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Management of mechanical ventilators in intensive care unit patients from a nursing perspective

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Abstract:
The Intensive Care Unit (ICU) requires continuous monitoring and advanced technologies, such as mechanical ventilation, to support critically ill patients. Proper management of this resource is essential for the quality of care provided. This study aims to evaluate managing patients undergoing mechanical ventilation in an intensive care unit. This cross-sectional, quantitative prevalence study involves nursing professionals working in adult intensive care units at the Hospital das Clínicas of the Federal University of Pernambuco, in Recife, Brazil. Data collection was carried out through three questionnaires: the first consisted of sociodemographic data of the participants, while the second and third were developed based on the sector's Standard Operating Protocol for mechanical ventilation and COFEN Resolution No. 639/2020, respectively. ICU nurses demonstrated a prevalence of good knowledge about mechanical ventilation of 28% (95% CI: 10.4-45.6), with a higher prevalence of women (84.0%) compared to men (16.0%). The prevalence of good knowledge regarding Resolution 639/2020 was 52% (95% CI: 33.5-70), while 48% of the nurses showed poor knowledge. Regarding skin color, 69.2% of Black and Brown nurses demonstrated good ethical knowledge, while 30.8% had regular or poor knowledge. The results of this study indicate that nurses' proficiency in managing mechanical ventilators and patients remains inadequate.

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INTRODUCTION

The Intensive Care Unit (ICU) is characterized by the adoption of more specific and individualized care for patients in a critical health condition, requiring constant monitoring of their vital signs and the use of more complex healthcare techniques and equipment, such as Mechanical Ventilation (MV) (Gomes et. al, 2020). MV is an artificial ventilation method designed to fully or partially replace the patient's spontaneous ventilation, aiming to improve gas exchange processes and reduce inspiratory and expiratory effort. It can be applied through different modalities, adjusted according to the patient's needs (Burša et al., 2023). Applied with different objectives and in various clinical scenarios, MV may be used due to a health condition when applied in the ICU or as part of procedures utilized during surgical interventions (Battaglini et al., 2023).

MV is characterized by intermittent positive pressure to the respiratory system through a tracheal prosthesis, which may be an orotracheal or nasotracheal tube or even a tracheostomy (Rubulotta et al., 2024). It assumes the role of spontaneous ventilation either fully or partially, depending on the programmed mode. Its primary objectives include promoting gas exchange and

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reducing respiratory workload (Roshdy, 2023). MV is indicated in cases of acute respiratory failure (ARF) or chronic respiratory failure with acute exacerbation (Fiatun et. al., 2024).

In this context, healthcare professionals must be capable of properly managing MV. MV involves multiple pulmonary function variables, including flow rates, pressures, volumes, and indices derived from these basic parameters (Paudel et al., 2021). These parameters can be dynamically obtained during the respiratory cycle without interrupting airflow or statically, requiring the suspension of the respiratory system (Gomes et. al, 2020).

Thus, professionals must be highly qualified in handling ventilatory parameters, as MV, a therapeutic intervention, is not risk-free. It can cause lung tissue injury through several mechanisms, such as volutrauma, barotrauma, atelectrauma, and biotrauma (Gandra et al., 2022). The injury resulting from this therapy is known as Ventilator-Induced Lung Injury (VILI) (Fiatun et. al., 2024).

However, in modern practice, intensivists can better analyze and understand the physiological characteristics of their patients, allowing them to adjust MV parameters according to individual needs (Pelosi et al., 2021). This aims to optimize pulmonary function while minimizing the risk of VILI. Technological innovations have made these advancements possible in developing modern mechanical ventilators and growing scientific knowledge regarding ventilator-induced lung injury (Heo et. al., 2023).

The demand for ventilatory support increased significantly with the emergence of COVID-19. Consequently, the frequency with which nurses must care for patients requiring ventilatory support has risen. It intensifies the need for in-depth knowledge to prevent adverse outcomes in nursing care (Plotnikow et al., 2020).

