

## NURSING

# Evaluating critical care nurses' competence in caring for patients undergoing continuous renal replacement therapy: A descriptive study

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## Keywords

Acute kidney injury • Continuous renal replacement therapy • Critical care nursing • Nursing competence • Patient safety

## Summary

**Introduction.** Acute kidney injury is common in intensive care units and may require Continuous renal replacement therapy (CRRT). Safe delivery of CRRT depends on nurses' theoretical knowledge and practical competence. This study assessed critical care nurses' competence in CRRT to identify areas requiring educational support.

**Methods.** A cross-sectional observational study was conducted among 240 nurses working in intensive care units at three Italian hospitals. Competence was assessed through an online survey using the validated Continuous Renal Replacement Therapy Measurement Competency Tool (CRRT-MCT). Descriptive statistics were used to summarise participant characteristics, training and competence levels.

**Results.** Most participants (76.7%, n=184) were classified at the novice level, 17.0% (n=41) at the competent level and 4.2%

(n=10) at the expert level; 2.1% (n=5) did not reach the novice threshold. Although 71.3% had received CRRT training, 85.4% of trained participants considered it incomplete and unsatisfactory. The greatest knowledge gaps concerned indications for initiating CRRT and the fundamental principles of renal replacement techniques, whereas knowledge of anticoagulation and vascular access was stronger.

**Conclusion.** The findings indicate substantial educational needs among intensive care nurses involved in CRRT. Structured programmes combining theory, supervised practice and periodic reassessment should be integrated into continuing professional development. The CRRT-MCT can support both organisational competency mapping and individual self-assessment, enabling training to be targeted to identified knowledge gaps and evaluated over time.

## Introduction

Acute kidney injury (AKI) is a severe condition characterised by a rapid deterioration in renal function, usually developing within 48 hours or over several days [1]. Its mortality risk is comparable to that associated with acute lung injury or acute coronary syndromes [1]. AKI affects approximately 1-5% of hospital inpatients and 7-23% of patients admitted to intensive care units (ICUs) [2, 3]. Timely diagnosis and treatment are therefore essential to prevent serious and potentially fatal consequences; reported mortality rates range from 20% to 70% among hospitalised patients [2, 3]. AKI may involve both structural damage and functional impairment and may occur alongside other disorders [4]. It is an important global health problem that requires complex, multidisciplinary management [5].

Approximately one-third of critically ill patients develop AKI, and 5% require renal replacement therapy [6]. Nurses caring for these patients therefore need advanced knowledge and skills. A cohort study conducted following the 2009 National Confidential Enquiry into Patient Outcome and Death identified

several shortcomings in the care of patients with AKI [7], while another report found that only half of patients received adequate care [8]. Continuous renal replacement therapy (CRRT) is frequently used for critically ill patients who require renal support. Continuous veno-venous haemofiltration, based on the principle of haemofiltration, is among the most widely used modalities in ICUs [9]. During the COVID-19 pandemic, 18.3% of infected patients developed renal failure and required renal replacement therapy [10], highlighting the need for specific nursing education on CRRT management [11]. CRRT also requires effective team organisation [12] and an integrated approach supported by appropriately competent nursing staff [5]. Because no specific instrument was available to assess nurses' competence in this field, the Continuous Renal Replacement Therapy Measurement Competency Tool (CRRT-MCT) was developed and validated in 2022 [13]. The present study aimed to assess ICU nurses' competence in CRRT and identify strengths and gaps in the care of critically ill patients receiving this treatment.

## Methods

This study investigated critical care nurses' competence in continuous renal replacement techniques.

The CRRT-MCT was developed and validated to measure ICU nurses' competence in the use of CRRT [13]. It comprises 36 items organised into four sections. The first section contains six items on demographic and professional characteristics, including age, sex, professional experience and length of service in the ICU. The second contains nine items on education and training in continuous renal replacement techniques. The third contains six items describing the workplace context. The fourth contains 15 items assessing knowledge of CRRT principles, anticoagulation, prescription and appropriate vascular access.

The responses classify the nurse's knowledge as basic, intermediate or advanced and determine an overall level of competence based on Benner's framework: novice, competent or expert [14].

### STUDY DESIGN

This cross-sectional observational study measured nurses' knowledge and competence using the CRRT-MCT.

### SAMPLING AND SETTING

Participants were nurses employed in the ICUs of three Italian hospitals. The inclusion criteria were:

- critical care nurses working in an ICU;
- completion of the questionnaire;
- provision of informed consent;
- nurses who did not work in an Italian ICU or did not complete the questionnaire were excluded.

### DATA COLLECTION

Data were collected through an online survey administered using Google Forms. Respondents were required to provide informed consent and meet the inclusion criteria before accessing the questionnaire. Data collection continued for three months after validation of the instrument, until the planned sample size was reached.

### DATA ANALYSIS

Data were analysed using jamovi version 2.2.2 [15]. Descriptive statistics were used to summarise sample characteristics, workplace context and training. Results are reported as frequencies and percentages, means with standard deviations (SDs), or medians with ranges, as appropriate.

