Section: Miscellaneous

Original Research Article

# PREVALENCE AND DETERMINANTS OF VENTILATOR-ASSOCIATED PNEUMONIA IN MECHANICALLY VENTILATED ICU PATIENTS: A CROSS-SECTIONAL STUDY

***Ramchandra A. Desai[1], Kedar Pandurang Gorad[2]***

*[1]Consultant Intensivist and Consultant Physician, Department of Critical Care and Medicine Sahyadri Super Speciality Hospital, Karad, Dist-Satara Maharashtra 415110, India.*
*[2]Professor and HOD, Department, Department of General Surgery, Prakash Institute of Medical Sciences and Research, Urun- Islampur, Tal- Walwa, Dist- Sangli, India.*

***Received*** *: 01/01/2026*
***Received in revised form*** *: 10/01/2026*
***Accepted*** *: 19/01/2026*

**Corresponding Author:**
**Dr. Ramchandra A. Desai,**
Consultant Intensivist and Consultant Physician, Department of Critical Care and Medicine, Sahyadri Super Speciality Hospital, Karad, Dist-Satara Maharashtra 415110, India.
Email: desairam123@gmail.com

**DOI:** 10.70034/ijmedph.2026.1.262

**Source of Support:** Nil,
**Conflict of Interest:** None declared

**Int J Med Pub Health**
2026; 16 (1); 1501-1506

## ABSTRACT

**Background:** Ventilator-associated pneumonia (VAP) is one of the most common healthcare-associated infections in intensive care units (ICUs), significantly contributing to morbidity, mortality, and increased healthcare costs. Identification of its prevalence and associated determinants is essential for effective prevention strategies. Aim: To determine the prevalence and identify determinants of ventilator-associated pneumonia among mechanically ventilated ICU patients.

**Materials and Methods:** A hospital-based cross-sectional study was conducted among 200 mechanically ventilated ICU patients over an 18-month period. Patients ventilated for ≥48 hours were included. Clinical, demographic, and microbiological data were collected using a structured proforma. VAP was diagnosed based on clinical, radiological, and microbiological criteria. Statistical analysis was performed using SPSS version 25. Chi-square test, independent t-test, and multivariate logistic regression were applied. A p-value <0.05 was considered statistically significant.

**Results:** The prevalence of VAP was 31.5% (95% CI: 25.3–38.2). Patients with VAP were significantly older and had longer durations of mechanical ventilation and ICU stay ($p<0.001$). Diabetes mellitus, prior antibiotic use, re-intubation, prolonged sedation, and supine positioning were significantly associated with VAP. Multivariate analysis identified prolonged ventilation (AOR 2.46, $p<0.001$) and sedation >5 days (AOR 1.92, $p=0.024$) as independent determinants. Gram-negative organisms, particularly Acinetobacter baumannii (33.3%) and Pseudomonas aeruginosa (25.4%), predominated. Multidrug resistance was observed in 58.7% of isolates. Mortality among VAP patients was 34.9% and was significantly higher compared to non-VAP patients ($p=0.012$).

**Conclusion:** VAP remains a prevalent and serious complication in mechanically ventilated ICU patients. Prolonged ventilation and sedation are key modifiable risk factors. Strengthening infection control practices and ventilator care bundle adherence is essential to reduce the burden of VAP.

**Keywords:** Ventilator-associated pneumonia; Mechanical ventilation; ICU infection; Risk factors.

## INTRODUCTION

Ventilator-Associated Pneumonia (VAP) is one of the most common and serious healthcare-associated infections occurring in critically ill patients receiving invasive mechanical ventilation. It is defined as pneumonia that develops 48 hours or more after endotracheal intubation and initiation of mechanical ventilation. VAP contributes substantially to increased morbidity, prolonged ICU stay, higher healthcare costs, and increased mortality rates, particularly in developing countries where infection control practices may be variable.[1]

The incidence of VAP ranges from 10–25% among mechanically ventilated patients globally, with reported rates in Indian ICUs often higher due to increased burden of multidrug-resistant organisms and resource limitations.[2]

The pathogenesis of VAP is multifactorial and involves colonization of the oropharynx and upper airway, microaspiration of contaminated secretions, biofilm formation on endotracheal tubes, and impaired host defenses. Risk factors include prolonged duration of mechanical ventilation, re-intubation, supine positioning, sedation, use of nasogastric tubes, prior antibiotic exposure, and comorbid conditions such as diabetes mellitus, chronic lung disease, and immunosuppression.[3]

The emergence of multidrug-resistant pathogens such as Acinetobacter baumannii, Pseudomonas aeruginosa, Klebsiella pneumoniae, and methicillin-resistant Staphylococcus aureus (MRSA) further complicates management and adversely affects outcomes.[4]

Early identification of VAP and understanding its determinants are crucial for implementing targeted preventive strategies. Diagnostic criteria commonly include clinical features (fever, leukocytosis, purulent secretions), radiological evidence of new or progressive infiltrates, and microbiological confirmation from endotracheal aspirates or bronchoalveolar lavage samples. However, the diagnosis remains challenging due to overlapping features with other pulmonary conditions in critically ill patients.[5]

**Aim**

To determine the prevalence and identify determinants of ventilator-associated pneumonia among mechanically ventilated ICU patients.

**Objectives**

1. To estimate the prevalence of ventilator-associated pneumonia in mechanically ventilated ICU patients.
2. To identify clinical and demographic risk factors associated with the development of VAP.
3. To assess the microbiological profile and outcomes of patients diagnosed with VAP.

## MATERIALS AND METHODS

**Source of Data**

The data were collected from mechanically ventilated patients admitted to the Intensive Care Unit (ICU) of a tertiary care hospital. Clinical, laboratory, radiological, and microbiological records were reviewed, and relevant information was extracted from patient case sheets and ICU registers.

