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The Invisible Face of ECMO: Anxiety Levels and Challenges Among Intensive Care Nurses

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The Invisible Face of ECMO: Anxiety Levels and Challenges Among Intensive Care Nurses

Abstract

Background: Extracorporeal membrane oxygenation (ECMO) is a technology that provides temporary life support to critically ill patients with heart and/or lung failure. However, the complexity of the care involved presents significant challenges for nurses. This study was conducted to determine the difficulties and anxiety levels experienced by nurses caring for patients undergoing ECMO support.

Methods: This study is a descriptive and cross-sectional research. It was conducted in Turkey. This study included 137 nurses working in third level intensive care units and caring for patients with ECMO support. Anxiety levels of nurses caring for ECMO patients were examined with the 'State and Trait Anxiety Inventory (STAI)'.

Results: The mean state anxiety score of nurses was 44.82 ± 10.89 and the mean trait anxiety score was 43.66 ± 8.58 (possible range 20–80). There was no significant relationship between age or total length of ICU experience and state or trait anxiety scores ($p > 0.05$). In contrast, a statistically significant negative correlation was observed between the duration of experience in caring for patients receiving ECMO and both state and trait anxiety scores ($p < 0.05$), indicating that nurses with more ECMO-care experience reported lower anxiety levels. Nurses perceived ECMO care as complex and reported substantial difficulties related to a high rate of complications and bleeding at the cannulation site, the risk of COVID-19 transmission, increased workload and organizational problems among team members.

Conclusions: The development of standardized protocols for the treatment and care of patients receiving ECMO plays a crucial role in improving care quality, particularly in managing bleeding risk at cannulation sites, which may support safer practices and help reduce nurses'

anxiety levels. Additionally, implementing regular training programs for nurses may help alleviate the challenges and anxiety they experience. Involving experienced nurses in ECMO care may further help alleviate these difficulties.

Keywords: Extracorporeal Membrane Oxygenation, Critical Care Nursing, Nursing Care, Intensive Care Units, Anxiety

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Background

Extracorporeal membrane oxygenation (ECMO) is a temporary life support method applied for patients with the potential to survive in treatable cardiopulmonary disorders such as severe life-threatening advanced cardiac and/or pulmonary failure [1]. ECMO circuit is applied in two ways: veno-venous (VV) and veno-arterial (VA). VV-ECMO is preferred in isolated respiratory failure cases that do not respond to mechanical ventilation, while VA-ECMO is used in cases where cardiac dysfunction is accompanied or dominant [2]. The treatment and care of patients receiving ECMO support—a complex and high-risk intervention—are managed by a multidisciplinary team consisting of a nurse, cardiac surgeon, perfusionist, respiratory therapist, and auxiliary personnel. Delivering safe and high-quality care to these patients requires healthcare professionals who are specifically trained and experienced in ECMO management [2]. Within this team, nurses play a vital role and assume significant responsibilities.

In the ECMO care setting, nurses are responsible for monitoring hemodynamic parameters, circuit rotation speed (RPM), pump flow rate (LPM), and the oxygenator, as well as observing circuit color changes, clot formation, and air emboli. In addition, they evaluate the distal perfusion catheter, monitor for bleeding or signs of infection at cannula insertion sites, evaluate limb circulation, and provide both routine nursing care and overall patient management [4,5]. Nurses face several challenges during the treatment and care of patients with ECMO due to the risk of developing many complications, the high mortality rate, and the need for effective teamwork and cooperation. Therefore, nurses experience anxiety [3,6-11].

In line with previous studies on critical care nurses, this anxiety can be understood not only as a psychological reaction but also as a physiological stress response: repeated exposure to high-acuity situations and complex life-sustaining treatments (e.g., ECMO support) may activate the sympathetic nervous system and hypothalamic–pituitary–adrenal axis, leading to increases in

heart rate, blood pressure and stress hormones, disturbances in sleep and fatigue, and longer-term immune and endocrine alterations[7,8].

Nurses involved in the care of patients receiving ECMO have been reported in the literature to experience high levels of anxiety and workload. Especially inexperienced nurses have been reported to experience anxiety due to the complex structure of patients and the dynamics of the intensive care environment [3]. Since ECMO applications require additional responsibilities such as prone positioning, mobilization, oxygenator and circuit monitoring in addition to standard intensive care, a nurse-patient ratio of 1:1 is recommended [10,11]. Complications, organizational deficiencies, and staff shortages exacerbate the emotional burden on nurses, potentially leading to burnout and a tendency to leave the profession [6,12,13]. During the pandemic period, the risk of infection, isolation practices, and prolonged patient hospitalization periods have further increased the difficulties experienced by nurses [14-16].