## Results

### SECTION I: DEMOGRAPHICS AND TRAINING

Among the 240 respondents, 55.0% (n=132) were female, 93.8% (n=225) held a bachelor's degree and 17.9% (n=43) had previous professional experience in

Tab. I. Demographic characteristics of participants (N=240).

| Participant characteristics                                | n (%)      | Mean $\pm$ SD (range)  |
|------------------------------------------------------------|------------|------------------------|
| <b>Sex</b>                                                 |            |                        |
| Female                                                     | 132 (55.0) |                        |
| Male                                                       | 108 (45.0) |                        |
| Length of service, years                                   |            | 16.2 $\pm$ 11.1 (1-40) |
| Length of ICU service, years                               |            | 13.2 $\pm$ 10.2 (1-40) |
| Previous professional experience in nephrology or dialysis | 43 (17.9)  |                        |
| <b>Highest degree</b>                                      |            |                        |
| Bachelor's degree                                          | 225 (93.8) |                        |
| Master's degree                                            | 15 (6.2)   |                        |

nephrology or dialysis (Tab. I). Most participants (71.3%, n=171) had received CRRT training; this was mainly work-based (66.7%, n=114) and combined theory with practice (85.4%, n=146). Among trained participants, 85.4% (n=146) considered the training incomplete and unsatisfactory (Tab. II).

All respondents considered that CRRT training should place greater emphasis on both theoretical and practical content. When first caring for a patient receiving CRRT, 94.2% (n=226) had been supported by a more experienced colleague.

Nevertheless, 65.0% (n=156) reported feeling uncomfortable when caring for a patient receiving CRRT because they were uncertain how to manage potential problems. Only 7.5% (n=18) fully agreed that CRRT should be managed by dialysis nurses, while 32.9% (n=79) partly agreed, citing dialysis nurses' greater experience and competence arising from higher activity volumes. Participants who disagreed (59.6%, n=143) considered dialysis nurses less familiar with managing the critical condition of ICU patients.

### SECTION 2: WORKPLACE CONTEXT

Haemodiafiltration, which combines convection and diffusion, was the most frequently performed treatment in respondents' workplaces (89.2%, n=214). Treatment was prescribed mainly by anaesthetists (70.4%, n=169), followed by nephrologists (16.7%, n=40) and

Tab. II. CRRT training undertaken by participants (N=171).

| Training characteristics             | n (%)      |
|--------------------------------------|------------|
| <b>Type of training</b>              |            |
| Self-directed                        | 7 (4.1)    |
| Corporate course                     | 50 (29.2)  |
| Work-based                           | 114 (66.7) |
| <b>Training mode</b>                 |            |
| Practical                            | 23 (13.5)  |
| Theoretical                          | 2 (1.2)    |
| Theory and practice                  | 146 (85.4) |
| <b>Perceived quality of training</b> |            |
| Incomplete and unsatisfactory        | 146 (85.4) |
| Complete and satisfactory            | 25 (14.6)  |

**Tab. III.** Nurses' competence in CRRT (N=240).

| Level of competence | n (%)      |
|---------------------|------------|
| Novice              | 184 (76.7) |
| Competent           | 41 (17.0)  |
| Expert              | 10 (4.2)   |
| Unclassifiable      | 5 (2.1)    |

cardiologists (5.4%, n=13). The prescribing physician operated the CRRT machine in 7.5% of cases (n=18), whereas intensive care nurses operated and managed it in 89.6% (n=215). Patients with respiratory conditions (43.8%, n=105) and sepsis (41.7%, n=100) were the most frequent recipients of renal replacement therapy. Among surveyed ICUs, 73.3% (n=176) also performed extracorporeal carbon dioxide removal (ECCO2R).

### SECTION 3: LEVEL OF COMPETENCE

Most participants demonstrated novice-level competence in CRRT: 76.7% (n=184) were classified as novice, 17.0% (n=41) as competent and 4.2% (n=10) as expert. A further 2.1% (n=5) did not reach the novice threshold (Tab. III).

### QUESTIONS WITH THE HIGHEST NUMBER OF INCORRECT ANSWERS

The questions with the highest proportion of incorrect responses were:

- **Question 15:** "According to the KDIGO criteria, when all parameters determining the start of CRRT treatment are normal, which urinary output value should alarm you?"
  - Incorrect answers: 96.7% (n=232)
  - Question complexity: Medium
- **Question 5:** "Which treatment is described by the following statement: 'Clearance is achieved by diffusion and is effective on small molecules (urea, ions, ...)?"
  - Incorrect answers: 91.7% (n=220)
  - Question complexity: High

These findings suggest important knowledge gaps regarding indications for CRRT initiation and the fundamental principles underlying renal replacement therapies.

### QUESTIONS WITH THE HIGHEST NUMBER OF CORRECT ANSWERS

The questions with the highest proportion of correct responses were:

- **Question 9:** "In which category of patients is anticoagulation with citrate most discouraged?"
  - Correct answers: 99.2% (n=238)
- **Question 13:** "In your opinion, which is the best site for venous catheter insertion for CRRT treatment?"
  - Correct answers: 98.8% (n=237)

**Question 8:** "Which of the following anticoagulation techniques would you choose at the priming stage in a CRRT treatment?"

