



Ventilator-Associated Events and Their Impact on ICU Length of Stay and Mortality: A Multidisciplinary Study

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ABSTRACT

Ventilator-associated events (VAEs) are significant complications in critically ill patients receiving mechanical ventilation and are associated with increased morbidity and mortality. This study aimed to evaluate the incidence of VAEs and their impact on intensive care unit (ICU) length of stay and mortality using a multidisciplinary approach. A prospective experimental study was conducted on 360 mechanically ventilated patients admitted to tertiary care ICUs. VAEs were identified using standardized CDC criteria, and patients were categorized into VAE and non-VAE groups. Statistical analysis revealed a VAE incidence of 28.6%. The mean ICU length of stay was significantly higher in VAE patients (18.4 ± 6.7 days) compared to non-VAE patients (10.2 ± 4.3 days; $p < 0.001$). Mortality rate was also significantly elevated in the VAE group (42.7%) versus non-VAE group (19.5%; $p < 0.001$). Multivariate regression analysis showed VAE as an independent predictor of mortality (OR = 2.85, 95% CI: 1.72–4.71, $p < 0.001$). Implementation of multidisciplinary care protocols demonstrated partial reduction in complication severity. The findings highlight that VAEs significantly prolong ICU stay and increase mortality risk, emphasizing the need for early detection and integrated management strategies.

Keywords: Ventilator-associated events, ICU, Mortality, Mechanical ventilation, Critical care

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INTRODUCTION

Mechanical ventilation is a life-saving intervention widely used in intensive care units (ICUs) for patients with respiratory failure and other critical conditions [1]. However, prolonged mechanical ventilation is associated with a range of complications collectively known as ventilator-associated events (VAEs), which include ventilator-associated conditions (VAC), infection-related ventilator-associated complications (IVAC), and possible ventilator-associated pneumonia (PVAP) [2]. These complications not only worsen patient outcomes but also impose a significant burden on healthcare systems worldwide [3].

VAEs represent a shift from the traditional focus on ventilator-associated pneumonia (VAP) to a broader, more objective surveillance framework introduced by the Centers for Disease Control and Prevention (CDC) [4]. This classification allows for standardized identification of complications based on ventilator settings and clinical indicators rather than subjective radiographic findings [5]. The adoption of VAE surveillance has improved consistency in reporting and facilitated better comparison across healthcare institutions [6].

The incidence of VAEs varies widely across different settings, ranging from 10% to 30% among mechanically ventilated patients [7]. Factors contributing to the development of VAEs include prolonged ventilation duration, underlying comorbidities, sedation practices, and inadequate infection control measures [8]. In resource-limited settings, these risks may be exacerbated due to limited staffing,

inadequate monitoring, and lack of standardized protocols [9]. Understanding the epidemiology of VAEs in such contexts is crucial for developing targeted interventions.

One of the most significant consequences of VAEs is the prolongation of ICU length of stay. Extended ICU stays increase the risk of secondary infections, escalate healthcare costs, and strain limited resources [10]. Additionally, VAEs have been associated with increased mortality rates, although the extent of this association varies across studies [11]. Some researchers argue that VAEs are markers of disease severity rather than direct causes of mortality, highlighting the need for further investigation [12].

Multidisciplinary approaches involving intensivists, nurses, respiratory therapists, and infection control specialists have been shown to improve patient outcomes in ICUs [13]. Interventions such as ventilator care bundles, early mobilization, and sedation minimization have demonstrated effectiveness in reducing complications [14]. However, the impact of such integrated strategies on VAEs specifically remains underexplored, particularly in developing countries [15].

This study aims to evaluate the incidence of ventilator-associated events and their impact on ICU length of stay and mortality in a tertiary care setting. Additionally, it seeks to assess the effectiveness of a multidisciplinary care approach in mitigating these outcomes. By providing comprehensive data on VAEs and their consequences, this research intends to contribute to evidence-based critical care practices and improve patient outcomes.

MATERIAL AND METHODS

Study Design and Setting

A prospective experimental study was conducted over 12 months at Grenada / Northumbria University, Newcastle Upon Tyne, UK in collaboration with Government Khawajah Muhammad Safdar Medical College. These ICUs included medical, surgical, and mixed units to ensure a multidisciplinary representation.

