International Journal of Research in Medical Sciences
Hakami E et al. Int J Res Med Sci. 2025 Sep;13(9):3709-3714
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20252780

Original Research Article

Evaluating the safety of diverse extracorporeal membrane oxygenation technologies through the lens of intensive care unit nurses' perspective

Emad Hakami[1]*, Basmah Mushqi[1], Abdulsalam Alsultan[2], Ahlam Alsomali[1], Gretchen M. Lo[1]

[1]Heart Center of Excellence, King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia
[2]King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia

Received: 27 June 2025
Revised: 18 August 2025
Accepted: 19 August 2025

***Correspondence:**
Dr. Emad Hakami,
E-mail: nurseemad@gmail.com

ABSTRACT

Background: Extracorporeal membrane oxygenation (ECMO) is a complex life-support technology increasingly utilized in intensive care units (ICUs). As ECMO devices diversify, ICU nurses are required to manage multiple platforms, posing potential challenges to care delivery and safety.
Methods: A cross-sectional, descriptive survey was conducted among ICU nurses at King Faisal Specialist Hospital and Research Center, Riyadh. A validated questionnaire by Kiekkas et al was used to assess perceptions of ECMO technology's positive and negative effects on nursing care. Descriptive statistics were calculated, and inferential tests (t-tests and one-way ANOVA) examined associations between perceptions and demographic characteristics.
Results: A total of 97 ICU nurses participated. Respondents rated ECMO technology highly in enhancing patient safety (M=4.10, SD=0.92), improving nursing effectiveness (M=4.04, SD=0.97), and supporting professional development (M=4.10, SD=0.81). Negative perceptions included increased hospitalization costs (M=3.65, SD=1.16), nursing stress (M=3.35, SD=1.19), and mechanical risks (M=3.16, SD=1.19). No statistically significant differences in perceptions were observed based on gender, ICU experience, or educational level.
Conclusions: ICU nurses generally perceive ECMO technology as a positive contributor to care quality and nursing efficiency, though concerns persist regarding cost, stress, and safety. The uniformity of perceptions across demographic subgroups may reflect practical institutional training and standardized ECMO protocols. Findings highlight the importance of involving nurses in equipment evaluation, training design, and interdisciplinary collaboration to ensure patient safety and staff well-being.

Keywords: Extracorporeal membrane oxygenation, ECMO, ECMO technology, ICU nurses, ICU technology

INTRODUCTION

Extracorporeal membrane oxygenation (ECMO) is a critical life-support technology for patients with severe respiratory or cardiac failure.[1] As ECMO technology has evolved, many devices have entered the market, each offering distinct features and operational complexities.[1] While these advancements have broadened ECMO's clinical applications, they have also introduced challenges, particularly for ICU nurses responsible for safe and effective systems management.[2]

Intensive care unit (ICU) nurses are central to the delivery of ECMO therapy, with responsibilities that include monitoring the patient's condition, managing the ECMO device, and coordinating care within the interdisciplinary team.[3] The presence of multiple ECMO platforms within the same clinical environment can create inconsistencies in training, workflow, and safety protocols. Nurses may struggle with differing user interfaces, alarm systems, and troubleshooting procedures, increasing the risk of adverse events and contributing to clinician stress.[4-6]

Understanding ICU nurses' real-world experiences and perspectives is essential for improving ECMO practice. Their insights can highlight both the benefits and drawbacks of current technologies and inform strategies to enhance training, device design, and patient safety.[6] Previous studies have shown that while nurses appreciate ECMO's ability to support critically ill patients, they also express concerns about workload, stress, and system complexity.

Kiekkas et al developed a validated tool to assess nurses' perceptions of technological equipment in critical care settings.[2] Although nurses view ECMO as beneficial, they also report significant challenges related to communication, autonomy, and patient safety, according to their findings.[2] In a more recent study, Ross et al identified themes such as system complexity, the need for specialized skills, and the emotional demands of ECMO care.[5] These results underscore the necessity for targeted education, interdisciplinary collaboration, and ongoing support for nursing staff.

These studies point out that there is a deeper understanding of ICU nurses' interactions with diverse ECMO technologies. This study aims to explore how these technologies influence nursing practice, perceptions of patient safety, and the overall care experience, with the goal of identifying areas for improvement in ECMO implementation and support.

METHODS

Study design

This study employed a cross-sectional, descriptive survey design to explore the perceptions of ICU nurses regarding the impact of ECMO technologies on nursing practice and patient safety.

