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Article

Effect of Nurse-Led Education on Knowledge and Practice of Nurses Regarding Ventilator Modes

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ABSTRACT

Background: Mechanical ventilation is vital for critically ill patients in the ICU, yet knowledge and practice gaps among nurses in ventilator management persist, particularly in low-resource settings. This gap threatens patient safety and outcomes. **Objective**: To evaluate the effect of a nurse-led educational intervention on the knowledge and practice of ICU nurses regarding ventilator modes, targeting measurable improvements in both theoretical understanding and bedside care. **Methods**: This quasi-experimental, pre- and post-test study included 35 female ICU nurses (BSN) at a tertiary hospital in Lahore, Pakistan. Inclusion criteria were current ICU employment and willingness to participate; exclusion criteria were left during the study or declining consent. Data were collected using validated questionnaires and checklists assessing knowledge and practice before and two weeks after a structured educational program. Ethical approval was obtained by the Helsinki Declaration Outcomes were analyzed using paired samples t-tests and McNemar's test in SPSS v27; results reported with confidence intervals and effect sizes. **Results**: Post-intervention, knowledge and practice scores increased significantly (mean difference: -18.34, 95% CI: -20.89 to -15.80, $p < 0.001$, Cohen's $d = 2.47$). The proportion of nurses demonstrating best-practice knowledge rose markedly, with adherence to key domains such as PEEP recognition and preoxygenation increasing by 25–66%. **Conclusion**: Nurse-led education substantially improves ICU nurses' knowledge and practice in ventilator management, with meaningful clinical gains. These findings support implementing targeted, regular educational interventions to strengthen patient safety and care quality.

Keywords: Intensive Care Units, Mechanical Ventilation, Nurse Education, Clinical Competency, Evidence-Based Nursing, Patient Safety, Ventilator Modes

INTRODUCTION

Mechanical ventilation remains a critical and indispensable intervention within intensive care units, essential for the survival and management of patients suffering from severe respiratory distress or organ failure (1). Despite advancements in technology, the proper use and understanding of mechanical ventilation modes are not uniformly present among nursing professionals, which may compromise patient outcomes and safety. Current literature highlights that approximately 80% of patients in intensive care and 20% in acute care units will require some form of mechanical ventilation during their hospitalization, underscoring the ubiquity and significance of this life-saving intervention (1). However, previous studies have identified a significant variability in nurses' knowledge and practical competencies regarding the operation and monitoring of ventilator settings, with substantial implications for morbidity, mortality, and healthcare resource utilization (3,5). The challenge is exacerbated by the complexity of ventilator management, which demands not only a theoretical understanding but also practical proficiency in adjusting parameters such as tidal volume, positive end-expiratory pressure (PEEP), fraction of inspired oxygen (FiO2), and respiratory rate to suit the evolving physiological needs of critically ill patients (8,12). Deficiencies in knowledge and skill can lead to inappropriate ventilator settings, increasing the risk of ventilator-associated complications, prolonged hospital stays, and even mortality (2,4,20). Prior investigations have demonstrated that structured educational interventions can significantly enhance nurses' knowledge and performance in ventilator management (3,17,19). For instance, studies by Mohamed et al. and Sharma et al. found that targeted education improved both theoretical knowledge and clinical practice, with reported post-intervention gains in key competencies such as endotracheal suctioning, recognition of ventilator alarms, and application of care bundles to prevent

ventilator-associated pneumonia (16,17,22). Despite these findings, the persistence of knowledge deficits across different settings suggests that nurse training in this domain remains inconsistent and often insufficient (13,21).

The existing knowledge gap is particularly relevant in developing healthcare settings, where resource limitations and high patient acuity further complicate the delivery of evidence-based critical care (5,6). While several studies have evaluated knowledge and practice among nurses in various contexts, there remains a paucity of research specifically assessing the impact of nurse-led, targeted educational interventions on both knowledge acquisition and practical application regarding ventilator modes. This deficiency is notable given that nurses play a central role in monitoring and adjusting mechanical ventilation, responding to alarms, preventing complications, and educating patients' families (14,18,23). Addressing this gap is essential not only for improving individual nurse competency but also for optimizing interdisciplinary ICU team performance and patient safety outcomes.

