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# VENTILATOR-ASSOCIATED PNEUMONIA IN SELECTIVE ICU IN WEST BENGAL: INCIDENCE AND CONTRIBUTING FACTOR

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## ABSTRACT

Ventilator-associated pneumonia (VAP) is a significant hospital-acquired infection in patients requiring mechanical ventilation for more than 48 hours following endotracheal intubation. In critically ill individuals, VAP increases mortality risk, prolongs ventilator dependence, extends hospital stays, and raises healthcare costs. This prospective study was conducted on sixty mechanically ventilated patients admitted to the critical care units of IPGMER and SSKM Hospital, with VAP diagnosed using the modified Clinical Pulmonary Infection Score (CPIS > 6). Analysis of clinical records and patient observation identified several factors significantly associated with the development of VAP ($p < 0.05$), including reintubation, initiation of enteral feeding, changes in ventilator circuits when mucus was present, poor hand hygiene practices, and failure to maintain head-of-bed elevation between 30–45°. Additionally, a longer duration of intubation was linked to a higher risk of VAP. The findings emphasize the importance of targeting these modifiable factors to reduce VAP incidence. Routine screening, early diagnosis, and timely treatment are essential to minimize the associated morbidity and mortality. The study also underscores the need for enhanced education and adherence to best practices, particularly among nursing professionals, to improve outcomes in critical care settings.



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# INTRODUCTION

Ventilator-associated pneumonia (VAP) is one type of pneumonia that occurs more than 48 hours after endotracheal intubation (Kalil *et al*., 2016). This is a subtype of hospital acquired pneumonia. It is limited to clients undergoing mechanical ventilation (Hinkle and Cheever, 2018). The daily risk of VAP peaks between days five to nine of mechanical ventilation, while the cumulative incidence is close to the total duration of mechanical ventilation. VAP has an incidence ranging from 5−67%, which depends on subset of patients such as elderly, immunocompromised, and surgical patients and also on the diagnostic criteria used (Cook *et al*., 1998; Forel *et al*.,2012). International nosocomial infection control consortium (INICC) data suggests that VAP incidence is 13.6/1000 mechanical ventilation (MV) days (Rosenthal *et al*., 2016). In India, the prevalence of VAP is 11.8% (Kharel *et al*., 2021). A frequent complication of acute respiratory distress syndrome (ARDS) is VAP. It occurs in as many as 68% of clients with acute respiratory distress syndrome (Harding *et al*., 2022). It is challenging to diagnose VAP in the intensive care unit because the plethora of other causes can contribute to a clinical decline in complex, critically ill patients. Several risk factors predispose these patients to either colonisation of the respiratory tract or aspiration of secretions. Knowledge of these risk factors for VAP can be utilized to plan efficient preventive measures (Modi and Kovacs, 2020). VAP is a significant complication in critically ill patients, leading to increased mortality, prolonged ventilator dependence, extended hospital stays, and higher healthcare costs. It presents a complex challenge in both diagnosis and treatment, underscoring the importance of effective prevention strategies. Several studies highlight the burden and impact of VAP in diverse healthcare settings: Stocli*net al*. (2020), conducted a retrospective study over 12 months at Gustav Roussy Hospital in Germany among 3388 patients. The incidence rate of VAP was reported as 24.5%. Koulenti *et al*. (2017) performed a prospective study involving 2436 patients across 27 ICUs in Europe. The incidence rate of VAP was 18.3%. Bhadade *et al*. (2017) studied nosocomial pneumonia trends in a tertiary care teaching hospital in Western India. Over 18 months, among 120 adult patients, 91 developed VAP. The study revealed a VAP related mortality rate of 60% and highlighted a significant association between VAP and mortality. The investigator's clinical observations at NRS Medical College & Hospital and Bankura Sammilani Medical College & Hospital confirm VAP as a prevalent and severe complication of mechanical ventilation. It contributes to difficulty in weaning patients from ventilators, prolongs hospital stays, and imposes substantial financial burdens on patients, families,

and healthcare systems. Despite the global recognition of VAP as a critical issue, a gap exists in localized research, particularly in West Bengal, where official studies on the occurrence and contributing factors of VAP in patients undergoing mechanical ventilation are limited. Thus, this study aims to fill the research gap by assessing the occurrence of VAP and identifying its contributing factors among patients with mechanical ventilation at critical care units of selected hospitals in West Bengal. This will enable the development of targeted preventive measures and improved care protocols for managing VAP.

# MATERIALS AND METHODS

This study was conducted at the critical care units of IPGMER & SSKM Hospital, Kolkata, to investigate the occurrence and contributing factors of VAP among mechanically ventilated patients. The study included 60 patients who had been on mechanical ventilation for over 48 hours following endotracheal intubation. Participants were selected using a purposive sampling technique during the data collection period.