Furthermore, psychological and physiological feelings of exhaustion, role confusion due to lack of standardization, emotional difficulties, and anxieties caused by facing patients in critical condition are stated among the difficulties experienced by Intensive Care Unit (ICU) nurses [6,12,13]. Therefore, this study aimed to determine the difficulties and state-trait anxiety levels experienced by nurses caring for patients receiving ECMO support. From a theoretical perspective, the study is informed by Spielberger's state-trait anxiety framework, which conceptualises anxiety as a transient, situation-specific state component superimposed on a more stable trait disposition. In the literature, there are few empirical studies examining the difficulties experienced by nurses caring for patients receiving ECMO in Turkey. Additionally, various reasons have increased the difficulties faced by nurses. These include the significant rise in ECMO use in Turkey over the past decade, particularly in tertiary and university hospitals, and the lack of standardized national protocols or an official certification program

regulated by the government for ECMO nursing. Furthermore, the training for caring for ECMO patients has not been systematically integrated into the undergraduate nursing curriculum; nurses are often involved in the care process with limited theoretical preparation and are required to rapidly acquire complex clinical skills in high-risk environments. In addition, during the COVID-19 pandemic, the increased demand for ECMO in public and university hospitals has further intensified nurses' workload and the clinical and ethical challenges they face. In this context, this study offered valuable insights into the challenges faced by nurses caring for ECMO patients, aiming to identify these issues and implement necessary precautions.

Materials and Methods

Research Design

This descriptive and cross-sectional study was conducted to determine the difficulties and anxiety levels experienced by nurses caring for patients receiving ECMO support. It was conducted between June 1, 2021, and February 1, 2022, among nurses working in the ICU and caring for patients with ECMO support at private, state, and foundation hospitals in Turkey.

Study Population

The study population consisted of intensive care nurses caring for patients receiving ECMO) in Turkey. Not all hospitals within the country were incorporated as study settings. Due to the absence of a publicly accessible national registry from the Ministry of Health specifying hospitals that provide ECMO support, constructing a comprehensive sampling frame of all eligible nurses. Therefore, snowball sampling, a non-probability sampling approach, was employed. This method involves identifying initial contact persons related to the study topic and subsequently requesting them to refer additional eligible colleagues [32]. Given that snowball sampling is non-probabilistic, it may introduce selection bias and restrict the generalizability of the results. To partially mitigate this limitation, recruitment commenced through nurses working in ICUs of different hospital types (public, private, and foundation

hospitals). Invitations were disseminated via professional nursing associations and online platforms that include nurses from diverse intensive care units across the country.

Sample

In determining the sample size, G*Power 3.1 was used. Using the effect size from the pilot study ($d = 0.31$), $\alpha = 0.05$ and power = 0.80, the standard formula for mean comparisons

$$n = (Z_{1-\alpha/2} + Z_{1-\beta})^2 / d^2$$

was applied. The minimum required sample size was calculated as 125, and considering 10% data loss, 137 participants were included. The inclusion criteria were nurses who have been working in the ICU for at least six months and have experience in caring for patients receiving ECMO support. Nurses with less than six months of experience working in the intensive care unit and those with no experience in caring for patients on ECMO support were excluded from the study.

Measurement

This descriptive and cross-sectional study was conducted to determine the difficulties and anxiety levels of nurses caring for patients receiving ECMO support. In this descriptive and cross-sectional study, the "Descriptive Information Form" prepared by the researchers and the "State and Trait Anxiety Inventory (STAI)" were used to determine the anxiety levels experienced by the nurses.

