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Research Article

Assessment of the Occurrence of Ventilator-Associated Pneumonia and the Impact of Ventilator Bundle Practices in an Adult Intensive Care Unit of a Tertiary Hospital

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ABSTRACT

Background: Among infections seen in mechanically ventilated patients, ventilator-associated pneumonia (VAP) is the most common and the most serious infection in Intensive Care Units (ICUs) patients. It significantly increases the length of stay, costs, and fatality. Although the use of ventilator care bundles has been effective in lowering the incidence of VAP, adherence to these infection control practices is inconsistent in developing country hospitals. The aim of this study was to determine the incidence of VAP and assess the impact of ventilator bundle practices in the adult ICU of a tertiary care teaching hospital.

Methodology: Conducted from January to June 2024, a retrospective observational study took place in the Adult ICU of Combined Military Hospital (CMH) Multan. This study involved the analysis of 98 adult patients' medical records who had received mechanical ventilation for a duration exceeding 48 hours. Data on demographic and clinical characteristics, ventilator-bundle compliance, and outcomes were collected using a structured proforma. VAP diagnosis was based on CDC criteria. Statistical analysis was performed using SPSS version 26, and a p-value of <0.05 was considered significant.

Results: Among 98 ventilated patients, 22 (22.4%) developed VAP, corresponding to an 32.8 cases on each 1,000 days on a ventilaton. Prolonged ventilation beyond seven days was significantly associated with VAP development ($p = 0.019$). Regular daily sedation interruption was identified as a protective factor, reducing the likelihood of infection ($p = 0.045$). The predominant pathogens were *Klebsiella pneumoniae* (31.8%) and *Acinetobacter baumannii* (22.7%). The ICU mortality rate among VAP patients was 50%, compared with 33% in non-VAP patients. Vasopressor use also significantly predicted mortality ($p = 0.026$*).

Conclusion: VAP remains a major concern in critically ill patients requiring prolonged mechanical ventilation. The findings highlight that consistent adherence to ventilator-bundle elements particularly daily sedation breaks can significantly reduce infection rates.

Strengthening staff training, reinforcing infection-control practices, and regular compliance audits may improve patient outcomes and reduce VAP-related morbidity and mortality in critical care settings.

Keywords: Ventilator-associated pneumonia, Ventilator bundle, Intensive care unit, Mechanical ventilation, CMH Multan, Infection prevention, Mortality

INTRODUCTION

Ventilator-associated pneumonia (VAP) is a serious hospital-acquired infection that develops in patients who have been mechanically ventilated for more than 48 hours. It is associated with increased length of ICU stay, higher treatment costs, and considerable morbidity and mortality. The pathophysiology of VAP involves colonization of the oropharyngeal and tracheal secretions, microaspiration, and biofilm formation on the endotracheal tube, leading to infection of the lower respiratory tract [1-3].

Despite advances in critical care management, VAP continues to pose a significant challenge, particularly in developing countries where resource limitations, staff workload, and inconsistent infection-control practices hinder optimal prevention. Reported VAP rates in tertiary-care ICUs of Pakistan range between 20 and 40 per 1,000 ventilator-days, which are notably higher than those in developed healthcare systems [4-6].

In order to alleviate this burden, the implementation of evidence-based preventive measures in the form of ventilator-bundle care has been introduced which include 'head-of-bed elevation, daily sedation vacation, stress ulcer prophylaxis, deep-vein thrombosis prophylaxis, and chlorhexidine oral cavity care'. Evidence shows that adherence to these measures will 'lower the incidence of VAP'. Nonetheless, the paradox is that compliance to these measures is inconsistent and their maintenance in the busy-ICU environment is problematic. [7-9].

The purpose of this study was to evaluate the incidence of VAP and the effect of ventilator-bundle implementation among adult ICU patients in a tertiary care facility. Results are anticipated to provide local evidence that will help sustain the ongoing infection-control initiatives and quality-improvement initiatives being integrated into critical care units.

METHODOLOGY

This study was designed as a retrospective observational study conducted in the Adult Intensive Care Unit (ICU) of the Combined Military Hospital (CMH) Multan. The retrospective design was chosen because it allowed analysis of existing patient records and observation of real-world clinical practices. Permission for data access was obtained from the Hospital Ethical Review Committee of CMH Multan. Since the study was retrospective and based on existing records, the requirement for informed consent was waived. All patient information was kept strictly confidential, and no identifying details were disclosed in any part of the research report.