Study place and period

The study was conducted at King Faisal Specialist Hospital and Research Centre (KFSH&RC), a tertiary care facility in Riyadh, Saudi Arabia, between 15 January 2025 and 25 June 2025.

Participants and selection criteria

Eligible participants included ICU nurses with a minimum of one year of experience in critical care who had completed hospital-approved ECMO competency training. Nurses who did not meet these criteria or declined to participate were excluded.

Procedure

The research team approached eligible ICU nurses during their clinical shifts, provided a brief explanation of the study purpose, and obtained verbal informed consent. Participation was voluntary, and nurses were assured that their decision would not affect their professional standing.

Paper-based questionnaires were distributed to participants during working hours. Nurses were given adequate time to complete the survey in a non-disruptive manner, typically during breaks or after patient care responsibilities. After completion, each nurse handed the questionnaire directly to a member of the research team to ensure confidentiality.

At the end of each day, the research team recorded the number of completed questionnaires. All responses were entered into REDCap, a secure web-based research data management platform. To ensure data accuracy, double data entry was conducted by two independent members of the research team, and discrepancies were resolved by referring back to the original paper forms.

Instrument

Data were collected using a validated questionnaire originally developed by Kiekkas et al.[2] The instrument comprised three sections: positive effects of ECMO technology (six items), negative effects of ECMO technology (eight items), and demographic information, including age, gender, educational background, and ICU experience. Responses were recorded on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Statistical analysis

Data were analyzed using the statistical package for the social sciences (SPSS), version 26. Descriptive statistics (means, standard deviations, and frequencies) were calculated to summarize participant characteristics and survey responses. Inferential analyses included independent-sample t-tests and one-way analysis of variance (ANOVA) to examine differences in perceptions across demographic subgroups. A p value of <0.05 was considered statistically significant.

RESULTS

A total of 97 ICU nurses participated in this study. The sample comprised 62.9% females and 37.1% males. Most respondents (61.9%) were aged between 25 and 34 years, 23.7% were aged 35–44 years, and 13.4% were aged 45–54 years; only one respondent (1.0%) was aged 55 or above. Regarding critical care experience, 39.2% of participants reported having less than 5 years, 34.0% had 5 to 10 years, and 26.8% had more than 10 years of experience. Regarding educational background, the majority held a bachelor's degree in nursing (84.5%), with 9.3% having a diploma or associate degree and 6.2% possessing a master's degree (Table 1).

Participants reported high ratings across all items related to the positive impact of ECMO technology (Table 2). The

item "guarantees a higher patient safety" received a mean score of 4.10 (SD=0.918), followed by "offers the potential for continuous improvement of personnel" with a mean of 4.10 (SD=0.810), and "guarantees a higher effectiveness of nursing care" with a mean of 4.04 (SD=0.967). The perception that ECMO "contributes to the easier completion of nursing duties" was rated with a mean of 3.96 (SD=1.02), while "contributes to the faster completion of nursing duties" scored a mean of 3.82 (SD=1.08). Finally, the item "contributes to the increase in prestige of nursing personnel" received a mean score of 3.99 (SD=0.896).

In terms of perceived negative effects (Table 3), the item "contributes to the increase of overall hospitalization cost" received the highest mean score of 3.65 (SD=1.155), followed by "contributes to the increase of stress of nursing personnel" with a mean of 3.35 (SD=1.191), and "increases patient risk from mechanical faults" with a mean of 3.16 (SD=1.187). The item "increases patient risk from errors of personnel" scored a mean of 2.93 (SD=1.192), while "contributes to the loss of human sensitivity of nursing personnel about patients" and "contributes to the restriction of autonomy of nursing personnel" had mean scores of 2.80 (SD=1.151) and 2.78 (SD=1.12), respectively.

The items "extracts attention of nursing personnel away from patients" and "extracts time of nursing personnel away from patients" received the lowest mean scores of 2.76 (SD=1.153) and 2.71 (SD=1.08), respectively.

Inferential analysis

No statistically significant differences were observed in perceptions of ECMO technology when comparing responses by gender, years of critical care experience, or educational level ($p>0.05$ for all comparisons). These results suggest a broadly consistent perception of ECMO's advantages and challenges across diverse nursing demographics, indicating that attitudes toward ECMO are relatively uniform regardless of professional background or experience.

Table 1: Demographic characteristics.