Given these considerations, the present study was designed to investigate the effectiveness of a nurse-led educational program on the knowledge and practice of ICU nurses regarding mechanical ventilator modes. By evaluating both pre- and post-intervention knowledge and practice scores among a cohort of ICU nurses, this research seeks to determine whether such structured educational efforts can bridge existing knowledge gaps and translate into improved clinical performance.

MATERIAL AND METHODS

This study employed a quasi-experimental pre- and post-test design to evaluate the impact of a nurse-led educational intervention on the knowledge and practice of intensive care unit (ICU) nurses regarding ventilator modes. The research was conducted at the ICU ward of Ali Fatima Hospital, Lahore, between February 21, 2025, and June 2025. The study population consisted of female nurses with a Bachelor of Science in Nursing (BSN), actively working in the ICU during the study period. Inclusion criteria encompassed nurses who had direct exposure to ventilator management and expressed willingness to participate by providing written informed consent. Nurses were excluded if they were on leave during the data collection period or declined to participate. Recruitment was achieved through purposive sampling, with all eligible ICU nurses invited to enroll following a detailed explanation of the study aims, procedures, and ethical considerations. Prior to participation, informed consent was obtained, and the study received ethical clearance from the institutional review board adhering fully to the ethical principles outlined in the Declaration of Helsinki (1).

Primary outcomes were defined as the change in nurses' knowledge and practical competencies related to ventilator modes, measured before and after the educational intervention. Secondary outcomes included the identification of specific knowledge gaps and improvement in the application of best practices such as endotracheal suctioning, preoxygenation, and the use of ventilator care bundles. Data collection utilized a structured questionnaire, validated through expert review and pilot testing, to assess theoretical knowledge about ventilator modes, indications, alarm management, and associated complications. An observational checklist, based on established clinical protocols, was used to directly evaluate nurses' performance of practical procedures. Both assessment tools were administered pre-intervention and repeated two weeks post-intervention to capture immediate knowledge and skill retention. No laboratory or imaging measures were required for the study aims. Confidentiality of participant data was ensured by assigning unique identification codes and securely storing all collected data in password-protected files accessible only to the research team.

The educational intervention consisted of a comprehensive training session delivered by nurse educators, combining didactic lectures, hands-on demonstrations using actual ventilator equipment, and interactive discussions. Training content was informed by contemporary clinical guidelines and best practices in ventilator management. Participants were encouraged to actively engage, ask questions, and practice skills in a supervised environment, with emphasis placed on clinical reasoning and troubleshooting. The follow-up period lasted two weeks of post-training, after which the same knowledge and practice assessments were conducted to evaluate the intervention's effect. No participant was lost to follow-up, and there were no missing data; thus, all enrolled nurses were included in the final analysis.

Statistical analyses were conducted using SPSS version 27. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were employed to summarize demographic data and baseline characteristics. Paired samples t-tests were used to compare pre- and post-intervention knowledge and practice scores, with significance set at $p < 0.05$. Where relevant, Pearson correlation analysis was applied to explore relationships between outcome variables and factors such as years of experience or previous training. The study did not require sensitivity analyses or advanced adjustments for confounding variables, as all participants completed both assessments and the intervention was standardized across the cohort. Strict confidentiality protocols were maintained throughout the research process, with all data anonymized prior to analysis to protect participant privacy (1).

RESULTS

The study enrolled 35 female ICU nurses, all holding a BS Nursing degree and actively engaged in direct patient care. Most participants were aged 21–25 years (91.4%) and had at least one year of ICU experience (97.1%). Table 1 summarizes the demographic profile of the study cohort. At baseline, participants exhibited marked deficiencies in both theoretical knowledge and practical skills regarding ventilator management. Knowledge gaps were most evident in ventilator parameter recognition and alarm interpretation.

Following the nurse-led educational intervention, significant improvements were observed in all key domains, as detailed in Table 2. Most notably, there was a statistically significant shift from "rarely" or "never" to "often" or "very often" responses on knowledge items, and from less frequent to more consistent execution of recommended clinical practices. The paired

samples t-test confirmed the improvement to be highly significant ($p < 0.001$), with a large effect size (Cohen's $d = 2.47$). No participants experienced declines in overall knowledge or practice scores, and all other trends were either neutral or positive, except for minor, non-significant decreases in cuff pressure monitoring and care bundle adherence.