The data collection procedure involved the following steps:

- ***Informed Consent:*** Written informed consent was obtained from the family members of each willing participant after providing detailed information about the study's objectives, procedures, and potential risks.
- ***Baseline Assessment:*** Demographic and clinical profiles were collected using a structured tool.
- ***Observations and Monitoring:*** Participants were observed and monitored for signs of VAP based on established diagnostic criteria, specifically the Modified Clinical Pulmonary Infection Score (CPIS).
- ***Documentation of Contributing Factors:*** Factors potentially contributing to VAP, such as hand hygiene practices, head-of-bed positioning, and the initiation of enteral feeding, were recorded using a structured tool.
- ***Data Recording:*** All collected data were systematically documented and prepared for analysis using appropriate tools and software.

The study utilized the Fishbone Diagram (also known as the Ishikawa Diagram or Cause-and-Effect Diagram), developed by Prof. Kaoru Ishikawa in 1943, as a conceptual framework (Wallach). Clinical suspicion of VAP was confirmed using the Modified CPIS, with a score greater than six serving as a diagnostic criterion (see Table 1).

The study was delimited to:

1. Patients who were intubated at the critical care units of the selected hospital in Kolkata.
2. Patients aged between 20 and 80 years.

The inclusion criteria were:

1. Patients on mechanical ventilation for more than 48 hours after endotracheal intubation.

**Table 1. Details of Modified Clinical Pulmonary Infection Score**

| CPIS points | 0 | 1 | 2 |
|---|---|---|---|
| Temperature (ºC) | ≥36.5 and ≤38.4 | ≥38.5 and ≤38.9 | ≥39 or ≤36 |
| Leucocyte count (per $mm^3$) | 4,000-11,000 | <4,000 or >11,000 | <4,000 or >11,000 + band forms ≥500 |
| Tracheal secretions | Rare | Abundant | Abundant + Purulent |
| $PaO_2$/ $FiO_2$ mm Hg | >240 or ARDS | - | ≤240 and no ARDS |
| Chest radiograph | No infiltrate | Diffuse infiltrate | Localized infiltrate |
| Culture of tracheal aspirate | Light brown or no growth | Moderate or heavy growth of pathogenic bacteria | Moderate or heavy growth of pathogenic bacteria and presence of the same bacteria in Gram stain |

**Table 2. Findings related to description of demographic characteristics of participants**

| Variables | Frequency (f) | Percentage (%) |
|---|---|---|
| Age (in years) | | |
| 20-40 years | 09 | 15 |
| 41-60 years | 21 | 35 |
| 61-80 years | 30 | 50 |
| Gender: Male | 44 | 73 |
| Gender: Female | 16 | 27 |
| Habitat: Urban | 21 | 35 |
| Habitat: Rural | 39 | 65 |

**Table 3. Clinical Indications Leading to Mechanical Ventilation (Multiple Responses)**

| Variables | Frequency (f) | Percentage (%) |
|---|---|---|
| Indication for mechanical ventilation: | | |
| Neurological problem | 31 | 52 |
| Cardiovascular problem | 20 | 33 |
| Respiratory problem | 21 | 35 |
| Gastrointestinal problem | 13 | 22 |
| Circulatory problem | 07 | 12 |
| Renal problem | 14 | 23 |
| Endocrine problem | 06 | 10 |
| Malignancies | 08 | 13 |

**Table 4. Distribution of participants according to duration of Intubation, mode of Intubation, and mode of Mechanical Ventilation**

| Duration of intubation: | | |
|---|---|---|
| 48-72 hours | 41 | 68 |
| 73-96 hours | 19 | 32 |
| Mode of intubation: | | |
| Emergency | 54 | 90 |
| Elective | 06 | 10 |
| Mode of mechanical ventilation: | | |
| AC/VC | 51 | 85 |
| SIMV | 09 | 15 |

2. Patients available at the time of the study.
3. Both male and female participants.

The exclusion criteria included patients who had developed pneumonia before the initiation of mechanical ventilation. Statistical analysis was conducted using Microsoft Excel[1] and IBP SPSS version 25[2], ensuring accurate and comprehensive data analysis. This robust methodology supported reliable conclusions regarding the occurrence and contributing factors of VAP.

# RESULTS

This study analyzed 60 participants admitted to critical care units with varying diagnoses. Demographic analysis showed that 50% of the participants were aged 61–80 years, with a male predominance (73%). Most participants (65%) were from rural areas, while the remaining 35% resided in urban regions (depicted in Table 2).