Descriptive Information Form: The Descriptive Information Form consisted of 25 items created by the researchers based on the literature. It included sociodemographic characteristics (age, gender, education level), professional background (years of experience, ICU experience, number of ECMO patients cared for per shift), ECMO-related training status, and the presence of ECMO care protocols in the ICU. In addition, the form included a set of researcher-prepared items asking nurses to rate various aspects of the difficulties they experienced while caring for

ECMO patients on a 0–10 scale, where 0 indicated “no difficulty at all” and 10 indicated “extreme difficulty”. Item D1 (“experiencing anxiety while caring for patients receiving ECMO”) was designed to capture ECMO-specific, task-related distress as one difficulty domain and is conceptually distinct from the general state and trait anxiety assessed by the STAI. These items were not part of an independent or validated scale; as non-standardized items, they reflect overall perceived difficulty rather than distinct dimensions (technical, emotional, institutional). The content relevance of the 25 items was reviewed by five nursing professors specializing in cardiovascular surgery and intensive care. A pilot study was conducted with 20 nurses to assess clarity and comprehensibility, and no changes were required. The full list of all 25 items is presented in Appendix 1.

The State and Trait Anxiety Inventory (STAI): This scale, developed by Spielberger et al. (1971) and adapted into Turkish by Öner and Le Compte (1985), measures an individual’s general feelings of anxiety [17]. The scale consists of two separate scales with a total of 40 items and 4-point Likert-type statements. Although there is no universal cut-off point, [18] in studies using the Turkish version of the STAI, scores of approximately 39-40 and above on the State Anxiety Scale have often been considered an empirical cut-off point indicating clinically significant anxiety.[18-21]. In the original validation study, the Cronbach’s alpha values were reported as 0.942 for state anxiety and 0.890 for trait anxiety [22]. In the present study, the Cronbach’s alpha values for these sub-dimensions were also found to be 0.942 and 0.890, respectively.

Data Collection

Data were collected between June 1, 2021, and February 1, 2022, with the online data collection link created via Google Form. Reference persons were identified among the nurses reached via the WhatsApp application, and the survey link was disseminated to other nurses through them and social media (Facebook, Twitter, etc.). All nurses who met the research criteria and agreed

to participate in the study participated in the survey.

Data Analysis

The data were analyzed using the IBM SPSS (Statistical Package for Social Sciences) for Windows 23.0 program. Frequency distribution (number, percentage) was used for categorical variables, and descriptive statistics (mean, standard deviation, minimum, maximum) were used for numerical variables. Data normality was assessed using the Kolmogorov–Smirnov test, histograms, and the Levene test. Since the numerical variables met the normality and variance-homogeneity assumptions, parametric tests were preferred. Accordingly, an independent samples t-test was used for comparisons between two groups, and a one-way analysis of variance (One-way ANOVA) was used for comparisons among more than two groups. Following ANOVA, the Bonferroni test was used for variables with homogeneous variances, whereas Tamhane’s T2 test was used for variables without homogeneous variances. Pearson correlation analysis was selected because normality assumptions were met, allowing the examination of linear relationships between the State Anxiety Inventory and STAI subscales. Cronbach’s alpha value was used to assess scale reliability. The findings were evaluated at a 95% confidence interval, and a significance level of $p < 0.05$ was considered statistically significant.

Results

The mean age of the participants was 28.96 ± 5.34 years. Of the participants, 75.9% were female and 75.9% were undergraduate graduates. The total working time of the nurses in the intensive care unit was 5.08 ± 4.79 years, and the duration of caring for the patient with ECMO was 2.64 ± 2.73 years. In terms of clinical setting, most participants worked in cardiovascular surgery ICUs (51.8%); in contrast, 7.3% were employed in a dedicated COVID ICU. 70.1% of participants reported providing care for a patient on ECMO during a specific shift, 57.6% had

received training on ECMO. Among those who received training, 58.2% received their instruction through hospital in-service training, 58.2% received training once a year, and 51.8% used protocols in the management of patients on ECMO within the intensive care units where they were employed.

Table 1. Nurses' sociodemographic characteristics (n=137)

		n	%
Gender	Male	33	24.1
	Female	104	75.9
Education level	High school	5	3.6
	Associate degree	6	4.4
	Bachelor degree	104	75.9
	Postgraduate	22	16.1
Types of intensive care unit (ICU)	Cardiovascular surgery ICU*	71	51.8
	Adult ICU*	37	27
	COVID ICU*	10	7.3
	Pediatrics KVC ICU*	12	8.8
	Cardiology ICU*	5	3.6
	Neonatal ICU*	2	1.5
Number of patients with ECMO that a nurse care for in a shift	≥ 2 patients	128	93.5
	< 2 patients	9	6.5
Type of education**	Occupational education (Undergraduate education)	6	7,7
	Hospital in-service training	65	82,2
	Congress, symposium	8	10,1
Frequency of training on ECMO	More frequently than every six months	5	6,2
	Once every six months	8	10,1
	Once a year	46	58,2