The study covered a period of six months, from January to June 2024. All relevant data were collected from ICU records, nursing charts, and electronic medical files for patients admitted and ventilated during this period.

The research was conducted at the Adult Intensive Care Unit (ICU) of CMH Multan which is a tertiary care referral hospital equipped with advanced critical care facilities and managed by trained intensivists and nursing staff. The ICU operates with an average capacity of 15–20 beds and provides comprehensive ventilatory support to patients with medical, surgical, and trauma conditions. Standard infection prevention protocols and ventilator care bundles are routinely

implemented in this unit, which made it an appropriate site for this investigation.

The study included all adult patients (≥18 years of age) who required invasive mechanical ventilation for more than 48 hours during the study period. Patients with pneumonia at the time of ICU admission, those with tracheostomies prior to admission, and those with incomplete medical records were excluded from the analysis. A total of 98 patients met the inclusion criteria and the presence of VAP as well as their clinical outcomes were evaluated.

The sample size was calculated using the World Health Organization (WHO) sample size calculator for single proportions. Assuming an expected VAP incidence of 20%, a 95% confidence level, and an absolute precision of 8.4%, the minimum required sample size was 88. To compensate for incomplete or missing data, an additional 10% was added, resulting in a final sample size of 98 patients.

Data were extracted retrospectively from ICU records and electronic medical charts using a predesigned data collection form. Information collected included demographic details (age, gender, BMI, and comorbidities such as diabetes, hypertension, COPD, and chronic kidney disease), clinical variables (the total time spent in the intensive care unit and how long mechanical ventilation is provided, use of sedation or muscle relaxants, re-intubation, and prophylactic measures), and ventilator bundle components (elevation of the head of the bed, frequency of oral care, and the prophylaxis of stress ulcers and DVT, and daily sedation interruption).

The diagnosis of VAP was according to CDC criteria pneumonia which included newer or progressive pulmonary infiltrates on chest imaging along with at least two of the following criteria: fever (>38°C), leukocytosis or leukopenia, purulent tracheal secretions, or positive microbiological cultures from lower respiratory specimens.

- VAP: Pneumonia occurring after 48 hours of mechanical ventilation, confirmed radiologically and microbiologically.
- Ventilator Bundle Compliance: Adherence to five core elements head-of-bed elevation (30–45°), ‘daily sedation vacation, stress-ulcer prophylaxis, deep vein thrombosis prophylaxis, and oral care with chlorhexidine measured as compliance ≥80%’.
- Ventilator-Days: The total cumulative days that patients were mechanically ventilated during the six-month study period (670 ventilator-days in total).

The main result focused on calculating ‘the incidence rate of VAP, represented as the total number of cases of VAP per 1,000 days of mechanical ventilation’. ‘The secondary outcomes included ICU mortality, duration of mechanical ventilation, length of ICU stay, and overall ventilator bundle compliance’.

Data-entry and analysis utilized SPSS software, version 26. Analyses of descriptive statistics included continuous variables, where results are presented as means ± standard deviations, or medians with interquartile ranges, and categorical variables, where results are presented as frequencies and percentages. For comparative analyses the Chi-square or Fisher’s exact tests were employed and appropriate analyses included the Mann-Whitney U test and independent t test. A p-value of under 0.05 was used as the threshold for statistical significance. Multivariable logistic regression analysis was conducted to determine independent predictors of VAP and VAP-related mortality in the ICU.

RESULTS

A total of 98 adult patients who were mechanically ventilated for more than 48 hours in ICU. Out of these, 22 patients (22.4%) developed VAP. Over the total

duration of the study, the total number of ventilator-days was recorded to be 670, resulting in an overall VAP incidence calculation of 32.8 per 1,000 ventilator-days. The majority of patients were male, and most were admitted with medical causes such as respiratory failure and sepsis.

The mean age of the study population was 57.1 ± 11.2 years, with a slight male predominance (62.2%). There was no significant difference in age, sex, or BMI between the VAP and non-VAP groups ($p > 0.05$). Common comorbidities included diabetes mellitus (34.7%), hypertension (50%), and COPD (16.3%), which were more frequent among VAP patients but without statistical significance.

