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ENHANCING VENTILATOR-ASSOCIATED PNEUMONIA PREVENTION BUNDLE COMPLIANCE: AN EVIDENCE-BASED INTERVENTION

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Abstract

Background: *Ventilator-Associated Pneumonia (VAP) is a significant healthcare-associated infection in intensive care units (ICUs), leading to increased morbidity, mortality, and healthcare costs. Adherence to evidence-based VAP prevention strategies, particularly by nursing staff, plays a crucial role in reducing its incidence.*

Objectives: *This study evaluates the knowledge of nurses in preventing VAP in ICU settings by assessing their adherence to VAP care bundle practices before and after an educational intervention.*

Methodology: *A quasi-experimental pre- and post-intervention study was conducted at Rawal General and Dental Hospital and Holy Family Hospital. A total of 63 registered nurses participated. The intervention consisted of structured training sessions focusing on VAP prevention strategies. Data on nurses' knowledge and adherence to VAP care bundle practices were collected using structured questionnaires and checklists before and after the intervention. Data were analysed by using SPSS version 27, employing descriptive and inferential statistics.*

Results: *There was a notable improvement in the overall adherence to ventilator-associated pneumonia (VAP) preventive procedures after the intervention. Overall, there was a 16.2% improvement in adherence, with the average pre-intervention adherence for all practices examined being 66.5% and rising to 82.7% post-intervention. This improvement shows how well the intervention worked to improve adherence to research-based VAP preventive techniques.*

Conclusion: *The study highlights the critical role of continuous education and training programs in improving nurses' adherence to VAP prevention protocols. Implementing structured educational interventions can significantly enhance patient safety and reduce the burden of VAP in ICU settings. Further research is recommended to assess the long-term sustainability of these improvements.*

INTRODUCTION

Ventilator Associated Pneumonia is a common and challenging respiratory infection that mostly affects patients using Mechanical Ventilation in critical care units. VAP is defined as a pulmonary parenchymal infection that develops at least 48 hours after mechanical breathing via endotracheal intubation, with the first day being the day the ventilator is installed. It is responsible for approximately one-third of all nosocomial pneumonia cases in intensive care units.(Al-Tamimi et al., 2023). VAP prolongs mechanical ventilation, leading to longer hospital stays, higher healthcare expenses, and increased morbidity and mortality among critically ill patients.(Kharel et al., 2021). VAP risk factors include reintubation, use of proton pump inhibitors, enteral nutrition, and thoracostomy tubes.(Jeengar et al., 2024).

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VAP and Ventilator Care Bundles are crucial in critical care. These bundles include head elevation (30–45°), sedation breaks, pressure ulcer and thrombosis prevention, and oral hygiene. Nurses are essential in their implementation due to their bedside presence.(De Melo et al., 2021). Combining evidence-based practices in the Ventilator-Associated Pneumonia (VAP) Bundle reduces VAP incidence. The bundle includes: 1) head elevation to 45° if hemodynamically stable, or >30° if not; 2) daily extubation readiness assessment; 3) endotracheal tubes with subglottic secretion drainage; 4) oral care with chlorhexidine; and 5) early enteral nutrition within 24–48 hours of ICU admission. (Mastrogianni et al., 2023).

Nurse compliance is crucial for VAP bundle success. Some tasks, like head elevation and oral care, are nurse-led, while others, such as extubation prep and early nutrition, are delegated. Though not part of the VAP bundle, proper hand hygiene helps prevent ICU-acquired infections, including VAP. (Chernet et al., 2020). The care bundle approach reduces VAP incidence and complications. It combines interventions to prevent ventilator-related issues. Medical studies strongly recommend its use for VAP prevention.(Alecrim et al., 2019). Preventing VAP is the most cost-effective strategy. Key measures include minimizing intubations and hypnotics, daily breathing and awakening trials, fluid management, transfusion thresholds, low-tidal volume ventilation, and early mobilization. (Alhamad & Elsayed, 2024).