	Once every two years	20	2,5
The presence of a protocol for the care of patients receiving ECMO in the ICU**	Yes	71	51,8
	No	66	48,2
		\bar{X}	S
			D
Age		28.96	5.34
Length of experience in ICU (year)		5.08	4.79
Length of experience in caring for patients with ECMO (year)		2.64	2.73

\bar{X} : Mean, n: Number, %: Percentage, SD: Standard deviation, Min.: Minimum, Max: Maximum, ECMO: Extracorporeal membrane oxygenation ICU: Intensive Care Unit *Level III ICU ** It includes participants who have received training in ECMO.

It was found that the average level of difficulty that nurses experienced ranged from 4.12 ± 2.56 at the lowest to 6.31 ± 3.23 at the highest (Table 2).

Table 2. The difficulties that Nurses experience while caring for patients with (n=137)

Difficulties	n (%)*	\bar{X}	SD	Min- Max
D1. Experiencing anxiety in caring for patients with ECMO	137 (100)	5.51	2.85	0-10
D2. Being experienced and uneducated in caring for patients with ECMO	133 (97.09)	5.29	2.88	0-10
D3. Having increased workload due to sending nurses to other units for support	120 (87.6)	5.55	3.23	0-10
D4. Difficulty in caring of cannula areas due to bleeding risk	136 (99.28)	6.42	2.86	0-10
D5. Increased workload and anxiety due to psychosocial factors related to family members and caregivers.	135 (98.55)	5.56	2.65	0-10

D6. Monitorization of the ECMO cycle and complications addition to intensive care procedures	136 (99.28)	5.63	2.63	0-10
D7. Decreased the quality of patient care due to caring more than two patients with ECMO	135 (98.55)	6.23	2.91	0-10
D8. Experiencing transmission anxiety due to caring for patients with ECMO and contagious infections such as COVID-19 and H1N1	134 (97.82)	5.89	2.95	0-10
D9. Increased working hours and workload due to caring for patients with ECMO and contagious infections such as COVID-19 and H1N1	133 (97.09)	6.11	2.93	0-10
D10. Working with protective equipment at all times due to caring for patients with ECMO and contagious infections such as COVID-19 and H1N1	133(97.09)	6.09	3.02	0-10
D11. Experiencing organizational problems in providing supplies used for the care and safety of patients with ECMO	131 (97.82)	5.14	2.87	0-10
D12. having organizational problems within the team members who care for patients with ECMO	134 (97.82)	4.95	2.56	0-10
D13. Patients with ECMO isolated and in separate rooms	115 (83.95)	4.12	2.76	0-10
D14. Patients with ECMO have a higher complication rate	135 (98.55)	6.31	2.93	0-10

*: Each nurse rated all difficulty items; items were not mutually exclusive, so nurses could report difficulty in more than one domain;

***: Difficulties were scored on a 0–10 numeric rating scale (0 = no difficulty, 10 = extreme difficulty; 0–3 = low, 4–6 = moderate, 7–10 = high difficulty);

\bar{X} : Mean; Min.: Minimum; Max.: Maximum; %: Percentage; n: Number.

It was found that the mean state anxiety score of all participants was 44.82 ± 10.89 and the mean trait anxiety score was 43.66 ± 8.58 . There was no significant relationship between age or total

length of ICU experience and state or trait anxiety scores ($p>0.05$). In contrast, a statistically significant negative correlation was observed between the length of experience in caring for patients receiving ECMO and both state and trait anxiety scores ($p<0.05$) (Table 3), indicating that nurses with more ECMO-care experience reported lower anxiety levels.