In this regard, the Federal Nursing Council (COFEN), through Resolution No. 639/2020, granted nurses greater autonomy in managing ventilatory support for patients in intra-hospital and extra-hospital settings. It also expanded their competencies, which require a solid understanding of the key concepts related to MV for their practical application (COFEN, 2020). Nursing care for MV patients is often shared with physiotherapy professionals, leading to the delegation of this responsibility in many instances. As a result, nurses may become distanced from the direct care of these patients due to various factors, ranging from insufficient theoretical and practical knowledge on the subject to high workload demands (Cavalcante et. al., 2022).

This study analyzed the nursing strategies adopted in managing patients under mechanical ventilation in the ICU, highlighting challenges and best practices. Therefore, this study aims to assess the management of mechanical ventilation in ICU patients requiring artificial ventilatory support via MV, admitted to the ICU of a University Hospital in the city of Recife. It seeks to answer the guiding research question: “What is the role of nurses in managing mechanical ventilation for ICU patients?”

METHOD

Study Design and Sample

This is a cross-sectional, quantitative prevalence study involving nursing professionals working in the intensive care unit of the Hospital das Clínicas at the Federal University of Pernambuco (HC/UFPE), Pernambuco, Northeast Brazil. The study follows the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) for observational studies.

The research was conducted in the adult Intensive Care Unit (clinical and surgical) from the Hospital das Clínicas (HC) of Federal University of Pernambuco between September and December 2024. The HC is a large federal public hospital (413 beds) and a tertiary care facility affiliated with the Federal University of Pernambuco. The adult ICU has 15 beds, with 10 designated for post-surgical patients and 5 for clinical patients. One of its primary objectives is training healthcare professionals and offering residency-based specialization programs in various fields. It also serves as a training site for undergraduate and technical-level students from multiple institutions.

The eligible population included all nurses in the ICU during the data collection period, excluding those on duty as temporary replacements.

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Socioeconomic and Demographic Assessment

Demographic and socioeconomic data related to participants' lifestyles were collected using a questionnaire recommended by the Brazilian Institute of Geography and Statistics (IBGE).

The research questionnaire included ten variables, covering identification details such as name, age, sex, ethnic-racial background, and marital status. Additionally, it included data on length of professional training, time working in the ICU, and previous training in mechanical ventilation.

Assessment of Knowledge on Mechanical Ventilation

To evaluate nurses' knowledge of mechanical ventilation, seventeen questions on the topic were analyzed, with a maximum possible score of seventeen points, as each question had only one correct answer. The classification ranges were defined as follows:

1. Good Knowledge: Correct answers in ≥12 variables (70% or more).
2. Moderate Knowledge: Correct answers between 6 and 11 variables (35% to 65%).
3. Poor Knowledge: Correct answers in ≤5 variables (≤30%).

This criterion is based on the frequency of correct responses. A performance above 70% is considered satisfactory, indicating a relevant mastery of the subject, while a performance below 35% suggests significant knowledge gaps.

Eight questions on the subject were analyzed to evaluate ethical knowledge regarding mechanical ventilation, with a maximum possible score of eight points, as each question had only one correct answer. The classification ranges were defined as follows:

1. Good Knowledge: Correct answers in ≥6 variables (75% or more).
2. Moderate Knowledge: Correct answers between 3 and 5 variables (35% to 62.5%).
3. Poor Knowledge: Correct answers in ≤2 variables (≤25%).

This criterion is also based on the frequency of correct responses. A performance above 75% is considered satisfactory, indicating a solid understanding of the subject, whereas a performance below 35% suggests substantial knowledge deficits.

Statistical Analysis

The database was organized using a spreadsheet in Microsoft Excel®, and the data were analyzed using the SPSS 20.0 statistical software [SPSS Inc., Chicago, IL, USA]. Using a 95% confidence interval (CI95%), a binomial-to-normal distribution approximation was applied to describe proportions. Fisher's exact test was used for the comparison of proportions.

All continuous variables were tested for normality using the Shapiro-Wilk test. Variables with a normal distribution were described using mean and standard deviation (m±SD), and comparisons were made using Student's t-test. For interpretation purposes, the type I error threshold was set at 5% ($p \leq 0.05$).