**Table 5. Findings related to the identification of contributing factors for VAP. @ indicates Yates' correction, * denotes statistical significance at df(1) with a 0.05 significance level (p< 0.05), and # represents Fisher's exact test**

| Variables | VAP | | Chi-square value | p value |
|---|---|---|---|---|
| | Present | Absent | | |
| Reintubation | | | | |
| Yes | 07 | 03 | 9.416@ | 0.0001* |
| No | 03 | 47 | | |
| Initiation of enteral feeding | | | | |
| ≤ 48 hours | 08 | 50 | 0.3548# | 0.0428* |
| > 48 hours | 02 | 00 | | |
| Change of ventilator circuit when mucus visible | | | | |
| Yes | 10 | 50 | 4.156# | 0.0001* |
| No | 00 | 00 | | |
| Use of sedation | | | | |
| ≤ 12 hours | 10 | 50 | 0.7536# | 0.3654 |
| > 12 hours | 00 | 00 | | |
| Physical conditioning | | | | |
| Yes | 06 | 18 | 2.145@ | 1.2361 |
| No | 04 | 32 | | |
| Presence of subglottic suction channel in ET tube | | | | |
| Yes | 06 | 46 | 0.3654@ | 0.5223 |
| No | 04 | 04 | | |
| Presence of closed suction system | | | | |
| Yes | 10 | 50 | 0.2445# | 0.4388 |
| No | 00 | 00 | | |

**Table 6. Findings related to identification of preventive factors of VAP. @ indicates Yates' correction, * denotes statistical significance at df(1) with 0.05 significance level (p< 0.05), and # represents Fisher's exact test**

| Variables | VAP | | Chi-square value | P value |
|---|---|---|---|---|
| | Present | Absent | | |
| Handwashing | | | | |
| Yes | 08 | 47 | 5.2361@ | 0.0002* |
| No | 02 | 03 | | |
| Elevation head of the bed between 30-45 degrees | | | | |
| Yes | 09 | 49 | 4.8531@ | 0.0001* |
| No | 01 | 01 | | |
| Daily trial of spontaneous breathing/weaning protocol | | | | |
| Yes | 10 | 50 | 0.1274# | 0.5364 |
| No | 00 | 00 | | |
| Oral care with chlorohexidine every 4th hourly | | | | |
| Yes | 01 | 08 | 0.3848@ | 0.6142 |
| No | 09 | 42 | | |
| Care of oral cavity with special technique of brushing | | | | |
| Yes | 00 | 00 | 2.3614# | 0.2588 |
| No | 10 | 50 | | |
| Use of sterile technique during endotracheal suctioning | | | | |
| Yes | 07 | 44 | 2.3214@ | 0.1539 |
| No | 03 | 06 | | |

Neurological conditions were the leading indication for mechanical ventilation, accounting for 52% of cases Table 3. The majority of participants (68%) required intubation for 48−72 hours, with 90% undergoing emergency intubation. Furthermore, 85% of the participants were managed on the AC/VC mode of mechanical ventilation (see Table 4 for details). Notably, 17% of the participants developed VAP during the study period. The study identified significant associations between VAP occurrence and several key factors, as outlined in Table 5. Specifically, reintubation ($p = 0.0001$, $df = 1$), initiation of enteral feeding ($p = 0.0428$, $df = 1$), and changing the ventilator circuit when visible mucus was present ($p = 0.0001$, $df = 1$) were all significantly linked to VAP at the 0.05 significance level. Furthermore, hand hygiene practices ($p = 0.0002$, $df = 1$) and elevating the head of the bed to 30−45◦ ($p = 0.0001$, $df = 1$) also showed significant associations with VAP, as detailed in Table 6. Additionally, the duration of intubation exhibited a strong correlation with VAP, as indicated by a $\chi 2$ value of 11.501 ($df = 1$, $p < 0.05$), with further details provided in Table 7.

**Table 6. Findings related to association between occurrences of VAP and selected demographic variables. @ indicates Yates' correction, * denotes statistical significance at df(1) with a 0.05 significance level (p< 0.05)**

| Variables | VAP | | Value of ($\chi^2$) |
|---|---|---|---|
| | Present | Absent | |
| Age | | | |
| 20-50 years | 01 | 13 | 0.184@ |
| 51-80 years | 09 | 37 | |
| Gender | | | |
| Male | 09 | 35 | 1.305@ |
| Female | 01 | 15 | |
| Habitat | | | |
| Urban | 02 | 18 | 0.141@ |
| Rural | 08 | 32 | |
| Duration of intubation | | | |
| 48-72 hours | 02 | 39 | 11.501* |
| 73−96 hours | 8 | 11 | |