Table 3. The relationship between descriptive variables and State and Trait Anxiety Inventory (STAI) scores

State and Trait Anxiety Inventory	$\bar{X} \pm SD$	Min.- Max.	Age	Length of experience in ICU	Length of experience in caring for patients with ECMO
State anxiety score	44.82 \pm 10.89	20-74	r	- 0.090	- 0.272
			p	0.296	0.001*
Trait anxiety score	43.66 \pm 8.58	20-70	r	- 0.112	-0.216
			p	0.193	0.011*

\bar{X} : Mean, SD: Standard deviation, Min.: Minimum, Max: Maximum, r: Pearson correlation coefficient, * $p<0.05$, ICU: Intensive Care Unit, ECMO: Extracorporeal membrane oxygenation

As shown in Table 4, state anxiety scores were positively and significantly correlated with D1, D8, D9 and D12 ($p<0.05$). Trait anxiety scores were positively and significantly correlated with D1, D4, D8, D12, D13 and D14 ($p<0.05$). The correlation between D13 and state anxiety showed a positive trend but did not reach statistical significance ($p=0.052$) (Table 4).

Table 4. The relationship between difficulties and State and Trait Anxiety Inventory (STAI) scores

Difficulties	State anxiety score	Trait anxiety score
State anxiety score	r	1
	p	0,000*
	r	0.640
		1

Trait anxiety score	p	0,000*	
D1	r	0.216	0.219
	p	0.011*	0.010*
D2	r	0.070	0.090
	p	0.418	0.296
D3	r	0.120	0.071
	p	0.161	0.408
D4	r	0.131	0.169
	p	0.128	0.048*
D5	r	0.074	0.140
	p	0.389	0.104
D6	r	0.109	0.160
	p	0.204	0.062
D7	r	0.157	0.131
	p	0.067	0.128
D8	r	0.226	0.222
	p	0.008*	0.009*
D9	r	0.169	0.167
	p	0.049*	0.051
D10	r	0.129	0.129
	p	0.132	0.134
D11	r	0.090	0.045
	p	0.294	0.601
D12	r	0.211	0.190
	p	0.013*	0.026*
D13	r	0.166	0.238
	p	0.052	0.005
D14	r	0.115	0.200
	p	0.183	0.019*

r:Pearson correlation coefficient, *:p<0.05, D:Difficulty

Discussion

Intensive care nurses work continuously in high-stress and acute environments, and accumulating evidence indicates that anxiety within this workforce is associated not only with depression, burnout, insomnia, and post-traumatic stress disorder but also with significant physiological effects such as tachycardia, hypertension, sweating, headaches, fatigue, and an increased risk of chronic illness. These physiological and cognitive alterations linked to anxiety can impair attention and decision-making processes, thereby elevating the risk of medical errors and compromising patient safety [7,8,36]. In this context, our study revealed that the mean state anxiety score among nurses caring for patients undergoing ECMO treatment was 44.82 ± 10.89 , while the mean trait anxiety score was 43.66 ± 8.58 . These scores correspond to mild-to-moderate anxiety levels and are slightly above the empirical cut-off of approximately 39–40 points that is commonly used to indicate clinically significant anxiety. Consistent with this, our findings showed that longer experience in caring for patients receiving ECMO was associated with lower state and trait anxiety, suggesting that increasing familiarity and skill with ECMO procedures may serve to mitigate nurses' anxiety over time. (Table 3). In addition, our results indicated that shorter experience in caring for patients receiving ECMO was associated with higher state and trait anxiety scores. Several difficulty domains, including the complexity of ECMO care, concerns about infection transmission when caring for infected patients, high bleeding risk, increased workload, and organisational problems such as difficulties in supplying materials, showed small but statistically significant positive correlations with state and/or trait anxiety (Table 4). Caring for ECMO patients in isolation rooms was significantly associated only with trait anxiety, suggesting that this organizational factor may contribute more to nurses' enduring anxiety than to their momentary anxiety. The increased use of ECMO and heightened infection risk during the COVID-19 period are likely to have amplified these stressors and may

partly explain the anxiety levels observed in our sample (Table 4).

Similar results were found in studies conducted in the literature. Asgari et al. (2022) reported that nurses experienced role confusion and fatigue while caring for complex and risky ECMO patients. In addition, it was emphasized that nurses caring for these patients with high mortality rates tend to experience psychological and physiological burnout [13]. In a qualitative study conducted by Salloum et al. (2023), it was reported that nurses caring for patients with ECMO experienced difficulties such as emotional difficulties and role confusion in addition to the standard workload of intensive care [12]. In the study, Knistey et al. (2019) found that complications developed in patients with ECMO, with high levels of anxiety in nurses [6]. Alshammari et al. (2022) reported that less experienced nurses caring for patients with ECMO experienced anxiety due to the patients being very complex [3].