Ethical aspects

The Research Ethics Committee of Clinical Hospital of the Federal University of Pernambuco approved the study under protocol number 7.112.788.

RESULT

The distribution of the sociodemographic profile associated with the ethical aspects of nursing care refers to the competencies of nurses in caring for patients on mechanical ventilation in the intra-hospital environment. This study addressed the management of mechanical ventilation (MV) in the intensive care unit (ICU), and ICU nurses demonstrated a prevalence of good knowledge about MV of 28% (95% CI: 10.4–45.6). No predictive variable was associated with knowledge about MV (Table 1).

In the nurses' sociodemographic profile distribution, a predominance of females (84.0%) was observed compared to males (16.0%), with women constituting the vast majority. Additionally, it was found that 60.0% of the respondents were between 36 and 50 years old, while 40% were between 24 and 35 years old. Regarding race/skin color, 48.0% identified as white and 52% as mixed race (pardo). Concerning marital status, 56% were married or in a stable union, and 44.0% were single.

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Family income data revealed that 24% earned below five minimum wages, while 76% had a family income above five.

Regarding postgraduate education, 52% had completed a residency program, while 48% held a specialization or a master's degree in health. The prevalence analysis based on the time since graduation showed that 32% had completed their undergraduate degree less than 10 years ago. Regarding the length of professional experience in the ICU, 52% had worked for less than 10 years.

The final item assessed was whether professionals had received training in mechanical ventilation during their ICU practice; 40% had not received any training or qualification in the management or operation of mechanical ventilation equipment. Finally, the proportion analysis using the student's t-test indicated that nurses with a mean age of 36.14 ± 8.03 years demonstrated good knowledge.

Table 1. Knowledge of nurses working in the Intensive Care Unit about mechanical ventilation according to socioeconomic and demographic variables in the State of Pernambuco - PE. Pernambuco, Brazil, 2024.

Variables	Knowledge about MV		PR($IC_{95\%}$)	p-value*
	Good	Fair/Poor		
	n (%)	n (%)		
	07 (28)	18 (72)		
Sex			0.476 (0.13 – 1.65)	0.307
Male	2 (50)	2 (50)		
Female	5 (23.8)	16 (76.2)		
Age			0.60 (0.14 – 2.51)	0.399
24-35	2 (20)	8 (80)		
36-50	5 (33.3)	10 (66.7)		
Skin color			0.43 (0.10 – 1.82)	0.223
White	2 (16.7)	10 (83.3)		
Black/ Mixed race	5 (38.5)	8 (61.5)		
Marital status			0.95 (0.26 – 3.40)	0.649
Single	3 (27.3)	8 (72.7)		
Married/Stable union	4 (28.6)	10 (71.4)		
Household income			0.53 (0.08 – 3.55)	0.443
≤ 5 salaries	1 (16.7)	5 (83.3)		
> 5 salaries	6 (31.6)	13 (68.4)		
Postgraduate (Residency)			1.23 (0.34 – 4.40)	0.550
Sim	4 (30.8)	9 (69.2)		
Não	3 (25)	9 (75)		
Training time			0.35 (0.05 – 2.47)	0.246
1-10 year	1 (12.5)	7 (87.5)		
> 10	6 (35.3)	11 (64.7)		
ICU time			1.23 (0.34 – 4.40)	0.550
≤ 10 years	4 (30.8)	9 (69.2)		
> 10 years	3 (25)	9 (75)		
MV training			1.66 (0.40 – 6.97)	0.399
Sim	5 (33.3)	10 (66.7)		
Não	2 (20)	8 (80)		
Age¥	36.14±8.03	35.89±5.62		0.929

PR: Prevalence ratio. 95%CI: 95% confidence interval. MV: Mechanical ventilation. ICU: intensive care unit. *Use of Fisher's exact test. ¥Student's t-test.

Table 2 describes the knowledge regarding the resolution of nursing care in mechanical ventilation (MV). The prevalence of good knowledge about the resolution was 52% (95% CI: 33.5–70), while 48% of the nurses interviewed demonstrated poor knowledge.