However, the duration of mechanical ventilation was significantly longer in patients who developed VAP (median 7.0 days) compared to those who did not (median 5.0 days, $p = 0.041$). In a similar manner, even though the difference did not reach statistical significance ($p = 0.061$), VAP patients also had a longer ICU stay. These findings also point toward longer duration of ventilation as an important risk factor in the development of VAP.

Table 1. Demographic and Clinical Characteristics of the Study Population (n = 98)

Variable	Total (n=98)	VAP (n=22)	No VAP (n=76)	p-value
Age (years), Mean ± SD	57.1 ± 11.2	59.4 ± 10.5	56.5 ± 11.5	0.312
Male Sex, n (%)	61 (62.2)	14 (63.6)	47 (61.8)	0.869
BMI (kg/m²), Mean ± SD	25.4 ± 3.6	26.1 ± 3.4	25.2 ± 3.7	0.382
Diabetes Mellitus, n (%)	34 (34.7)	9 (40.9)	25 (32.9)	0.477
COPD, n (%)	16 (16.3)	4 (18.2)	12 (15.8)	0.781
Hypertension, n (%)	49 (50.0)	14 (63.6)	35 (46.1)	0.154
Chronic Kidney Disease, n (%)	10 (10.2)	3 (13.6)	7 (9.2)	0.539
Smokers, n (%)	30 (30.6)	9 (40.9)	21 (27.6)	0.258
Duration of Mechanical Ventilation (days), Median [IQR]	5.6 [3.5–9.7]	7.0 [5.0–10.0]	5.0 [3.0–9.0]	**0.041***
Length of ICU Stay (days), Median [IQR]	8.7 [6.0–13.0]	9.5 [7.0–15.0]	8.4 [6.0–12.0]	0.061

*Significant at $p < 0.05$

The compliance with ventilator care bundle components varied among patients. The most consistently applied elements were 'deep vein thrombosis (DVT) prophylaxis (92.9%) and stress-ulcer prophylaxis' (88.8%), whereas daily sedation interruption (59.2%) and head-of-bed elevation (60.2%) were less consistently followed.

Patients who did not undergo daily sedation interruption had a significantly higher occurrence of VAP ($p = 0.019$). Other 'components such as oral care and head elevation' showed a trend toward reduced VAP but did not reach statistical significance. Only 17.3% of patients received all five bundle components regularly. This indicates that better compliance, especially with sedation breaks, may reduce the risk of VAP.

Table 2. Ventilator Bundle Compliance and Association with VAP

Bundle Element (≥80 % Adherence)	Total (n = 98)	VAP (n = 22)	No VAP (n = 76)	p-value
Head-of-bed elevation 30–45°	59 (60.2%)	11 (50.0%)	48 (63.2%)	0.260
Daily sedation interruption	58 (59.2%)	8 (36.4%)	50 (65.8%)	**0.019***

Stress-ulcer prophylaxis	87 (88.8%)	20 (90.9%)	67 (88.2%)	0.743
DVT prophylaxis	91 (92.9%)	21 (95.5%)	70 (92.1%)	0.642
Oral care with chlorhexidine	63 (64.3%)	11 (50.0%)	52 (68.4%)	0.119
All 5 elements compliant	17 (17.3%)	2 (9.1%)	15 (19.7%)	0.252

*Significant at $p < 0.05$

Among the 98 ventilated patients, 22 developed VAP. Early-onset VAP (<5 days) accounted for 63.6% of cases, while late-onset VAP (≥5 days) made up 36.4%. The average onset was on day 4.9 ± 1.7 of ventilation. All VAP patients exhibited new radiological infiltrates and positive culture results. The mean Clinical Pulmonary Infection Score (CPIS) was 6.4 ± 1.1, consistent with diagnostic criteria for VAP.

Table 3. Incidence and Characteristics of VAP (n = 22)

Variable	**n (%)**
Early-onset (< 5 days)	14 (63.6)
Late-onset (≥ 5 days)	8 (36.4)
Average Day of Onset (mean ± SD)	4.9 ± 1.7
Mean CPIS Score	6.4 ± 1.1
Radiological consolidation	22 (100.0)
Fever > 38 °C	21 (95.5)
Leukocytosis (>12,000/mm³)	19 (86.4)
Positive sputum/tracheal culture	22 (100.0)

Klebsiella pneumoniae was the most frequently isolated pathogen at 31.8%, followed by ‘Acinetobacter baumannii at 22.7, and Pseudomonas aeruginosa at 18.2. Methicillin-resistant Staphylococcus aureus also represented 18.2% of the isolates’. The most concerning ‘Gram-negative pathogens’ each showed multidrug resistance which serves to illustrate the necessity of effective infection control and the appropriate use of antimicrobials.