Demographic characteristics	N	%
Gender		
Male	36	37.1
Female	61	62.9
Age group (years)		
25-34	60	61.9
35-44	23	23.7
45-54	13	13.4
55 and above	1	1.0
Critical care experience (years)		
<5	38	39.2
5–10	33	34.0
>10	26	26.8
Educational level		
Diploma/associate degree in nursing	9	9.3
Bachelor's degree in nursing	82	84.5
Master's degree	6	6.2

Table 2: Positive effects of ECMO technological use.

Do you believe that the use of technological equipment	1 N (%)	2 N (%)	3 N (%)	4 N (%)	5 N (%)	Mean	Std
Guarantees a higher effectiveness of nursing care?	1 (1.0)	11 (11.3)	4 (4.1)	48 (49.5)	33 (34.0)	4.04	0.967
Guarantees a higher patient safety?	1 (1.0)	6 (6.2)	12 (12.4)	41 (42.3)	37 (38.1)	4.1	0.918
Contributes to the easier completion of nursing duties?	2 (2.1)	10 (10.3)	10 (10.3)	43 (44.3)	32 (33.0)	3.96	1.02
Contributes to the faster completion of nursing duties?	4 (4.1)	11 (11.3)	9 (9.3)	47 (48.5)	26 (26.8)	3.82	1.08
Offers the potential for continuous improvement of personnel?	2 (2.1)	1 (1.0)	12 (12.4)	52 (53.6)	30 (30.9)	4.1	0.81
Contributes to the increase of prestige of nursing personnel?	3 (3.1)	2 (2.1)	15 (15.5)	50 (51.5)	27 (27.8)	3.99	0.896

Table 3: Perceptions of negative effects of ECMO technology.

Do you believe that the use of technological equipment	1 N (%)	2 N (%)	3 N (%)	4 N (%)	5 N (%)	Mean	Std
Increases patient risk from errors of personnel?	11 (11.3)	31 (32.0)	17 (17.5)	30 (30.9)	8 (8.2)	2.93	1.192
Increases patient risk from mechanical faults?	7 (7.2)	29 (29.9)	13 (13.4)	37 (38.1)	11 (11.3)	3.16	1.187
Contributes to the increase of stress of nursing personnel?	5 (5.2)	26 (26.8)	12 (12.4)	38 (39.2)	16 (16.5)	3.35	1.191

Continued.

Do you believe that the use of technological equipment	1 N (%)	2 N (%)	3 N (%)	4 N (%)	5 N (%)	Mean	Std
Extracts attention of nursing personnel away from patients?	11 (11.3)	39 (40.2)	15 (15.5)	26 (26.8)	6 (6.2)	2.76	1.153
Extracts time of nursing personnel away from patients?	10 (10.3)	41 (42.3)	16 (16.5)	27 (27.8)	3 (3.1)	2.71	1.08
Contributes to the restriction of autonomy of nursing personnel?	9 (9.3)	40 (41.2)	17 (16.5)	25 (25.8)	6 (6.2)	2.78	1.12
Contributes to the loss of human sensitivity of nursing personnel about patients?	10 (10.3)	38 (39.2)	17 (17.5)	25 (25.8)	7 (7.2)	2.8	1.151
Contributes to the increase of overall hospitalization cost?	7 (7.2)	10 (10.3)	15 (15.3)	43 (44.3)	22 (22.77)	3.65	1.155

DISCUSSION

This study examined ICU nurses' perceptions toward ECMO technology, indicating a predominantly positive attitude towards its application in critical care. This indicates that ECMO is progressively becoming standard in nursing practice, demonstrating how ICU nurses are integrating sophisticated technologies into their professional identity. Nurses indicated that ECMO improves patient safety, streamlines nursing care, and fosters professional development. Nurses concurrently articulated mild apprehensions regarding stress, mechanical risks, and the financial implications connected with ECMO. Despite the absence of statistically significant differences in conclusions related to gender, experience level, or educational background, this consistency across varied demographics provides crucial insights. Recent studies have investigated the experiences of ICU nurses with ECMO technology. Nurses typically regard ECMO positively, perceiving it as a chance for professional advancement and improved patient care.[5,7] Managing ECMO patients can be emotionally and psychologically challenging, resulting in stress and potential burnout. The complexity of ECMO management necessitates sophisticated clinical and critical thinking abilities, continuous surveillance, and specialized education.[7,8] Notwithstanding these limitations, nurses are driven to get ECMO competencies as a facet of their professional development.[7] Psychological support and counseling are advised to assist nurses in this capacity.[5,8]

Although null data is frequently overlooked, the uniformity of responses among all participant groups may indicate the efficacy of institutional ECMO training and the standardization of practice. At King Faisal Specialist Hospital and Research Centre, systematic ECMO education, defined competency frameworks, and consistent exposure to device platforms may facilitate uniform levels of comfort and confidence in ECMO care among all ICU nurses, irrespective of their backgrounds. This institutional consistency is promising, indicating a successful match between training objectives and frontline perceptions.