The results of this association showed that, in the analysis by sex, 75% of male nurses demonstrated good knowledge, compared to 47.6% among female nurses. Age was categorized into two groups: in the 24–35 age group, 40% demonstrated good knowledge, and 60% had fair or poor knowledge. In the 36–50 age group, 60% demonstrated good knowledge, while 40% had fair

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or poor knowledge. Regarding skin color, 69.2% of Black and mixed-race (pardo) participants demonstrated good ethical knowledge, while 30.8% had fair or poor knowledge. Among those who identified as white, 33.3% had good ethical knowledge, whereas 66.7% demonstrated poor knowledge.

Marital status analysis revealed that 36.4% of single participants demonstrated good knowledge, while 63.6% had poor knowledge. Among married participants or those in a stable union, 64.3% had good knowledge, and 35.7% had fair or poor knowledge.

Regarding postgraduate education, 38.5% of those with a residency demonstrated good knowledge, while 61.5% of those with fair or poor knowledge had not completed a residency program.

Regarding household income, 66.7% of those earning less than five minimum wages demonstrated good knowledge, while 33.3% had fair or poor knowledge. Among those earning more than five minimum wages, 47.4% demonstrated good knowledge, and 52.6% had fair or poor knowledge.

Regarding time since graduation, 62.5% of those with less than 10 years since graduation demonstrated good knowledge, while 37.5% had fair or poor ethical knowledge. In contrast, among those with more than 10 years since graduation, 47.1% demonstrated good knowledge, while 52.9% had fair or poor knowledge.

The variable "length of experience in the ICU" showed that those with less than 10 years of ICU experience had a good level of ethical knowledge in nursing care (69.2%), while 30.8% had fair knowledge. Conversely, among those with more than 10 years of ICU experience, 33.3% demonstrated good knowledge, while 66.7% had fair or poor knowledge.

Regarding previous training in mechanical ventilation, 46.7% of respondents who reported having received training demonstrated good knowledge, while 53.3% had fair or poor knowledge. Among those without training, 60% demonstrated good knowledge, and 40% had fair knowledge.

Finally, the average age of participants who demonstrated good knowledge was 36.9 ± 5.85 years, while those with fair or poor knowledge were 34.9 ± 6.66 years.

Table 2. Ethical knowledge of nurses working in the Intensive Care Unit about mechanical ventilation, according to socioeconomic and demographic variables in the State of Pernambuco - PE, Brazil, 2024.

Variables	Ethical knowledge about MV resolution		PR(IC95%)	p-value*
	Good	Fair/Poor		
	n (%)	n (%)		
	13 (52)	12 (48)		
Sex			0.635 (0.31 – 1.31)	0.328
Male	3 (75)	1 (25)		
Female	10 (47.6)	11 (52.4)		
Age			0.66 (0.28 – 1.58)	0.284
24-35	4 (40)	6 (60)		
36-50	9 (60)	6 (40)		
Skin color			2.07 (0.86 – 4.99)	0.081 0.360§
White	9 (69.2)	4 (30.8)		
Black/ Mixed race	4 (33.3)	8 (66.7)		
Marital status			0.56 (0.23 – 1.35)	0.163
Single	4 (36.4)	7 (63.6)		
Married/Stable union	9 (64.3)	5 (35.7)		
Household income			0.57 (0.26 – 1.28)	0.157
≤ 5 salaries	5 (38.5)	8 (61.5)		
> 5 salaries	8 (66.7)	4 (33.3)		
Postgraduate (Residency)			1.40 (0.67 – 2.94)	0.363
Sim	4 (66.7)	2 (33.3)		
Não	9 (47.4)	10 (52.6)		
Training time			1.32 (0.63 – 2.77)	0.387

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Variables	Ethical knowledge about MV resolution		PR(IC95%)	p-value*
	Good	Fair/Poor		
	n (%)	n (%)		
	13 (52)	12 (48)		
1-10 year	5 (62.5)	3 (37.5)		
> 10	8 (47.1)	9 (52.9)		
ICU time			2.07 (0.86 – 4.99)	0.081 0.360§
≤ 10 years	9 (69.2)	4 (30.8)		
> 10 years	4 (33.3)	8 (66.7)		
MV training			0.77 (0.37 – 1.63)	0.404
Sim	7 (46.7)	8 (53.3)		
Não	6 (60)	4 (40)		
Age¥	36.9±5.85	34.9±6.66		