In this study, the average length of experience of nurses in providing care to patients on ECMO was found to be 2.64 ± 2.73 (Table 1), and there was a significant relationship between the length of time nurses provided care to patients on ECMO and state and trait anxiety levels ($p < 0.05$; Table 2). As the length of time nurses provided care to patients on ECMO increased, a decrease in state and trait anxiety scores was observed. In situations where nurses lack sufficient experience, particularly when caring for patients receiving advanced life support such as ECMO, the primary sources of anxiety include the fear of making errors and causing harm to patients [14]. In line with this, one study highlights the significance of deploying experienced nursing staff to mitigate the challenges associated with ECMO [13]. Furthermore, a recent investigation emphasizes that practical experience not only improves patient safety and nurses' confidence in ECMO care but also highlights the importance of ensuring sufficient manpower to care for patients undergoing ECMO, whose utilization has increased during pandemics such as COVID-19 [30].

The study found that almost all nurses experienced difficulties (Table 2). Several studies have

indicated that nurses caring for patients with ECMO experience various difficulties [3,6,10]. Alshammari et al. (2022) found that nurses experienced difficulties such as workload, high ECMO patient: nurse ratio, problems in supplying materials, transferring nurses skilled in caring for patients with ECMO to other units, not having several healthcare professionals who could affect patient care, insufficient appreciation, and lack of knowledge regarding the ECMO [3]. The same studies indicated that nurses providing care to patients with ECMO encountered challenges, such as extended working hours, a substantial workload, concerns regarding infection, and feelings of loneliness due to non-compliance with infection control protocols while caring for a patient with H1N1[13,31]. In the study by Peig et al. (2021), it was noted that nurses faced challenges in informing family members of patients and managing interactions between patients and their relatives due to the hospital's limited visitation policy during the COVID-19 pandemic [23]. This study, similar to previous studies, showed that the difficulties experienced by ICU nurses caring for patients with ECMO are universal and become even more pronounced, especially during epidemic periods such as the COVID-19 pandemic. In addition, it was noted that the absence of a protocol in hospitals for the care of patients with ECMO and the lack of training for nurses on ECMO presented difficulties (Appendix 2).

This finding indicates a significant association between receiving ECMO training and the level of difficulty reported by nurses in caring for patients receiving ECMO (Appendix 2). In this context, similar to the study by Ross et al. (2023), which emphasized that ECMO nursing workload is complex and intense and that inadequate training threatens workforce preparedness, we consider that implementing structured, competency-based ECMO education programs that combine didactic teaching with supervised clinical practice and regular refresher updates may assist in reducing the challenges faced by nurses[31]. Furthermore, in accordance with the findings of Emmarco et al. (2023), which highlighted nurses' concerns, fear of harming patients, and the importance of reinforced clinical experience following an ECMO crash course,

we believe that protocols incorporating clear role descriptions, checklists for routine ECMO care, multidisciplinary communication pathways, and continuous mentorship may mitigate these difficulties by supporting nurses' confidence and competence[14]. Importantly, the presence of a "no-protocol" subgroup in our sample indicates a significant institutional gap in standardized ECMO nursing care, which may plausibly amplify practice variability and cognitive workload during circuit surveillance and complication detection. This interpretation aligns with the wider ECMO nursing literature reporting protocol-related issues (e.g., the absence of a standardized heparin protocol alongside communication gaps and staffing challenges) [33] At the same time, workload data using the Nursing Activities Score(NAS) shows that nursing workload peaks within the first 24 hours of ECMO support (mean 139.8%), and that COVID-19 is linked to higher workload; the authors explicitly highlight the need for structured care protocols and sufficient nurse staffing to reduce excessive workload while optimizing outcomes [11,15]. In the present study, the use of an institutional ECMO care protocol was significantly associated with the level of difficulty reported for D6 (monitoring the ECMO circuit and ECMO-related complications in addition to routine intensive care procedures) ($p < 0.05$): nurses working in units without a protocol reported higher difficulty scores than those working with an established protocol (Appendix 3). Taken together, these findings support the institutional development and implementation of ECMO care protocols—ideally integrated with competency-based training and nurse-to-patient allocation aligned with ECMO acuity—as a systemic strategy to reduce D6-related difficulties. However, given the observational design, protocol use may also be a marker of broader unit resources and organizational maturity; therefore, the observed associations should be interpreted with appropriate caution.

