study were explained to all participants and written informed consent was obtained. Written informed consent was also obtained from the standardised patient in the study. In addition all participants were given a written consent form stating that video recordings would be made during the simulation practice, that the video recordings would be used for the evaluation of simulation performances and for providing feedback during debriefing sessions, that the recordings would only be shared with researchers, and that they would not be shared with third parties without the participants' consent. All procedures were performed in accordance with the principles of the Helsinki Declaration.

Consent for publication

Written permission was obtained to share descriptive images of the participants and the standardised patient in the study. Necessary technical arrangements were made on the Fig. 2 to ensure the anonymity of participants and to protect the privacy of personal data.

Competing interests

The authors declare no competing interests.

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