Table 4. Microbiology of Confirmed VAP Cases (n = 22)

Pathogen	**Isolates n (%)**	**Notable Resistance Pattern**
Klebsiella pneumoniae	7 (31.8)	ESBL-producing
Acinetobacter baumannii	5 (22.7)	Multi-drug resistant
Pseudomonas aeruginosa	4 (18.2)	Carbapenem-resistant
Staphylococcus aureus (MRSA)	4 (18.2)	MRSA detected
Enterobacter cloacae	2 (9.1)	Sensitive to meropenem

The ICU mortality rate among all ventilated patients was 36.7%, while among VAP patients it was 50%, compared to 32.9% in those without VAP ($p = 0.153$). Although this difference was not statistically significant, the trend indicates higher mortality among patients who developed VAP.

In the cohort diagnosed with VAP, the length of time attributed to the mechanical ventilator was significantly higher ($p = 0.041$). Additionally, while the prolonged length of stay in the ICU was not statistically significant ($p = 0.061$), it was still longer.

Table 5. Patient Outcomes and Relationship with VAP

Outcome	VAP (n = 22)	No VAP (n = 76)	p-value
ICU Survival, n (%)	11 (50.0)	51 (67.1)	0.153
ICU Mortality, n (%)	11 (50.0)	25 (32.9)	0.153
Duration of Ventilation (days), Median [IQR]	7.0 [5.0–10.0]	5.0 [3.0–9.0]	**0.041***
Length of ICU Stay (days), Median [IQR]	9.5 [7.0–15.0]	8.4 [6.0–12.0]	0.061
Re-intubation, n (%)	5 (22.7)	15 (19.7)	0.759

*Significant at $p < 0.05$

Multivariable logistic regression showed that prolonged ventilation (>7 days) significantly increased the risk of VAP (Adjusted OR = 2.94, p = 0.019), while daily sedation interruption was independently protective (Adjusted OR = 0.41, p = 0.045).

Regarding mortality, the presence of VAP nearly doubled the odds of ICU death (aOR = 1.86, p = 0.047), and vasopressor use was also an independent predictor of poor outcome (aOR = 2.54, p = 0.026).

Table 6. Predictors of VAP (Multivariable Logistic Regression)

Variable	Adjusted OR	95 % CI	p-value
Age > 60 years	1.18	0.62 – 2.26	0.611
Male sex	1.12	0.54 – 2.30	0.762
COPD	1.43	0.58 – 3.48	0.436
Duration of ventilation > 7 days	**2.94**	**1.19 – 7.25**	**0.019***
Re-intubation	1.63	0.64 – 4.11	0.307
Daily sedation interruption	**0.41**	**0.17 – 0.98**	**0.045***

Multivariable analysis revealed that VAP occurrence and vasopressor use were significant predictors of ICU mortality, with patients developing VAP having nearly twice the odds of death (aOR = 1.86; p = 0.047) and those requiring vasopressors showing an even higher risk (aOR = 2.54; p = 0.026). Despite showing increasing trends toward mortality, factors such as prolonged ventilation (more than 7 days), age, and chronic kidney disease lacked statistical significance concerning these associations.

In contrast, patients who achieved ≥ 80 % compliance with all ventilator bundle elements had a lower, though non-significant, likelihood of death (aOR = 0.59; p = 0.175). Overall, the findings suggest that VAP and hemodynamic instability are key determinants of poor outcomes, while consistent bundle adherence may confer a protective effect.