PR: Prevalence ratio. 95%CI: 95% confidence interval. MV: Mechanical ventilation. ICU: intensive care unit. *Use of Fisher's exact test. §Test valueo Phi (φ). ¥Student's t-test

DISCUSSION

This study evaluated the role of nurses in the management of mechanical ventilation (MV) in intensive care units (ICUs), correlating it with their knowledge, skills, and ethical aspects of nursing care, based on Resolution No. 639/2020 of the Federal Nursing Council (COFEN) and the Standard Operating Procedure (SOP) for Nursing Care of Mechanically Ventilated Patients used in the ICU of the Hospital das Clínicas of the Federal University of Pernambuco (HC/UFPE).

The sociodemographic profile of the nurses revealed a predominance of female professionals (84.0%) compared to males (16.0%). This finding is consistent with a study conducted in Australia involving 112 ICU nurses, where 83% were women and 17% were men (Gürçay et. al., 2024). Additionally, a 2014 national survey of ICU nurses across different Brazilian regions revealed that 80% were female and only 20% were male. Although these are recent data, the overrepresentation of women in nursing is longstanding, tracing back to its origins as a pre-professional, manual, domestic, religious, and humanitarian activity primarily carried out by women without specialized training or remuneration (Lombardi et al., 2018).

In this study, nurses' knowledge was correlated with sociodemographic characteristics, allowing for an analysis of their ability to effectively manage MV based on evidence-informed practices derived from their clinical experience and the institutional SOP.

The most relevant statistical finding was that only 28% of ICU nurses demonstrated good knowledge of MV (95% CI: 10.4–45.6), while 72% had fair or poor knowledge. Interestingly, factors such as longer professional experience, years working in ICUs, and receiving MV training did not correlate with better knowledge. In fact, those who had undergone training and had more ICU experience often demonstrated less knowledge than those without such a background. This aligns with findings by Hassen et al. (2023), who reported that 68.8% of ICU nurses were unfamiliar with ventilation modes and parameter settings. Additionally, 76.7% could not identify reference values for arterial oxygen pressure (PaO_2), 61.5% were unaware of critical respiratory rates, and 51.4% did not know critical pH values necessary to initiate ventilation (Hassen et. al, 2023).

A 2015 study published in the International Journal of Science and Research reported moderate-to-regular knowledge regarding ventilatory modes, parameter settings, extubation, and weaning processes. However, significant deficiencies in configuring ventilators during treatment were also noted, reflecting insufficient knowledge of patient-specific clinical scenarios and therapy progression (Atiyah et al., 2015).

In another study involving 185 ICU nurses responsible for MV management, 91% had nearly 10 years of ICU experience. Despite this, only 50.8% demonstrated adequate knowledge of ventilator management and endotracheal tube care. Knowledge was notably lacking concerning cuff

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pressure monitoring and correct oral hygiene practices, with only 18% reporting adequate hygiene practices and 63.2% reporting incorrect tracheal suctioning techniques (Colombage et. al., 2020).

These findings underscore that nurse knowledge related to MV is substantially below what is necessary for safe and effective care. Mechanical ventilation management requires a systematic, evidence-based approach, including initial patient assessment, appropriate ventilator mode selection, parameter adjustment (volume, pressure, frequency, FiO_2), continuous monitoring of respiratory and hemodynamic variables, and early identification of adverse events such as ventilator-associated pneumonia (VAP) and acute lung injury (Schetaki et. al., 2023). Strategies to prevent ventilator-induced lung injury, including using lung-protective volumes and maintaining plateau pressures below 30 cm H_2O, are essential. Implementing these evidence-based practices improves clinical outcomes, reduces morbidity and mortality, and enhances care quality (Branson, 2018).