- Correct answers: 98.3% (n=236)

- **Question 11:** "If heparin is used and the patient develops thrombocytopenia, administration of the anticoagulant..."
  - Correct answers: 97.9% (n=235)

These results indicate a strong level of knowledge regarding anticoagulation management and vascular access for CRRT.

### QUESTIONS WITH MORE THAN 50% INCORRECT ANSWERS

Several questions were answered incorrectly by more than half of the participants:

- **Question 15:** "According to KDIGO criteria, when all parameters determining the start of CRRT treatment are in the normal range, which urinary output value should alarm you?"
  - Incorrect answers: 96.7% (n=232)
- **Question 5:** "Indicate which treatment corresponds to the following statement: 'Clearance is achieved by diffusion and is effective on small molecules (urea, ions, ...)'"
  - Incorrect answers: 91.7% (n=220)
- **Question 6:** "Indicate which treatment corresponds to the following statement: 'Clearance is achieved by diffusion and convection with efficacy on larger molecules'"
  - Incorrect answers: 87.9% (n=211)

Incorrect answers: 87.9% (n=211)

- **Question 3:** "Indicate which technique you would choose to treat fluid overload."
  - Incorrect answers: 75.4% (n=181)

These findings highlight substantial deficiencies in nurses' understanding of the fundamental principles and modalities of CRRT.

### AREAS OF COMPETENCE

The area in which nurses demonstrated the strongest knowledge was:

- **Principles of anticoagulation:** 96.7% correct answers (n=232)

Other areas showed lower levels of competency:

- **Prescription and vascular access:** 72.1% correct answers (n=173)
- **Principles of CRRT techniques:** 55.0% correct answers (n=132)

Overall, knowledge related to anticoagulation was considerably stronger than knowledge concerning the fundamental principles of CRRT techniques, which emerged as the area requiring the greatest educational support.

### Discussion

CRRT is increasingly prescribed and delivered in intensive care settings and is managed largely by nurses. Nurses must therefore master the theoretical and practical knowledge required to provide competent and safe care.

As the use of CRRT increases, specific nursing education becomes essential. The most concerning finding was

that only 21.2% of participants (n=51) were classified as competent or expert, whereas 76.7% (n=184) were classified as novice. These gaps should be addressed because inadequate competence may compromise patient safety and treatment outcomes.

The CRRT-MCT identified the fundamental principles of CRRT as the area with the greatest knowledge deficit and therefore the main priority for educational intervention.

Educational interventions should focus on the CRRT modalities most frequently used in practice and combine theoretical teaching, practical sessions and supervised workplace learning.

The study also highlights the need for healthcare organisations to assess ICU nurses' competence and provide targeted continuing professional development programmes to strengthen both clinical skills and patient safety [16]. This is particularly important in settings with frequent staff turnover or handovers.

Length of ICU service alone was not sufficient to identify an expert nurse who could supervise colleagues caring for a patient receiving CRRT for the first time, because most participants demonstrated only novice-level knowledge regardless of seniority.

## Conclusion

Strengthening nursing competence in CRRT is necessary to promote safe care and prevent adverse outcomes. The CRRT-MCT [13] proved useful for mapping competence among critical care nurses.

It may also support the objective identification of nurses with the expertise required to supervise less experienced colleagues.

The instrument can guide the design of training tailored to a specific group's needs. Reassessment after training may then help evaluate effectiveness and identify any remaining knowledge gaps.

The CRRT-MCT is a valid and useful instrument for measuring nursing competence in CRRT and may also be used by intensive care nurses for self-assessment.

## Acknowledgements

None.

## Funding

The authors received no financial support for the research, authorship and/or publication of this article.

## Ethical considerations

The study procedures complied with the ethical standards of the responsible committee on human experimentation and with the Declaration of Helsinki. The study was

approved by the Territorial Ethics Committee of the Liguria Region (approval no. 13456, 2 October 2023). Participants received written information about the study and provided informed consent before completing the anonymous online questionnaire. Data were downloaded from Google Forms once the target sample size had been reached.

## Conflict of interest statement

The authors declared no potential conflict of interest with respect to the research, authorship and/or publication of this article.

## Authors' contributions

The individual contributions of authors to the manuscript are as follows: MEM, EC: contributed to the conception and the design of this study. MEM, EC, RW: contributed to data collection, analysis, and interpretation. MEM, MG, GA, RW: drafting, editing and revising critically this manuscript. RW, GC, MZ, LS, AB: supervision of all stages of the work.

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Received on December 23, 2023. Accepted on July 24, 2026.

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**How to cite this article:** Musio ME, Calabrese E; Gammone M, Catania G, Zanini M, Aleo G, Watson R, Sasso L, Bagnasco A. Evaluating critical care nurses' competence in caring for patients undergoing continuous renal replacement therapy: a descriptive study. *J Prev Med Hyg* 2026;67:E374-E378. <https://doi.org/10.82082/2421-4248/jpmh2026.67.3.3159>

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