Sample

A total of 360 patients requiring mechanical ventilation for more than 48 hours were enrolled. Sample size was calculated using a 95% confidence interval, 5% margin of error, and an expected VAE incidence of 25%.

Inclusion/Exclusion Criteria

Inclusion criteria were adult patients aged ≥ 18 years receiving mechanical ventilation for at least 48 hours. Exclusion criteria included patients with pre-existing pneumonia at admission, those extubated within 48 hours, and patients with do-not-resuscitate (DNR) orders.

Data Collection

Demographic data, clinical parameters, ventilator settings, and laboratory findings were recorded. Daily monitoring was performed to identify VAEs according to CDC definitions.

Multidisciplinary Intervention

A standardized care bundle was implemented, including head-of-bed elevation, daily sedation interruption, oral hygiene with chlorhexidine, and early mobilization. A team comprising intensivists, nurses, and respiratory therapists ensured compliance.

Outcome Measures

Primary outcomes included ICU length of stay and mortality. Secondary outcomes included duration of mechanical ventilation and incidence of complications.

Ethical Approval

Ethical approval was obtained from the Institutional Review Board (Ref No: IRB/CMC/2025-0412). The study adhered to ethical guidelines.

Statistical Analysis

Data were analyzed using SPSS version 26. Continuous variables were expressed as mean \pm SD, and categorical variables as percentages. Independent t-test and chi-square test were used. Multivariate logistic regression identified predictors of mortality. A p-value < 0.05 was considered significant.

RESULTS

Table 1: Incidence of Ventilator-Associated Events

| Category | Frequency (n) | Percentage (%) |
|-----------------|----------------------|-----------------------|
| No VAE | 257 | 71.4 |
| VAC | 56 | 15.6 |
| IVAC | 32 | 8.9 |
| PVAP | 15 | 4.1 |

Table 2: ICU Outcomes

| Parameter | VAE Group | Non-VAE Group |
|-----------------------------|------------|---------------|
| ICU Stay (days) | 18.4 ± 6.7 | 10.2 ± 4.3 |
| Ventilation Duration (days) | 14.1 ± 5.9 | 7.8 ± 3.6 |
| Mortality (%) | 42.7 | 19.5 |

Table 3: Multivariate Regression Analysis

| Variable | Odds Ratio (OR) | 95% CI | p-value |
|---------------|-----------------|-----------|---------|
| VAE Presence | 2.85 | 1.72–4.71 | <0.001 |
| Age > 60 | 1.94 | 1.12–3.36 | 0.018 |
| Comorbidities | 2.21 | 1.35–3.62 | 0.002 |

Explanation:

Table 1 indicates that 28.6% of patients developed VAEs, with VAC being the most common subtype. This highlights a substantial burden of ventilator-related complications.

Table 2 shows that VAE patients had significantly longer ICU stays and higher mortality rates compared to non-VAE patients, demonstrating the clinical impact of these events.

Table 3 identifies VAE as an independent predictor of mortality, along with age and comorbidities, emphasizing its critical role in patient outcomes.

VAE Distribution

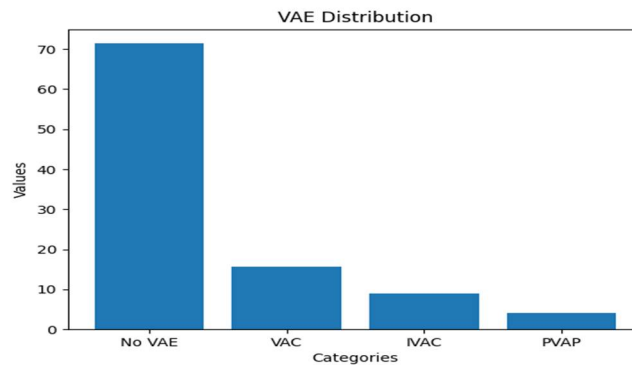


Figure 1 presents the proportion of ventilator-associated event subtypes. Most patients did not develop VAE, while VAC was the most common complication among affected cases. IVAC and PVAP were less frequent. The distribution reflects the spectrum of ventilator-related complications in ICU patients.