Another significant result was the moderate association between ethical knowledge, being Black or mixed-race, and having ≤10 years of ICU experience. These variables were associated with higher levels of knowledge about Resolution Nº. 639/2020, although statistical significance was marginal ($p = 0.08$; $\varphi = 0.36$). The small sample size may have affected these estimates.

Resolution COFEN Nº. 639/2020, issued in 2020, defines the nurse's role in caring for patients on MV in both hospital and prehospital settings. It emphasizes the nurse's responsibility in decision-making and executing procedures such as patient prone positioning and managing associated complications. However, only 52% of respondents reported active participation in such decisions, and 48% were only partially familiar with the resolution. Regarding prescription and performance of prone positioning, only 12% reported partial performance despite legal authorization, and 4% reported lacking necessary skills.

Regarding race/ethnicity, 69.2% of Black and mixed-race nurses reported good knowledge, compared to 33.3% of white nurses. Although the sample size was limited, this result may reflect the effects of social inclusion policies such as Law No. 12,711/2012, which establishes racial and socioeconomic quotas for access to federal universities, and Law Nº. 12,990/2014, which reserves 20% of public job vacancies for Black candidates (Brazil, 2012; Brazil, 2014).

Despite over a decade of affirmative policies, it is premature to assert that such measures have fully equalized access to professional roles for Black individuals. In Brazilian nursing, historical exclusion rooted in white cultural dominance and eugenic ideologies has shaped professional identities and interpersonal dynamics. While the growing university presence of Black individuals is noteworthy, equal representation across professions remains a work in progress. Nonetheless, as Black professionals increasingly occupy spaces traditionally held by white individuals, they become positive role models, encouraging others to pursue academic and professional pathways (Anchrum, 2025; Iheduru-Anderson, 2020).

No significant association was found between time since graduation and familiarity with Resolution Nº. 639/2020. However, 62.5% of nurses with <10 years of graduation reported good ethical knowledge, compared to 47.1% of those with ≥10 years. Similar findings were observed regarding ICU experience: 69.2% of those with ≤10 years in the ICU showed good knowledge versus 33.3% among those with >10 years. Thus, longer professional experience and time since graduation were not correlated with better ethical knowledge, corroborating previous studies involving similar populations and settings (Colombage et. al., 2020; Hassen et. al, 2023).

Among the strengths of the present study is nurses' use of mechanical ventilation management as a parameter of knowledge and its relationship with ethical aspects.

However, this study has limitations that must be considered when interpreting the results. It is a cross-sectional study in which causal relationships cannot be established; the nurse population analyzed was homogeneous from an ethnic perspective. Therefore, the findings need to be re-evaluated in more diverse nursing populations. There was a high refusal rate among nurses to participate in the study, which reduced the final sample size. An additional limitation concerns the absence of statistical adjustment for multivariate regression analysis. The final model was inconsistent due to the limited data sample. It is understood that this adjustment would have provided greater internal validity to the study.

The findings from this sample may contribute to planning new actions to reduce the knowledge gap related to mechanical ventilation management among nurses. These findings support the

development of more effective training strategies on mechanical ventilation. Future research should explore approaches that promote more robust interventions within the Brazilian nursing curriculum guidelines.

CONCLUSION

The findings of this study indicate a general deficiency in nurses' knowledge and competencies regarding the management of mechanical ventilation and the associated care of critically ill patients. Beyond continuing education, it is imperative to integrate more comprehensive MV content into undergraduate nursing curricula to better prepare graduates for clinical practice in settings where such skills are essential.

Ethical knowledge related to MV was also found to be insufficient. Many nurses were unfamiliar with Resolution COFEN No. 639/2020, which defines nursing competencies for managing mechanically ventilated patients in intra- and extra-hospital environments.

Deficiencies were evident in ventilator setup, testing, parameter configuration, and weaning/extubation processes. Nurses often lacked the skills to select appropriate ventilatory modes or conduct safe extubation procedures, which were frequently deferred to other healthcare professionals. These findings highlight the need to strengthen educational and institutional strategies to enhance nursing practice in critical care environments.

CONFLICT OF INTEREST

The authors declare no conflict of interest related to the present study.

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