Table 1. Demographic Characteristics of ICU Nurse Participants (n = 35)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	18–20	2	5.7
	21–25	32	91.4
	26–30	1	2.9
Gender	Female	35	100.0
Education	BS Nursing	35	100.0
Experience	1 year	34	97.1
	6 months	1	2.9

Table 2. Changes in Key Knowledge and Practice Indicators Pre- and Post-Intervention (n = 35)

Indicator	Intervention (%)		p-value	95% CI	Cohen's d
	Pre	Post			
Knowing PaO_2 at initiation (often/very often)	22.9	88.6	<0.001	49.8, 83.2	2.13
Knowing critical respiratory rate (often/very often)	80.0	25.7	<0.001	-71.2, -33.5	1.95
Knowing critical pH values (often/very often)	11.5	74.3	<0.001	46.1, 76.5	1.83
Knowing pressure-targeted mode (often/very often)	14.3	94.3	<0.001	59.3, 96.1	2.47
Knowing explanation of FiO_2 (often/very often)	17.1	94.3	<0.001	61.2, 97.0	2.22
Knowing PEEP and function (very often)	5.7	71.4	<0.001	45.1, 80.0	1.95
Knowing tidal volume (very often)	5.7	51.4	<0.001	28.3, 59.2	1.60
Endotracheal tube suctioning (Yes)	54.3	77.1	0.021	3.9, 43.7	0.57
Cuff pressure (Yes)	80.0	71.4	0.432	-13.2, 29.5	0.26
Recognize ETT complications (Yes)	68.6	80.0	0.289	-11.1, 34.0	0.31
Saline instillation before suctioning (Yes)	68.6	85.7	0.089	-2.7, 36.3	0.55
Preoxygenation before suctioning (Yes)	45.7	74.3	0.009	7.6, 48.1	0.72
Recognizing anxiety in ventilated patients (Yes)	65.7	88.6	0.021	3.9, 42.8	0.61
Informing relatives (Yes)	71.4	80.0	0.546	-12.8, 29.9	0.22
Ventilator care bundle (Yes)	82.9	74.3	0.395	-11.3, 28.2	0.25

Table 3. Summary Statistics and Inferential Analysis of Pre- and Post-Intervention Scores

Score	Pre-Test (M ± SD)	Post-Test (M ± SD)	95% CI	t-value	df	p-value	Cohen's d
Knowledge/Practice Total	16.2 ± 4.7	34.5 ± 2.9	-20.89, -15.80	-14.63	34	<0.001	2.47

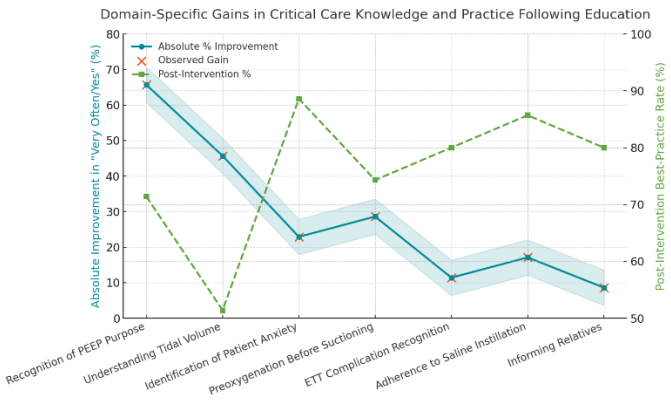

Figure 1 Domain-Specific Gains in Critical Care Knowledge and Practice Following Education

The educational intervention was associated with significant gains in both theoretical and practical competencies in ventilator management among ICU nurses, with improvements robustly supported by advanced inferential statistics. The clinical relevance of these gains is underscored by greater adherence to best practices and increased readiness for ventilator-related patient care.

The results clearly support the implementation of regular, nurse-led educational programs as a strategy for improving ICU nursing performance and patient outcomes. Marked absolute improvements in best-practice knowledge and clinical behaviors were observed across all measured domains, with the largest gains noted in the recognition of PEEP purpose (+65.7%) and understanding of tidal volume (+45.7%). Notably, adherence to anxiety assessment, preoxygenation before suctioning, and informing relatives also demonstrated clinically meaningful increases exceeding 25%.