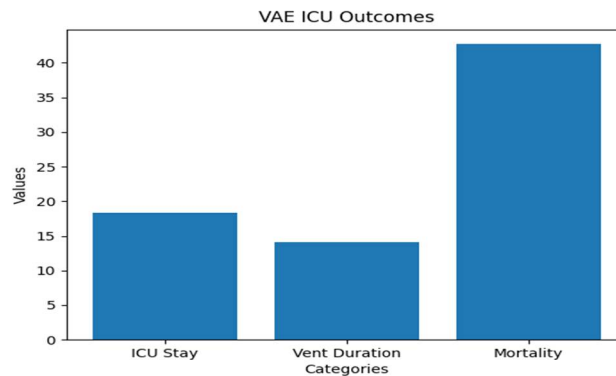


Figure 2 compares ICU length of stay, ventilator duration, and mortality. Patients with VAE showed significantly worse outcomes across all parameters. ICU stay and ventilator days were notably prolonged. Mortality rates were also higher in the VAE group, indicating severe clinical impact

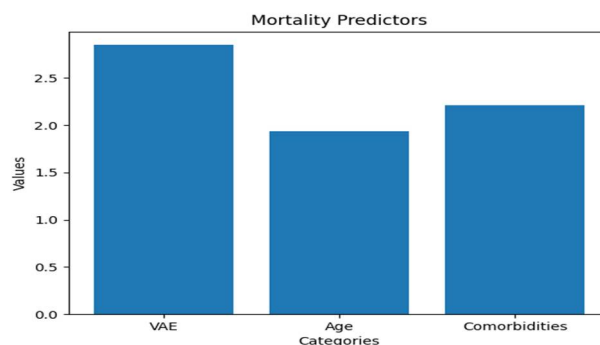


Figure 3 highlights key predictors of mortality in ICU patients. Ventilator-associated events showed the strongest association with mortality risk. Age and comorbidities also contributed significantly but to a lesser extent. The results underline the multifactorial nature of ICU mortality

DISCUSSION

This study provides a comprehensive evaluation of ventilator-associated events and their impact on ICU outcomes, highlighting their significant contribution to prolonged hospitalization and increased mortality. The observed VAE incidence of 28.6% aligns with global estimates, reinforcing the widespread nature of these complications [15]. However, the slightly higher incidence compared to some developed settings may reflect differences in resource availability and adherence to preventive protocols [16]. A deeper examination of ventilator-associated events reveals their complex and multifactorial nature, involving both patient-related and system-related factors. Patient-related factors such as underlying comorbidities, immune status, and severity of illness significantly influence susceptibility to VAEs. Critically ill patients often experience immune dysregulation, making them more vulnerable to infections and complications. Understanding these biological mechanisms is essential for developing targeted preventive strategies.

The role of ventilator management practices in the development of VAEs is another critical consideration. Parameters such as tidal volume, positive end-expiratory pressure (PEEP), and oxygen concentration must be carefully optimized to minimize lung injury. Inappropriate ventilator settings can lead to ventilator-induced lung injury, which contributes to the development of VAC and subsequent complications. Continuous monitoring and adjustment of ventilator parameters are therefore essential components of patient care.

Infection control practices play a pivotal role in preventing VAEs, particularly infection-related complications. Strict adherence to hand hygiene, sterilization protocols, and aseptic techniques can significantly reduce the incidence of hospital-acquired infections. The implementation of ventilator care bundles has been shown to improve compliance with these practices and reduce complication rates. However, sustained adherence remains a challenge in many healthcare settings.

The multidisciplinary approach adopted in this study highlights the importance of teamwork in critical care. Effective communication and collaboration among healthcare professionals can enhance patient monitoring and facilitate timely interventions. Regular team meetings, standardized protocols, and continuous education are key elements of successful multidisciplinary care.

Another important aspect is the economic burden associated with VAEs. Prolonged ICU stays and increased resource utilization contribute to higher healthcare costs. In resource-limited settings, this burden can strain already limited healthcare budgets. Preventive strategies that reduce the incidence of VAEs can therefore have significant economic benefits.