The bundle strategy is key to preventing VAP in neonates. It involves simultaneous interventions, checklists, and operational tools. Evidence supports its effectiveness, especially when combined with NICU nurse training. (Abiramalatha et al., 2021).

Regular collaborative training ensures key personnel's proficiency with the VAP bundle, addressing high nurse turnover.(Abad et al., 2021). The Institute for Healthcare Improvement Ventilator Bundle, with proper cuff pressure and subglottic suctioning, effectively reduces VAP. A successful approach includes multidisciplinary efforts, education, and compliance monitoring. (Mastrogianni et al., 2023). Severe VAP cases and high infection rates in resource-limited nations require continuous local evaluation and education on prevention strategies. (Pinilla-González et al., 2021). Surveys show resource-limited countries need ongoing review and education on VAP prevention due to high infection risks and severe consequences. (Bankanie et al., 2021).

Literature review:

In Pakistan, the prevalence of VAP in children was 17%, whereas in adults, it was 13.5%. Worldwide, the prevalence of pneumonia linked to ventilator use is 12.6%, 13.5% in the United States, 19.4% in Europe, 13.8% in Latin America, and 16% in South Asia. (Aziz et al., 2020). The duration of mechanical ventilation directly impacts the risk for developing VAP. A wide range of VAP development rates from 30 to 70% and VAP-related mortality rates between 8 to 33% exist in intensive care units. Medical research indicates VAP typically leads patients to need mechanical ventilation duration expansions by 7.6 to 11.5 days and extends their overall hospital stay durations. The additional expense per episode reaches up to 40000 USD.(Da Rocha Gaspar et al., 2023). Health organizations and societies like the Centre for disease and prevention and the European Centre for Disease Prevention and Control have been working to establish and update evidence-based guidelines and strategies that have significantly improved outcomes and the incidence of VAP.(Klompas et al., 2022).

VAP is a prevalent nosocomial infection in ICUs, with infection rates ranging from 6% to 52%, and in some cases as high as 76%. It is the major cause of morbidity, mortality, and higher management expenses in ICUs. VAP affects 9% to 27% of people who require assisted ventilation worldwide and is the major cause of death. VAP usually emerges within 2-3 days of receiving an endotracheal tube and mechanical ventilation. (Azizullah et al., 2022). Nurse compliance is the extent to which a nurse's actions follow the rules set forth by the hospital where they work or by the nurse leader. Compliance may be impacted by a variety of factors, such as education, age, environment, social situation, customs, interactions, knowledge, attitude, and more (Vaismoradi et al., 2020).

Aspirating contaminated fluids into the lungs is the most common cause of ventilator-associated pneumonia (VAP). This is because endogenous microbes enter the lung through the colonized naso/oropharynx, tracheal secretions, and the gastric fluid pool. Furthermore, extrinsic sources such biofilms on ventilator circuits, endotracheal tubes (ETTs), and caregiver hands might allow microorganisms to enter the lungs.(Osman et al., 2020). Despite the correction of dependent factors, the chance of having VAP decreased significantly. The protective effects of the preventive bundle differed from our multivariate analysis, which revealed that male patients had an increased risk of VAP. According to research, male sex is a recognized risk factor for VAP development. (Mogyoródi et al., 2023). As these infections occur often in this population, nurses must prioritize VAP when performing membrane ventilation.

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Multiple studies demonstrating how VAP generates pricing that increase healthcare costs, elongates hospitalization periods, and resulting in more patient fatalities.(Aloush & Al-Rawajfa, 2020b). The effectiveness of bundle implementation is dependent on strict on-site commitment to all interventions within the framework. The outcomes of research studies on bundle compliance rates range from 16.2% to 90%. Investigators conducted these investigations, along with educational programs for subjects in find cases.(Leong et al., 2024). Our study examined the impact of VAP bundle adherence on VAP rates. Challenges included inadequate data collection, a small control group, a short study period, and ineffective chart reviews. Despite this, the data helped assess the benefits of bundled care. (Wolfensberger et al., 2020).