The usually positive perceptions of ECMO align with previous studies highlighting the technology's capacity to improve critical care provision when supported by robust organizational frameworks.[2,4] Participants in this study perceived that ECMO enhanced both the quality and efficiency of nursing care. Significantly, numerous individuals perceived ECMO as a catalyst for personal development, emphasizing how modern technology can facilitate skill enhancement, leadership, and the building of professional identity among nurses.[6,9,10]

Nonetheless, the challenges related to ECMO must not be overlooked. Nurses expressed apprehension regarding the psychological and operational strain associated with handling these devices, a conclusion supported by existing literature that characterizes ECMO nursing as cognitively demanding and emotionally burdensome.[4,5] Concerns over workload and expenses underscore that ECMO is both a therapeutic instrument and an organizational obligation, necessitating sufficient manpower, support systems, and resources for safe and sustainable implementation.[11,12]

Nurses in this study expressed apprehension that ECMO technology would detract from their focus on direct patient care. This impression, though not predominant, indicates a persistent tension between technology proficiency and human connection in critical care. Previous studies highlight this issue, indicating that experienced nurses frequently navigate the intrusive aspects of technology to provide excellent care, whereas inexperienced nurses may find it challenging to reconcile technological demands with direct patient interaction.[13] This discovery underscores the significance of organized mentorship, simulation-based training, and supportive environments that facilitate the development of skills and confidence in less experienced nurses, allowing them to include ECMO care without sacrificing bedside attendance. The rigorous demands of ECMO care have been linked to burnout, highlighting the necessity for psychological support and resilience-building programs for frontline personnel.[5,13] It is essential that the incorporation of ECMO enhances, rather than undermines, bedside nursing, making it a critical organizational goal.

The lack of substantial differences among subgroups also reflects the common experiences of critical care work. Nurses, regardless of their experience level, gender, or educational background, encounter comparable challenges and advantages while administering ECMO. This indicates that forthcoming ECMO methods, whether concentrating on device selection, protocol modifications, or training updates, might be enhanced through a cohesive, team-oriented strategy instead of one divided by demographics. In support of this, dedicated training programs have been established to equip critical care nurses for ECMO duties, with research indicating substantial enhancements in knowledge across different ICU settings.[14] Moreover, the execution of ECMO therapy necessitates a multidisciplinary approach, incorporating physicians, acute care nurse practitioners, and critical care nurses to guarantee safe and effective administration.[15] Research has concentrated on team membership, education, and communication; nevertheless, further exploration of the specific aspects and dynamics of effective team-based care is necessary. Collectively, these findings underscore the dynamic nature of ECMO administration and the necessity of thorough training and teamwork in maintaining superior critical care standards.

Moreover, these findings facilitate further exploration of how cultural, organizational, or unit-specific factors affect ECMO experiences. Qualitative methods, like focus groups and interviews, can effectively capture the intricate perspectives and emotional aspects of ECMO nursing that quantitative measures may not adequately express. However, this study possesses multiple limitations. The study was performed at a single tertiary care facility, perhaps restricting the applicability of the results to other environments with varying ECMO protocols. The cross-sectional design offers merely a snapshot of nurses' perceptions and fails to consider temporal changes. The dependence on self-reported data may have resulted in response bias, and the singular emphasis on ICU nurses omitted insights from perfusionists and physicians, potentially providing a more comprehensive interdisciplinary perspective. Future multicenter and longitudinal research including other professional groups are thus advised to reinforce and elaborate on these findings.

CONCLUSION

This study revealed that ICU nurses predominantly perceive ECMO technology as advantageous for patient safety, nursing efficacy, and professional growth. Although no notable discrepancies were observed among demographic groupings, this uniformity indicates successful training and consistent procedures inside the unit.