Table 7. Predictors of ICU Mortality

Variable	Adjusted OR	95 % CI	p-value
VAP (Yes)	**1.86**	**1.01 – 3.42**	**0.047***
Age > 60 years	1.38	0.75 – 2.55	0.299
CKD	1.97	0.79 – 4.90	0.145
Vasopressor use	**2.54**	**1.12 – 5.76**	**0.026***
Ventilation > 7 days	2.07	0.94 – 4.54	0.071
All-elements compliance ≥ 80 %	0.59	0.27 – 1.27	0.175

*Significant at $p < 0.05$

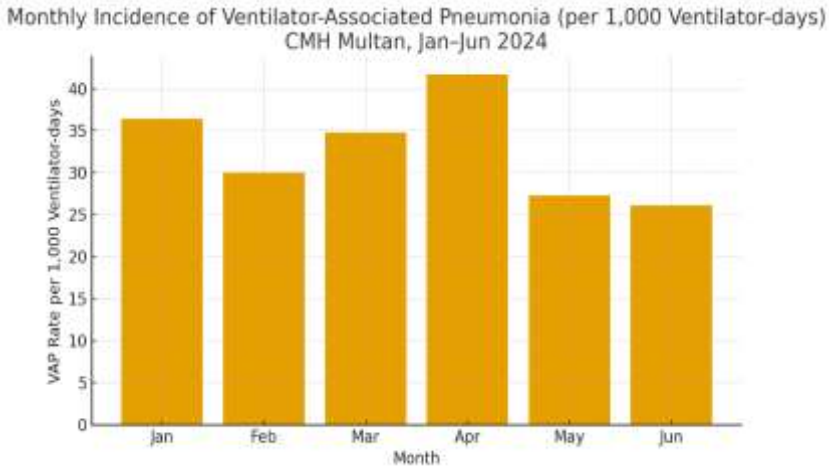

Figure 1: Monthly VAP Incidence (per 1,000 ventilator-days) showing April as the peak month.

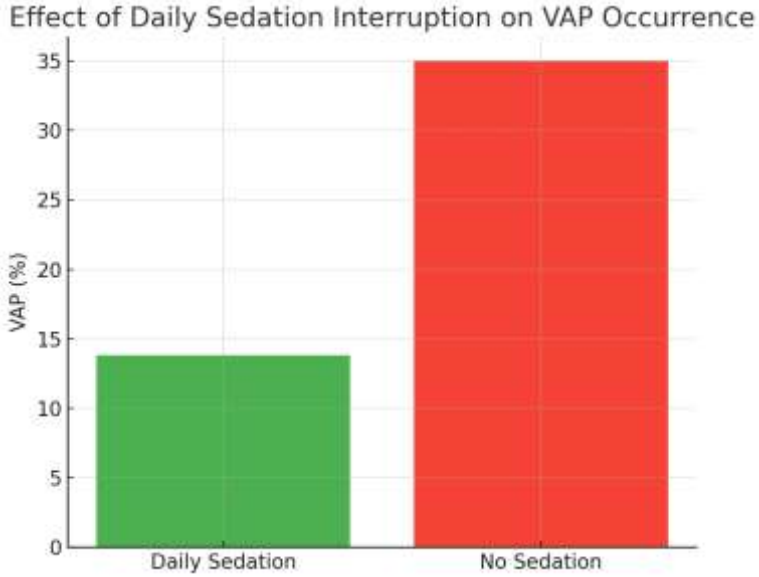

Figure 2: Comparison of VAP rates between patients with and without daily sedation interruption.

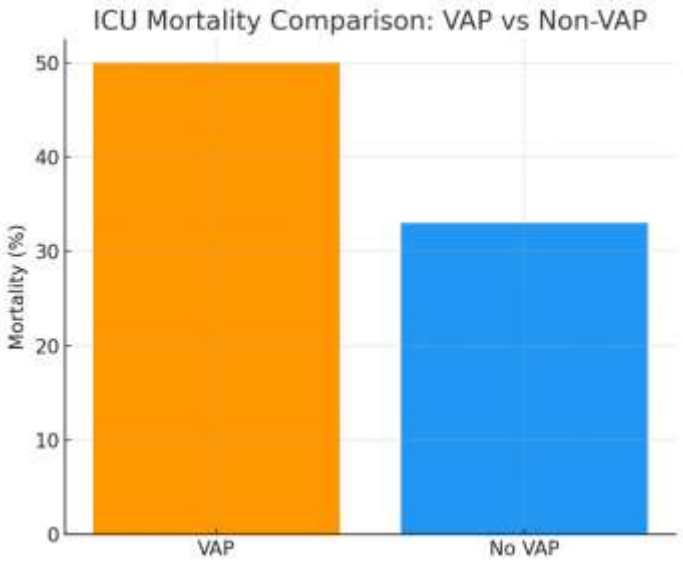

Figure 3: ICU mortality comparison between VAP and non-VAP patients.