Materials and Methodology

Study Design and Duration:

The quasi experiment pre and post interventional study was conducted with repeated measurements to evaluate the knowledge of nurses on ventilator associated pneumonia (VAP). The study was conducted at a tertiary care hospital ICU in Rawal General and Dental Hospital and Holy Family Hospital. The study was conducted from 6 Feb 2025 to April 2025 and target population was registered nurses in all Intensive Care Units. Non-probability Purposive Sampling was utilized. The population in this study was 75 nurses and the sample was determined to be 63 nurses with the known sample calculation by using Slovin's Formula n=N/1+Ne2. Nurses included in our study who have experience of six months or more in Intensive Care Units.

Data collection Tool:

The data was collected through pre validated tool, allowing respondents to complete it independently. Before gathering data, the participants were briefly informed of the study. Most participants took approximately 20-30 minutes to complete the questions. The level of knowledge of VCB was measured using the questionnaire developed by (Hussein et al., 2023). The questionnaire consisted of 20 items in English. Demographic section included Age, gender, year of study, previous clinical experience. Knowledge Assessment Section was based on Multiple choice questions based on Nursing Care Bundle for the prevention of Ventilator Associated Pneumonia including hand hygiene, and risk identification. The pre validated questionnaires had good internal reliability with a Cronbach alpha of 0.7819. (Hussein et al., 2023).

A pre-test was administered before to intervention to assess nurses' understanding of VAP care bundles, and after washed out period, we conducted a teaching session based on ppts of the standard VAP bundle of care.

Training Session:

All the participants attended a 30-minute lecture based on presentation(ppt) of the standard VAP bundle of care. The total duration of the training session was 30minutes (5minutes introduction, 10minutes scenarios, and 15minutes VAP bundle protocols). Each session began with a brief introductory session, explanation about the protocols.

After 6 weeks washed out period of intervention, a post-test was given to nurses to assess their knowledge of VAP care bundles.

Ethical consideration:

Ethical approval was obtained from the Institutional Review Board (IRB) Rawal Institute of Health Sciences Islamabad (RIHS /IRB/02/2025). Participants had their consent confirmed before the study began with an additional assurance of their right to withdraw at any time. The project protected data confidentiality by securely storing information and through anonymization methods.

Statistical Analysis:

Data were analysed by using software SPSS version 27. Qualitative variables which include gender, education, and experience were expressed as frequency and percentage and were analysed using the chi-square test as applicable. Pre- and post-intervention comparison was performed utilizing the Paired T-test. Continuous variables which include age and knowledge scores were expressed as mean, standard deviation, and median.

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Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	20-24	10	15.9	15.9	15.9
	25-29	25	39.7	39.7	55.6
	30-34	24	38.1	38.1	93.7
	35-39	4	6.3	6.3	100.0
	Total	63	100.0	100.0	

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	18	28.6	28.6	28.6
	Female	45	71.4	71.4	100.0
	Total	63	100.0	100.0	

Results:

In this study, a total of 63 registered nurses participated of which 18 (28.6%) were males and 45 (71.4) were female. The average age of the participants was 25-29 (39.7%) with ages ranging from 20-39 years. Most participants worked in the Neonatal Intensive Care Unit (N=24, 38.1%) followed by the Medical Intensive Care Unit (N=23, 36.5%) and Surgical Intensive Care Unit (N=16, 25.4%). Regarding work experience, the average number of years of clinical experience was (N=39, 61.9%) of participants having more than 5 years of experience and (N=24, 38.1%) of participants was having less than 5 years of experience. Baseline demographic and other parameters are presented in ►Table 1.