In this study, a significant relationship was found between nurses' state anxiety levels and their exposure to certain clinical challenges. Specifically, contamination concerns while caring for

patients with infectious diseases such as H1N1 and COVID-19, increased workload, and organizational issues within the healthcare team were associated with higher state anxiety levels ($p < 0.05$, Table 4). Furthermore, trait anxiety levels were found to be elevated in response to more persistent and structural challenges. These included the complex clinical condition of ECMO patients, the risk of bleeding at cannulation sites, ongoing concerns about contamination, the need for patient isolation, high complication rates, and organizational difficulties within the team ($p < 0.05$, Table 4). Although the number of studies in the literature examining the problems and anxiety levels encountered by ICU nurses in the care of patients with ECMO is very limited, there are some studies investigating the anxiety and difficulties experienced by nurses [3,9,10,13]. Alshammari et al. (2022) stated that the 1:1 patient-nurse ratio was not adhered to when caring for patients with ECMO. Furthermore, since patients require a workforce and their care requires a lot of attention, communication problems occur within the team, and nurses experience anxiety [3]. Asgari et al. (2022) reported that ECMO care imposes a significant emotional burden on nurses and that the ongoing uncertainty and intensive monitoring requirements can predispose to stress and burnout[13]. Salloum et al. (2023) observed that incorporating ECMO into routine intensive care workloads generates substantial professional stress for nurses; additionally, due to the absence of standardized practice norms, role ambiguity and emotional exhaustion increase the pressure [12]. In a study conducted by Besey and Dağcı (2020), the first five problems experienced by nurses in the ICU were identified as insufficient staff, excessive workload, job description issues, hazardous situations, and stress resulting from critical patient care [24]. Ross et al. (2023) stated that nurses feel tired due to providing continuous care support to ECMO patients and suffering from heavy workloads. This situation causes low motivation, hopelessness, and anxiety [31]. Due to the stress experienced by nurses, the care they provide to patients can be negatively affected [30].

A recent study emphasizes that the role of nurses as integral team members in the care of ECMO patients necessitates substantial mental and emotional resilience. Furthermore, they must be adequately equipped with the knowledge and competence to manage potential complications effectively.(30) In this study, nurses reported feeling anxious while caring for ECMO patients and attributed this anxiety mainly to excessive workload, communication problems within the team, and the high risk of complications and bleeding during ECMO care. Especially during the COVID-19 pandemic, ECMO devices were used to support heart and lung functions [25,26]. In parallel, the pandemic-related surge in ECMO caseload intensified the care burden on ICU teams. Shaffi et al. evaluated a single-site ECMO clinical support team implemented during this period and reported that nurses caring for ECMO patients experienced marked stress and anxiety[27]. In this study examining the effects of ECMO interventions on burnout levels in physicians and nurses during the COVID-19 pandemic, it was found that having a COVID-19 infection, knowing other healthcare professionals infected with COVID-19, salary dissatisfaction, and excessive workload were among the important determinants of burnout.[28]. Fregene et al. (2020) determined that the use of personal protective equipment required for COVID-19 patients in the ICU caused additional anxiety and discomfort in healthcare workers due to the risk of infection [29]. In this study, it was thought that the increase in the number of patients requiring ECMO during the COVID-19 pandemic, the fear of infection among nurses, as well as the increase in workload and working hours, and the additional difficulty in nursing care and communication between team members due to the frequent use of personal protective equipment caused nurses to experience more anxiety.

Limitations

This study has several limitations. Firstly, the research was conducted during the ongoing COVID-19 pandemic. Since anxiety is a dynamic emotional state that can be easily affected by environmental factors, the pandemic process can directly affect the mental state of nurses. The

increased workload and psychological states of nurses working in the ICU during the pandemic may have reduced the participation rate in the study. Therefore, the anxiety levels of nurses involved in the care of ECMO patients during the COVID-19 pandemic may have been affected by these unusual conditions. Pandemic-specific anxiety levels were not evaluated separately in this study; consequently, it is not possible to clearly distinguish anxiety related to the pandemic from anxiety arising directly from ECMO caregiving. In particular, nurses' anxiety about contracting COVID-19 may have contributed to elevated anxiety scores independently of their ECMO-related caregiving responsibilities. Furthermore, no subgroup analysis was performed based on different phases of the COVID-19 pandemic, as data collection occurred within a single continuous period without clearly defined institutional pandemic phases. Therefore, the potential influence of varying pandemic conditions on anxiety levels could not be evaluated separately.