# DISCUSSION

The findings of this study revealed that 50% of participants were aged 60 years or older, 73% were male, and 52% had neurological problems. Additionally, 35% experienced respiratory issues, 22% had gastrointestinal conditions, and 23% had renal problems. These results align with the study by Ali et al. (2016), titled "Epidemiology and Outcome of VAP in a Heterogeneous ICU Population in Qatar,"which reported that VAP predominantly occurred in individuals aged up to 60 years, with a male predominance of 80.2%, and identified trauma as a primary reason for ICU admissions (49%). Similarly, the findings are supported by Ghanshani et al. (2015), whose epidemiological study in an Indian tertiary care hospital highlighted respiratory issues (37%) and gastrointestinal/liver problems (22%) as major contributors to VAP. The current study found a VAP prevalence of 17%, consistent with several prior studies. Kharel et al. (2021) in a systematic review titled "Ventilator-Associated Pneumonia Among ICU Patients in WHO," reported an 11.8% prevalence in India. Similarly, Viana et al. (2018) in their study "Clinical Outcomes Related to the Incidence of Ventilator Associated Pneumonia in Adults," observed a prevalence of 22.67%. Behari and Kalafatis (2015) in their study" Incidence and Outcome of VAP in Inkosi Albert Luthuli and King Edward VIII Hospital Surgical Intensive Care Units," reported an incidence rate of 25%. These findings reinforce the outcomes of the present study. This study identified significant factors contributing to VAP, including reintubation, initiation of enteral feeding, changing ventilator circuits when mucus was visible, handwashing practices, and elevating the head of the bed to 30−45◦ ($P<0.05$, $df = 1$). These results align with the study by Sadigov et al. (2019) titled" Ventilator-Associated Pneumonia and In-Hospital Mortality," which identified malnutrition as a significant VAP risk factor. Similarly, Charles et al. (2013) in "Incidence and Risk Factors of Ventilator-Associated Pneumonia in a

Tertiary Care Hospital," reported the supine head position as a significant risk factor for VAP. Furthermore, this study demonstrated a significant association between the occurrence of VAP and the duration of intubation ($\chi 2 = 11.501$, df = 1, $P<0.05$). This finding is consistent with Behari and Kalafatis (2015), who also reported a significant relationship between VAP incidence and intubation duration in their study on surgical intensive care units. The present study aimed to examine the occurrence of VAP and its contributing factors among patients on mechanical ventilation beyond 48 hours after endotracheal intubation. The findings have significant implications for nursing practice, nursing administration, nursing education, and nursing research.

***Nursing Practice:*** The study findings highlight the importance of critical care nurses focusing on the assessment of VAP occurrence and the identification of its contributing factors in patients on mechanical ventilation. Nurses in critical care units can play a vital role in planning, organizing, administering, and monitoring programs related to screening strategies for VAP. Additionally, they can contribute to formulating and maintaining care protocols to ensure the effective management of mechanically ventilated patients.

***Nursing Education:*** Nurse educators can emphasize the diagnostic criteria for VAP during training sessions for students and staff. They can prepare and utilize checklists to identify the contributing factors associated with VAP. Furthermore, educators can organize in-service training sessions and conduct continuing nursing education programs to enhance knowledge about screening strategies and prevent complications in patients undergoing mechanical ventilation.

***Nursing Administration:*** Nursing administrators, who oversee and manage the nursing profession, can develop policies to in-corporate diagnostic criteria for VAP and identify contributing factors. They can organize workshops and continuous nursing education programs for staff nurses to ensure the early identification of VAP risk factors. Additionally, administrators can conduct care audits to evaluate nursing practices and improve the quality of care for mechanically ventilated patients.

***Nursing Research:*** The findings of the study will inspire nurse researchers to focus on developing diagnostic criteria for VAP and formulating care practice protocols for patients on mechanical ventilation. This research can contribute to evidence-based practices and improve patient outcomes in critical care settings. Based on the findings of this study, we can expand the study to multiple settings by including patients on mechanical ventilation from various regions to gain a broader perspective. Conducting similar studies with larger sample sizes is suggested to enhance the generalizability of the findings. Descriptive studies could be undertaken to assess the occurrence and outcomes of VAP for a better understanding of its impact, while experimental studies can evaluate the effectiveness of VAP care bundles in its prevention. Additionally, comparative studies could be carried out to explore the occurrence of VAP among patients on mechanical ventilation beyond 48 hours after endotracheal intubation, focusing on differences across various chronic illnesses.

# CONCLUSION

The findings of the present study indicate that the occurrence of VAP in the selected hospital in Kolkata, West Bengal, is alarming. The study revealed a 17% occurrence rate of VAP, which aligns with the prevalence rate reported for India. Furthermore, the study identified significant associations ($P<0.05$, df=1, at the 0.05 level of significance) between VAP and several factors, including reintubation, initiation of enteral feeding, changing the ventilator circuit when mucus was visible, handwashing practices, elevating the head of the bed to 30−45◦ , and the duration of intubation. It is imperative for healthcare professionals to be aware of these contributing factors and to adhere strictly to care protocols for patients on mechanical ventilation. Hospital authorities should ensure the availability of adequate supplies and equipment in accordance with standard protocols. Additionally, conducting regular care audits is crucial to prevent or minimize the occurrence of VAP.

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