Table 1. Demographic characteristics of participants

Unit type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MICU	23	36.5	36.5	36.5
	SICU	16	25.4	25.4	61.9
	NICU	24	38.1	38.1	100.0
	Total	63	100.0	100.0	

Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 5 years	24	38.1	38.1	38.1
	More than 5 years	39	61.9	61.9	100.0
	Total	63	100.0	100.0	

Participants completed the recommended route of intubating a patient, the mean pretest score was 1.6667 (SD=0.80322) and the mean posttest score was 1.6349 (SD=0.86699). The subscale on route of intubation in Qn. 1 decreased the risk of VAP, the mean pre-test score was 2.0000 (SD=0.93326) and the mean post-test was 1.8889 (SD=0.11758). The subscale on disposes a suction catheter, the mean pre-test score was 1.7460 (SD=0.62135) and the mean post-test score was 1.4444 (SD=0.81869). The subscale of recommendation to change humidifiers, the mean pre-test score was 1.8571 (SD=0.66858) and the mean post-test score was 1.4921 (SD=0.64441). The subscale of Insertion of the suction catheter into the Endotracheal tube, the mean pre-test score was 1.8889 (SD=0.76435) and the mean post-test score was 1.2381 (SD=0.42934). The subscale on bedside equipment with antiseptic should be done, the mean pre-test score was 1.7143 (SD=0.68223) and the mean post-test score was 1.6190 (SD=0.65816). The subscale head of the bed elevation range, the mean pre-test score was 2.0794 (SD=0.72516) and the post-test score was 2.5079 (SD=0.69266). The subscale of a nurse caring a

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ventilated patient is required to wear sterile gloves, the mean pre-test score was 1.9206 (SD=0.72516) and the mean post-test score was 2.3016 (SD=0.85449). The subscale on level of handwashing, the mean pre-test score was 2.2540 (SD=0.82243) and the mean post-test score was 2.2857 (SD=0.86934). Analysis of the subscale to perform oral care, the mean pre-test score was 1.6984 (SD=0.75423) and the post-test score was 1.8571 (SD=0.64401). The subscale on prolonged use of stress ulcer prophylaxis, the mean pre-test score was 2.3016 (SD=0.83540) and the mean post-test score was 2.0952 (SD=0.68895). The subscale figuring maintenance of a high nurse to patient ratio, the mean pre-test score was 1.8889 (SD=0.69818) and the mean post-test score was 1.9206 (SD=0.37251). The subscale on continuous education on prevention of nosocomial infection, the mean pre-test score was 2.0317 (SD=0.82243) and the mean post-test score was 2.0000 (SD=0.50800). The subscale to perform chest physiotherapy, the mean pre-test score was 1.9206 (SD=0.76836) and the mean post-test score was 1.6508 (SD=0.76535). the subscale on adjustable vs. non-adjustable beds, the mean pre-test score was 2.4127 (SD=0.68709) and the mean post-test score was 2.3016 (SD=0.71018). The subscale of ETT suctioning done, the mean pre-test score was 1.8730 (SD=0.68373) and the mean post-test score was 1.9683 (SD=0.62135). Analysis of a subscale of early weaning, the mean pre-test score was 1.7460 (SD=0.89746) and the mean post-test score was 1.5079 (SD=0.71556). The subscale on over feeding a ventilated patient, the mean pre-test score was 1.6032 (SD=0.68485) and the mean post-test score was 1.3651 (SD=0.57646). The subscale on maintenance of adequate cuff pressure, the mean pre-test score was 2.0794 (SD=0.93845) and the mean post-test score was 1.6825 (SD=0.83907). Analysis of the subscale on extubating the patient, the mean pre-test score was 1.8571 (SD=0.87726) and the mean post-test score was 1.5079 (SD=0.73776).