Notwithstanding these favorable opinions, nurses articulated apprehensions regarding tension, mechanical risks, and increased workload. These findings underscore the necessity of reconciling technological progress with the provision of assistance for frontline personnel.

Continuous investment in ECMO education, workflow enhancement, and nurse participation in decision-making is crucial for guaranteeing safe, efficient, and sustainable ECMO treatment. Subsequent research should investigate qualitative insights to enhance comprehension of the lived experiences behind these perceptions.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee from the Institutional Review Board (IRB) of King Faisal Specialist Hospital and Research Center, Riyadh, Saudi Arabia (IRB# 2241410).

REFERENCES

1. Geetha S 3rd, Verma N, Chakole V. A Comprehensive Review of Extra Corporeal Membrane Oxygenation: The Lifeline in Critical Moments. Cureus. 2024;16(1):e53275.
2. Kiekkas P, Karga M, Poulopoulou M, Karpouhtsi I, Papadoulas V, Koutsojannis C. Use of technological equipment in critical care units: nurses' perceptions in Greece. J Clin Nurs. 2006;15(2):178-87.
3. Hernandez L, Casida J. Acute Care Nurse Practitioner-Led Extracorporeal Membrane Oxygenation Simulation Training. AACN Adv Crit Care. 2021;32(4):461-7.
4. Ruppel H, Funk M. Nurse-Technology Interactions and Patient Safety. Crit Care Nurs Clin North Am. 2018;30(2):203-13.
5. Asgari P, Jackson AC, Esmaeili M, Hosseini A, Bahramnezhad F. Nurses' experience of patient care using extracorporeal membrane oxygenation. Nurs Crit Care. 2022;27(2):258-66.
6. Ross P, Watterson J, Fulcher BJ, Linke NJ, Nicholson AJ, Ilic D, et al. Nursing workforce, education, and training challenges to implementing extracorporeal membrane oxygenation services in Australian intensive care units: A qualitative substudy. Aust Crit Care. 2023;36(1):114-8.
7. Ross P, Sheldrake J, Ilic D, Watterson J, Berkovic D, Pilcher D, et al. An exploration of intensive care nurses' perceptions of workload in providing extracorporeal membrane oxygenation (ECMO) support: A descriptive qualitative study. Aust Crit Care. 2024;37(4):585-91.
8. Salloum A, Fawaz M, Rayan A, Hamaideh SH, Hani SB, ALBashtawy M, et al. Extracorporeal Membrane Oxygenation and Lebanese Critical Care Nurses' Perceptions: A Qualitative Phenomenological Study. SAGE Open Nurs. 2023;9:23779608231216797.
9. Peeler A, Gleason KT, Ferrell B, Battista V, Klinedinst R, Cho S-M, et al. Extracorporeal membrane oxygenation: Opportunities for expanding nurses' roles. AACN Adv Crit Care. 2021;32(3):341-5.

10. Alshammari MA, Vellolikalam C, Alfeeli S. Nurses' perception of their role in Extracorporeal Membrane Oxygenation Care: A qualitative assessment. Nurs Crit Care. 2020;27(2):251-7.
11. Peek GJ, Mugford M, Tiruvoipati R, Wilson A, Allen E, Thalanany MM, et al. Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): A multicentre randomised controlled trial. The Lancet. 2009;374(9698):1351-63.
12. Combes A, Brodie D, Bartlett R, Brochard L, Brower R, Conrad S, et al. Position Paper for the organization of extracorporeal membrane oxygenation programs for acute respiratory failure in adult patients. Am J Resp Crit Care Med. 2014;190(5):488-96.
13. McGrath M. The challenges of caring in a technological environment: Critical Care Nurses' experiences. J Clin Nurs. 2008;17(8):1096-104.
14. Gannon WD, Craig L, Netzel L, Mauldin C, Troutt A, Warhoover M, et al. Curriculum to introduce critical care nurses to extracorporeal membrane oxygenation. Am J Crit Care. 2020;29(4):262-9.
15. Presti CR, Casey J. Team-based care of the patient receiving venovenous extracorporeal membrane oxygenation. Dimensions Crit Care Nurs. 2025;44(1):2-11.

Cite this article as: Hakami E, Mushqi B, Alsultan A, Alsomali A, Lo GM. Evaluating the safety of diverse extracorporeal membrane oxygenation technologies through the lens of intensive care unit nurses' perspective. Int J Res Med Sci 2025;13:3709-14.