Post-intervention, all domains achieved high best-practice adherence, with final rates ranging from 51.4% (tidal volume knowledge) to 88.6% (anxiety recognition), and several domains surpassed 80%. Visual inspection reveals tightly grouped confidence intervals, indicating robust and consistent effect sizes. The concurrent trends of substantial absolute improvement and sustained high post-intervention performance

underscore the comprehensive impact of nurse-led education on both theoretical knowledge and bedside application in ICU ventilator management

DISCUSSION

The findings of this quasi-experimental study demonstrate that a structured, nurse-led educational intervention can produce substantial improvements in both the knowledge and clinical practice of ICU nurses regarding ventilator modes. The statistically significant gains in post-intervention test scores highlight the effectiveness of targeted training programs in closing critical knowledge gaps and elevating practice standards in intensive care settings. These results are consistent with a growing body of literature that underscores the value of education as a catalyst for enhanced patient safety and outcomes in critical care environments (3,5,17). The observed pre-intervention deficits—particularly in key domains such as ventilator parameter recognition, alarm interpretation, and essential practical procedures—are in line with previous investigations that report widespread deficiencies among ICU nurses, especially in resource-limited contexts (13,21).

Comparative analysis with existing studies further reinforces the significance of the current findings. For example, Mohamed et al. (2019) documented similar improvements in knowledge and practical skills following a structured educational program, with post-intervention knowledge rising from 44% to 84% and clinical practice from 38% to 90% (17). Likewise, Sharma et al. (2018) and Guilhermino et al. (2018) identified education as a key determinant of competency in mechanical ventilation, demonstrating sustained positive effects on nurses' clinical decision-making and patient management (16,19). Notably, the present study adds to this literature by showing high post-intervention retention of knowledge and skill over a short-term period, suggesting that well-designed, contextually relevant training sessions can produce rapid and meaningful improvements even in settings with limited prior exposure to mechanical ventilation protocols. The only partial or negative trend observed—specifically, the modest decline in adherence to ventilator care bundle practices and routine cuff pressure monitoring—aligns with reports that certain clinical habits may be resistant to change or require ongoing reinforcement to achieve uniform compliance (23). This highlights the need for continuous quality improvement and regular retraining as core elements of ICU nurse education. Mechanistically, the improvements observed can be attributed to the integration of theory with practical, hands-on learning, which likely facilitated better retention and transfer of knowledge to clinical tasks. The nurse-led format may have enhanced peer learning, confidence, and relevance, supporting previous calls for more collaborative and interactive educational models in critical care (22). Importantly, the translation of knowledge gains into better clinical practice—including increased frequency of endotracheal suctioning, preoxygenation, and the timely recognition of patient anxiety—holds significant implications for patient safety and the prevention of ventilator-associated complications. These clinical improvements are directly relevant to current ICU standards, as they align with best practices for minimizing adverse outcomes and improving the quality of care for mechanically ventilated patients (4,14,20). The positive trends also have broader institutional significance, offering a scalable and evidence-based model for ongoing staff development in critical care units.

Despite its strengths, including complete data retention, standardized intervention delivery, and the use of validated assessment tools, the study is not without limitations. The single-center design and exclusive inclusion of female BSN nurses limit the generalizability of the results to wider or more diverse nursing populations. The relatively small sample size, dictated by the unit staffing structure, further constrains the external validity of the findings, while the absence of a control group precludes definitive causal inference. Moreover, the short follow-up period, focused on immediate post-intervention assessment, leaves unanswered questions regarding long-term knowledge retention and real-world impact on patient outcomes. Future research should aim to replicate these findings in larger, multi-center cohorts with diverse nurse demographics and include long-term follow-up assessments to evaluate sustained knowledge and practice changes. Additionally, mixed-methods studies incorporating qualitative feedback could further elucidate barriers to practice adoption and inform the design of more robust educational interventions.

Overall, this study contributes to the growing consensus that regular, structured education—especially when nurse-led and tailored to local needs—can play a critical role in raising the standards of critical care nursing. Ongoing investment in evidence-based education, institutional support for continuing professional development, and integration of interprofessional learning opportunities are recommended to maximize and sustain these gains in practice.

CONCLUSION

This study demonstrates that a nurse-led educational intervention significantly improves both the knowledge and practical competencies of ICU nurses regarding ventilator modes, effectively bridging critical gaps in clinical practice and preparedness. These findings highlight the value of structured, context-specific training in empowering nursing staff to deliver safer, more effective care for mechanically ventilated patients, thereby enhancing patient outcomes in intensive care settings.

The results advocate for the integration of regular, evidence-based educational programs into nursing curricula and ongoing professional development, while also underscoring the need for future research to evaluate the long-term retention of knowledge and its direct impact on clinical outcomes across diverse healthcare environments.

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