Table 2.
Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Which route is best recommended when intubating a patient	1.6667	63	.80322	.10120
	Post-Which route is best recommended when intubating a patient	1.6349	63	.86699	.10923
Pair 2	Pre-The recommended route of intubation in Qn. 1 decreases the risk of VAP because	2.0000	63	.93326	.11758
	Post-The recommended route of intubation in Qn. 1 decreases the risk of VAP because	1.8889	63	.65034	.08193
Pair 3	Pre-A nurse is required to dispose a suction catheter	1.7460	63	.62135	.07828
	Post-A nurse is required to dispose a suction catheter	1.4444	63	.81869	.10315
Pair 4	Pre-It is recommended to change humidifiers	1.8571	63	.66858	.08423
	Post-It is recommended to change humidifiers	1.4921	63	.64441	.08119

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Pair 5	Pre-Insertion of the suction catheter into the Endotracheal tube	1.8889	63	.76435	.09630
	Post-Insertion of the suction catheter into the Endotracheal tube	1.2381	63	.42934	.05409
Pair 6	Pre-Dusting of respiratory and bedside equipment with antiseptic should be done	1.7143	63	.68223	.08595
	Post-Dusting of respiratory and bedside equipment with antiseptic should be done	1.6190	63	.65816	.08292
Pair 7	Pre-Head of the bed elevation should be ranging from	2.0794	63	.72516	.09136
	Post-Head of the bed elevation should be ranging from	2.5079	63	.69266	.08727
Pair 8	Pre-A nurse caring a ventilated patient is required to wear sterile gloves during	1.9206	63	.72516	.09136
	Post-A nurse caring a ventilated patient is required to wear sterile gloves during	2.3016	63	.85449	.10766
Pair 9	Pre-A nurse caring a ventilated patient is required to wash hands	2.2540	63	.82243	.10362
	Post-A nurse caring a ventilated patient is required to wash hands	2.2857	63	.86934	.10953
Pair 10	Pre-It is recommended to perform Oral care by using a swab moistened with mouth wash and water	1.6984	63	.75423	.09502
	Post-It is recommended to perform Oral care by using a swab moistened with mouth wash and water	1.8571	63	.64401	.08114
Pair 11	Pre-Prolonged use of Stress ulcer prophylaxis to a ventilated patient	2.3016	63	.83540	.10525
	Post-Prolonged use of Stress ulcer prophylaxis to a ventilated patient	2.0952	63	.68895	.08680
Pair 12	Pre-Maintenance of a high nurse to patient ratio in critical care setting is associated with	1.8889	63	.69818	.08796
	Post-Maintenance of a high nurse to patient ratio in critical care setting is associated with	1.9206	63	.37251	.04693

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Pair 13	Pre-Continuous education to ICU nurses on prevention of nosocomial infection is associated with	2.0317	63	.82243	.10362
	Post-Continuous education to ICU nurses on prevention of nosocomial infection is associated with	2.0000	63	.50800	.06400
Pair 14	Pre-It is recommended to perform chest physiotherapy due to the following reason	1.9206	63	.76836	.09680
	Post-It is recommended to perform chest physiotherapy due to the following reason	1.6508	63	.76535	.09643
Pair 15	Pre-Adjustable vs. non-adjustable beds	2.4127	63	.68709	.08657
	Post-Adjustable vs. non-adjustable beds	2.3016	63	.71018	.08947
Pair 16	Pre-ETT suctioning should be done to patient	1.8730	63	.68373	.08614
	Post-ETT suctioning should be done to patient	1.9683	63	.62135	.07828
Pair 17	Pre-Early weaning	1.7460	63	.89746	.11307
	Post-Early weaning	1.5079	63	.71556	.09015
Pair 18	Pre-Over feeding a ventilated patient is associated with	1.6032	63	.68485	.08628
	Post-Over feeding a ventilated patient is associated with	1.3651	63	.57646	.07263
Pair 19	Pre-During the care of ventilated patient maintenance of adequate cuff pressure	2.0794	63	.93845	.11823
	Post-During the care of ventilated patient maintenance of adequate cuff pressure	1.6825	63	.83907	.10571
Pair 20	Pre-Unplanned extubating is associated with increased risk of aspiration therefore	1.8571	63	.87726	.11052
	Post-Unplanned extubating is associated with increased risk of aspiration therefore	1.5079	63	.73776	.09295