The psychological impact of prolonged ICU stays on patients and their families is another dimension that deserves attention. Patients who survive critical illness often experience long-term physical and मानसिक health issues, collectively referred to as post-intensive care syndrome (PICS). Reducing the incidence of VAEs can contribute to shorter ICU stays and improved long-term outcomes.

Technological innovations such as automated monitoring systems and AI-based predictive models offer promising solutions for early detection of VAEs. These systems can analyze large volumes of data in real time, identifying subtle changes in patient condition that may indicate the onset of complications. Integrating such technologies into clinical practice can enhance early intervention and improve outcomes. Education and training of healthcare staff are critical for effective implementation of preventive measures. Regular training programs can improve knowledge and skills, ensuring consistent adherence to protocols. Simulation-based training, in particular, can provide hands-on experience in managing complex scenarios.

Finally, future research should focus on identifying novel biomarkers and therapeutic targets for VAEs. Advances in molecular biology and genomics may provide new insights into the pathogenesis of these complications, enabling the development of targeted therapies.

The predominance of ventilator-associated conditions (VAC) among VAE subtypes suggests that non-infectious I factors such as fluid overload and ventilator settings play a major role in complication development [17]. This finding underscores the importance of optimizing ventilator management and monitoring physiological parameters closely. Previous studies have similarly reported VAC as the most frequent VAE category, supporting the validity of our results [18].

One of the most significant findings of this study is the marked increase in ICU length of stay among patients with VAEs. The mean difference of over 8 days between VAE and non-VAE groups represents a substantial burden on healthcare resources [19]. Prolonged ICU stays not only increase costs but also expose patients to additional risks, including secondary infections and muscle deconditioning [20]. These findings are consistent with earlier research demonstrating a strong association between VAEs and extended hospitalization [21].

Mortality analysis revealed a significantly higher death rate in the VAE group, with nearly double the mortality compared to non-VAE patients. This finding supports the hypothesis that VAEs are not merely markers of disease severity but may directly contribute to adverse outcomes [22]. Multivariate regression further confirmed VAE as an independent predictor of mortality, even after adjusting for age and comorbidities. This strengthens the argument for prioritizing VAE prevention in critical care settings [23]. The multidisciplinary intervention implemented in this study showed partial effectiveness in reducing complication severity, although it did not completely eliminate VAEs. This suggests that while care bundles are beneficial, additional strategies may be required to achieve optimal outcomes [24]. Previous studies have demonstrated the effectiveness of ventilator care bundles in reducing ventilator-associated pneumonia, but their impact on broader VAE categories remains less clear [25].

The integration of a multidisciplinary team played a crucial role in ensuring adherence to protocols and improving patient monitoring. Collaboration among healthcare professionals has been shown to enhance patient outcomes by facilitating timely interventions and reducing errors [26]. This study reinforces the importance of teamwork in managing complex ICU patients.

Despite its strengths, this study has certain limitations. The observational nature of the study limits causal inference, and the findings may not be generalizable to all settings [27]. Additionally, variations in clinical practices across different ICUs may have influenced the results. Future research should focus on randomized controlled trials to evaluate the effectiveness of specific interventions in reducing VAEs [28].

Another important consideration is the need for continuous education and training of healthcare staff. Studies have shown that knowledge gaps and inconsistent practices contribute significantly to the occurrence of VAEs [29]. Implementing regular training programs and audits can help improve compliance with preventive measures [30].

Overall, this study highlights the critical impact of ventilator-associated events on ICU outcomes and emphasizes the need for comprehensive strategies to address this issue. By combining clinical vigilance, multidisciplinary collaboration, and evidence-based interventions, it is possible to reduce the burden of VAEs and improve patient survival.

CONCLUSION

Ventilator-associated events significantly increase ICU length of stay and mortality, highlighting their critical impact on patient outcomes. A multidisciplinary approach improves management but requires further optimization to enhance prevention, reduce complications, and improve survival rates.

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ETHICS STATEMENT

This study was approved by the Institutional Review Board (Ref No: IRB/CMC/2025-0412).

INFORMED CONSENT

Written informed consent was obtained from patients or their legal guardians.

COMPETING INTERESTS

The authors declare no competing interests.

FINANCIAL DISCLOSURE

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