DISCUSSION

The computed overall rate of VAP in our study stands at 22.4% or '32.8 cases per 1,000 ventilator days'. This finding is in accordance with VAP rates documented in similar tertiary care facilities in Pakistan and other developing countries which range from 20-40 per 1,000 ventilator days. Specifically, other studies recorded VAP rates of '28 and 35 per 1,000 ventilator days respectively' highlighting the continued impact of this avoidable infection in local intensive care units. [10-12].

Protracted periods of mechanical ventilation exceeding seven days were a notable predictor of VAP as indicated in the study. These findings correspond with other research wherein the length of ventilation was reported as one of the most significant predictors of pneumonia's onset. Prolonged ventilation increases airway colonization, biofilm formation, and risk of aspiration, which may collectively explain this association. The results highlight the importance of early weaning protocols and daily readiness assessments to limit unnecessary ventilation time [13, 14].

An encouraging outcome of the present analysis was the protective role of daily sedation interruption, which significantly reduced the risk of VAP. This is consistent with studies who demonstrated that daily sedation breaks facilitate earlier extubation and reduce pulmonary complications. In the current setting, inconsistent adherence to this bundle element was observed, with only 59% of patients receiving regular sedation interruption [15, 16]. This may reflect variations in staff training, workload, or concerns regarding patient agitation. Improving staff education and adherence auditing could enhance compliance and further lower infection rates.

Among patients with Ventilator-Associated Pneumonia (VAP), the mortality rate was higher (50%), while the rate was only (33%) for patients without VAP; however, the difference was not statistically significant. Studies describe similar patterns, while VAP does increase the duration of ICU stays and the length of time a patient is on a ventilator, the impact of VAP on overall mortality is largely determined by patient comorbidities and the specific organism causing VAP [17, 18]. In this cohort, the predominance of multidrug-resistant Gram-negative organisms, such as *Klebsiella pneumoniae* and *Acinetobacter baumannii*, likely contributed to adverse outcomes. These findings underscore the importance of antimicrobial stewardship and infection control measures in critical care environments.

The use of vasopressors emerged as an independent predictor of mortality in the ICU, illustrating the extent of the underlying disease, and hemodynamic instability. These observations are in line with the conclusions for international literature which states that in the critical care setting, the associated mortality with vasopressor dependence is disproportionate to the underlying illness. Although the sample analyzed did not return statistically significant results, there were higher mortality association trends with advanced age and chronic kidney disease which were not statistically significant.

This study continues to uphold the clinical relevance of the implementation of the ventilator bundles. While only a minority of patients (17%) achieved full adherence, the decline in VAP incidence among patients with greater adherence certainly, though perhaps indirectly, contributes evidence vindicating the operational value of well-defined, organized, preventative measures. Even small, incremental gains in adherence to the bundles seem to positively impact the rates of infections sustained. This is probably indicative of the effectiveness of evidence-based procedures aligned with the sustained efforts of nursing personnel on the

frontline in flagging the infection in the first place [19, 20].

From a pragmatic perspective, progress in adherence to sedation interruption, head-of-bed elevation and timely oral hygiene will lower VAP incidence and associated morbidity. Enhancing the infection control audit, fostering multidisciplinary teamwork, and conducting periodic educational in-service training would lay a foundation for sustainable compliance.

CONCLUSION

This study demonstrated that VAP remains a significant clinical challenge in critically ill patients receiving mechanical ventilation at a tertiary-care hospital in Multan. The incidence rate was comparable to that reported in similar resource-limited settings. Extended use of mechanical ventilation and vasopressors are identified as key predictors of mortality; however, components of the ventilator bundle, especially daily sedation breaks, are ‘associated with a lower risk of developing VAP’.

These findings emphasize the importance of reinforcing ventilator bundle compliance as an essential component of patient safety and quality improvement in intensive care practice. Enhanced staff training, consistent monitoring of preventive practices, and early weaning strategies may collectively reduce infection burden and improve patient outcomes. Further multicenter prospective studies are recommended to validate these observations and evaluate the long-term impact of sustained bundle adherence on infection rates and survival in critically ill populations.