Moreover, the difficulties experienced by nurses were assessed using a set of researcher-developed items scored on a 0–10 scale, which were not part of a validated multidimensional instrument. As these items were not subjected to psychometric evaluation, the difficulty ratings capture nurses' overall perceived difficulty rather than clearly defined dimensions (e.g. technical, emotional, institutional). This limits the reliability, standardization, and reproducibility of these measurements and should be taken into account when interpreting the findings. In addition, hospital type was not recorded as a separate variable, which prevented us from examining potential differences in anxiety across different organizational contexts. Furthermore, ECMO configuration (VV vs VA and hybrid modes) was not recorded at the patient/unit exposure level; thus, modality-stratified analyses of STAI state and trait anxiety were not feasible. The use of a snowball sampling method may also limit the representativeness of the sample, as participants were recruited through professional networks rather than random selection. Although the sample size met the calculated requirement, it remains relatively limited

and may reduce the generalizability of the findings and interpreting the results. Finally, the over-representation of cardiovascular surgery ICU nurses and the small sample sizes in some ICU categories limited our ability to make robust comparisons across ICU types.

Conclusion

This study demonstrated that Intensive Care Unit (ICU) nurses caring for patients receiving ECMO) encounter significant challenges across various domains of care. Moreover, higher levels of state and trait anxiety are correlated with increased perceived difficulty. These findings suggest that anxiety among ECMO nurses should be regarded not only as psychological distress but also as an indicator of physiological and occupational stressors. Considering that the research was conducted during the COVID-19 pandemic- a period marked by exceptionally high workload and uncertainty- our results likely reflect a particularly challenging context and should be interpreted with this context in mind.

In practical terms, the findings emphasize the necessity for structured, ECMO-specific training programs that incorporate didactic modules, high-fidelity simulation-based practice, supervised bedside experience, and regular refresher sessions to maintain competence, especially in low-volume centers. Furthermore, institutional protocols should include clear role descriptions for nurses, standardized checklists for routine and emergency ECMO care, and nurse-support strategies such as mentorship, debriefing sessions, and access to psychological services. These measures aim to mitigate anxiety and prevent burnout.

Future research recommendations

In future studies, the development and psychometric validation of a multidimensional difficulty scale, including factor analysis, reliability testing (e.g., Cronbach's alpha), and content validity assessment, is recommended to provide a more standardized and comparable measurement of the difficulties experienced by nurses caring for ECMO patients. Future research should also expand upon these findings through longitudinal designs to track changes in nurses' anxiety

levels, physiological stress markers, and perceived difficulties over time and within various clinical settings. Additionally, intervention studies are needed to assess the effectiveness of ECMO-focused education, simulation-based training, staffing models, and support programs in reducing anxiety, enhancing competence, and promoting both nurse well-being and patient safety. Finally, future studies should record ECMO modality (VV/VA) and nurses' modality-specific exposure to determine whether ECMO configuration predicts anxiety outcomes.

List of Abbreviations

ECMO: Extracorporeal membrane oxygenation

STAI: State and Trait Anxiety Inventory

VV: Veno-venous

VA: Veno-arterial

RPM: Revolutions per minute

LPM: Pump blood flow rate

IBM SPSS: Statistical Package for Social Sciences

ICU: Intensive Care Unit

H1N1: Hemagglutinin 1 – Neuraminidase 1

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Gazi University Ethics Committee (Number: E-77082166-302.08.01-142880, dated August 10, 2021). During the implementation phase of the study, the purpose and details of the study were explained to participants on the first page that opened when they clicked the link sent to them. After the participants read this information, they were asked whether they wanted to participate in the study and were asked to respond with 'Yes/No'. Informed consent for participation was obtained from the participants. After obtaining the consent of those who agreed to participate, they were allowed to proceed to the

questionnaire part of the study. All stages of this study were conducted in accordance with the Declaration of Helsinki. Data can be shared by the corresponding author upon reasonable request and with permission from the relevant ethics committee and institution.

Consent for publication

Not applicable.

Availability of data and materials

Data and materials are available.

Competing interests

None.

Funding

None.

Authors' contributions

E.O: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

H.B: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

A.K: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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