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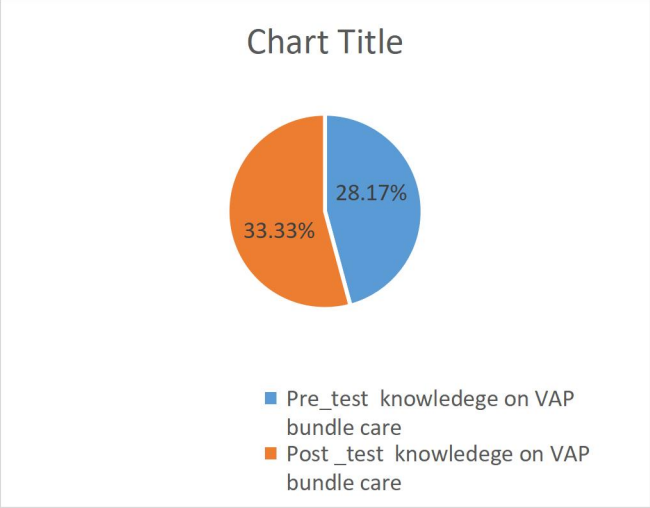

Discussion:

The findings of this study highlight the critical role of nurse compliance in the prevention of ventilator-associated pneumonia (VAP). VAP remains a significant concern in intensive care units (ICUs) due to its association with increased morbidity, prolonged hospital stays, and higher healthcare costs. The findings of this quasi-experimental study demonstrate that the training program considerably improved nurses' knowledge of ventilator-associated pneumonia (VAP) prevention. The pre-intervention knowledge evaluation determined that those taking part had an average knowledge of VAP risk factors, preventative measures, and evidence-based guidelines. However, post-intervention results revealed a major rise in knowledge evaluations, illustrating the effectiveness of constructed educational programs in improving VAP-related skills among nurses. The study from India has same findings. The results demonstrate a significant improvement in nurse compliance with prevention measures and a reduction in VAP incidence in the post-intervention phase. (Ravi Kumar Jeengar, 2021)

Those results correspond with previous investigations indicating the important role of constant training for professionals in preventing healthcare-associated illnesses. The same Indian study has discovered that training sessions highlighting VAP prevention practices, including as hand cleanliness, ETT care, and adequate head-of-bed elevation, result in enhanced adherence to preventive measures and better patient outcomes. The study emphasizes the critical significance of integrating formal educational institutions into typically nursing practice for the purpose to cover knowledge gaps and standardize care strategies. (Ravi Kumar Jeengar, 2021)

In order to demonstrate the beneficial effects of educational interventions on clinical characteristics and VAP rates, additional research may include observational studies of the nursing process as well as patient data on outcomes. The immediate evaluation of knowledge retention is another issue. It is unclear if these knowledge gains would endure over time, even though post-intervention tests revealed an immediate improvement.

Furthermore, this investigation concentrated a higher value on gaining information than on major developments in patient outcomes or practical activities. Although improved understanding is advantageous, potential research must involve initial observations, monitoring of compliance, and patient data (for example, VAP incidence rates, length of ICU stay) to figure out if educational interventions contribute to measurable improvements in the standard of care.

Conclusion:

The results show that knowledge scores significantly improved after the intervention, highlighting the significance of ongoing professional development in lowering the prevalence of VAP. Because nurses are the ones who carry out the VAP prevention bundle, improving their commitment to focused training can enhance patient outcomes and lower the frequency of healthcare-associated infections.

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Recommendations:

Ongoing education, compliance monitoring, and integration of VAP training into standard nursing practice are essential for infection control. Strict adherence to hand hygiene and infection control protocols further reduces pathogen transmission, and the use of endotracheal tubes with subglottic secretion drainage capabilities prevents secretion build up, a common cause of VAP. Studies have demonstrated that implementing these practices leads to a significant decline in VAP rates, improving patient outcomes and reducing hospital stays. Therefore, healthcare facilities should integrate these evidence-based measures into routine care to enhance patient safety and quality of care.

Conflict of interest:

This author declares no conflict of interest.

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