REFERENCES

1. Liu, W., et al., Evaluation of the effects of applying the ventricular care bundle (VCB) method for reducing ventilator-associated pneumonia (VAP) in the intensive care unit of a general Chinese tertiary hospital. 2020. 9(5): p. 2853861-2852861.
2. Kalovwe, J.K., Evaluation of Nurses’ Practice on Utilization of Ventilator-associated Pneumonia Care Bundle in Criticalcare Unit at Kenyatta National Hospital. 2020, University of Nairobi.
3. Aziz, Z., et al., Knowledge and practice of ventilator care bundle for preventing ventilator associated pneumonia by ICU nurses of tertiary care hospitals of Lahore. 2020. 24(4): p. 426-434.
4. Osman, S., et al., The incidence of ventilator-associated pneumonia (VAP) in a tertiary-care center: comparison between pre-and post-VAP prevention bundle. 2020. 13(4): p. 552-557.
5. Khalil, N., H. Mohamed, and O.J.M.N.J. Sayed, Impact of Educational Program Regarding Ventilator-Associated Pneumonia Bundle on Critical Care Nurses""Knowledge and Practices. 2021. 8(3): p. 301-318.
6. Weheida, S., E. Omran, and A.J.E.-B.N.R. Taha, Effect of Designed Bundle Protocol about Ventilator Associated Pneumonia on Nurses' Performance, Compliance, and Patient Outcomes. 2022. 4(3): p. 71-85.
7. Hassan, E.A. and S.E.A.J.B.n. Elsaman, Relationship between ventilator bundle compliance and the occurrence of ventilator-associated events: a prospective cohort study. 2022. 21(1): p. 207.
8. Branco, A., et al., Education to prevent ventilator-associated pneumonia in intensive care unit. 2020. 73(6): p. e20190477.
9. Ladbrook, E., et al., A systematic scoping review of the cost-impact of ventilator-associated pneumonia (VAP) intervention bundles in intensive care. 2021. 49(7): p. 928-936.
10. Kharel, S., A. Bist, and S.K.J.P.o. Mishra, Ventilator-associated pneumonia among ICU patients in

WHO Southeast Asian region: A systematic review. 2021. 16(3): p. e0247832.
11. Radhakrishnan, R., et al., Effect of training and checklist based use of ventilator associated pneumonia (VAP) prevention bundle protocol on patient outcome: a tertiary care centre study. 2021. 69(8): p. 11-12.
12. Papazian, L., M. Klompas, and C.-E.J.I.c.m. Luyt, Ventilator-associated pneumonia in adults: a narrative review. 2020. 46(5): p. 888-906.
13. Sánchez Peña, M., et al., Impact of an educational intervention aimed at nursing staff on oral hygiene care on the incidence of ventilator-associated pneumonia in adults ventilated in intensive care unit. 2021. 39(3).
14. Mahmudin, A.A., et al., Reducing incidence rate of ventilator-associated pneumonia (VAP) using prevention bundle in the ICU. 2020. 14(2).
15. Shudaifat, Y., et al., The role of nursing practice to prevent ventilator-associated pneumonia in the intensive care units. 2021. 21(21): p. 270-3.
16. Amin, F.M., O.M. Abu Samra, and J.A.J.T.S.N.J. Lawend, Effect of care bundle strategies on nurses' performance regarding prevention of ventilator associated pneumonia at neonatal intensive care units. 2021. 23(4): p. 96-115.
17. Liu, H., et al., Data-Driven Multicriteria Decision Analysis of Bundles of Care for Patients with Ventilator-Associated Pneumonia. 2021. 2021(1): p. 4436056.
18. Jalal, S.M., A.M. Alrajeh, and J.A.A.J.I.J.o.G.M. Al-Abdulwahed, Performance assessment of medical professionals in prevention of ventilator associated pneumonia in intensive care units. 2022: p. 3829-3838.
19. Zhou, M., et al., Bundles of care for prevention of ventilator-associated pneumonia caused by carbapenem-resistant Klebsiella pneumoniae in the ICU. 2021. 13(4): p. 3561.
20. Fortaleza, C.M.C.B., et al., Sustained reduction of healthcare-associated infections after the introduction of a bundle for prevention of ventilator-associated pneumonia in medical-surgical intensive care units. 2020. 24(5): p. 373-379.