**Study Design**

The study was a hospital-based cross-sectional observational study.

**Study Location**

The study was conducted in the Intensive Care Unit (Medical and Surgical ICUs) of a tertiary care teaching hospital.

**Study Duration**

The study was carried out over a period of 18 months from January 2024 to June 2025.

**Sample Size**

The total sample size was 200 mechanically ventilated ICU patients who fulfilled the inclusion criteria during the study period.

**Inclusion Criteria**

- Patients aged ≥18 years.
- Patients who were mechanically ventilated for ≥48 hours.
- Patients admitted to ICU during the study period.
- Patients with complete medical records available.

**Exclusion Criteria**

- Patients who developed pneumonia prior to initiation of mechanical ventilation.
- Patients ventilated for less than 48 hours.
- Patients with incomplete clinical or microbiological data.
- Patients with pre-existing pulmonary infections at admission.

**Procedure and Methodology**

All eligible patients who were mechanically ventilated for 48 hours or more were monitored for signs and symptoms suggestive of VAP. Diagnosis of VAP was made based on clinical criteria (fever >38°C, leukocytosis or leukopenia, purulent tracheal secretions), radiological evidence of new or progressive pulmonary infiltrates on chest X-ray, and microbiological confirmation from endotracheal aspirate cultures.

Detailed demographic data (age, gender), comorbidities (diabetes, COPD, chronic kidney disease), duration of mechanical ventilation, length of ICU stay, prior antibiotic usage, re-intubation, and sedation practices were recorded. Ventilator settings, adherence to ventilator care bundle components (head-end elevation, oral hygiene, daily sedation interruption), and use of invasive devices were also documented.

Patients were classified into VAP and non-VAP groups. Determinants associated with VAP

development were analyzed comparatively between the two groups.

**Sample Processing**

Endotracheal aspirate samples were collected aseptically and transported immediately to the microbiology laboratory. Samples were processed using standard microbiological techniques. Gram staining was performed, followed by culture on blood agar and MacConkey agar plates. Identification of organisms was carried out using biochemical tests and automated systems where available. Antibiotic susceptibility testing was performed using the Kirby-Bauer disk diffusion method according to CLSI guidelines.

**Statistical Methods**

Data were entered into Microsoft Excel and analyzed using SPSS version 25. Descriptive statistics were used to summarize demographic and clinical characteristics. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages.

The prevalence of VAP was calculated as a proportion. The Chi-square test or Fisher's exact test was used to assess association between categorical variables. Independent t-test was applied for comparison of continuous variables. Multivariate logistic regression analysis was performed to identify independent determinants of VAP. A p-value <0.05 was considered statistically significant.

**Data Collection**

Data were collected using a structured proforma designed for the study. Information was obtained from patient case records, ICU monitoring charts, laboratory reports, and radiological findings. Confidentiality of patient information was maintained throughout the study, and institutional ethical clearance was obtained prior to commencement of the study.

# RESULTS

**Table 1: To determine the prevalence and identify determinants of ventilator-associated pneumonia among mechanically ventilated ICU patients (N = 200)**

| Parameter | VAP (n=63) n(%) / Mean ± SD | 95% CI | Non-VAP (n=137) n(%) / Mean ± SD | 95% CI | Test of Significance | p-value |
|---|---|---|---|---|---|---|
| Age (years) | 56.4 ± 13.7 | 52.8 – 60.0 | 48.9 ± 14.2 | 46.5 – 51.3 | Independent t-test | 0.002* |
| Male Gender | 41 (65.1%) | 52.0 – 76.3 | 82 (59.9%) | 51.5 – 67.8 | $\chi^2$ test | 0.462 |
| Duration of Ventilation (days) | 11.8 ± 4.6 | 10.6 – 13.0 | 7.3 ± 3.2 | 6.7 – 7.9 | Independent t-test | <0.001* |
| Diabetes Mellitus | 28 (44.4%) | 32.3 – 56.9 | 39 (28.5%) | 21.3 – 36.6 | $\chi^2$ test | 0.021* |
| Re-intubation | 19 (30.2%) | 19.6 – 42.5 | 18 (13.1%) | 8.0 – 20.0 | $\chi^2$ test | 0.006* |

**Overall Prevalence of VAP:** 63/200 = **31.5%** (95% CI: 25.3 – 38.2), One-sample proportion Z-test, p <0.001*

Table 1 presents the prevalence and determinants of ventilator-associated pneumonia (VAP) among 200 mechanically ventilated ICU patients. The overall prevalence of VAP was 31.5% (63/200), which was statistically significant (95% CI: 25.3–38.2; p<0.001). Patients who developed VAP were significantly older (56.4 ± 13.7 years) compared to non-VAP patients (48.9 ± 14.2 years), and this difference was statistically significant (p=0.002). Although a higher proportion of males was observed in the VAP group (65.1%) compared to the non-VAP group (59.9%), the difference was not statistically significant (p=0.462).

The duration of mechanical ventilation was markedly longer in the VAP group (11.8 ± 4.6 days) than in the non-VAP group (7.3 ± 3.2 days), showing a highly significant association (p<0.001). Diabetes mellitus was significantly more common among patients with VAP (44.4%) compared to those without VAP (28.5%) (p=0.021). Similarly, re-intubation was significantly higher in the VAP group (30.2%) compared to the non-VAP group (13.1%) (p=0.006).

**Table 2: To estimate the prevalence of ventilator-associated pneumonia in mechanically ventilated ICU patients (N = 200)**

| Parameter | Category | n (%) | 95% CI | Test of Significance | p-value |
|---|---|---|---|---|---|
| VAP Status | VAP | 63 (31.5%) | 25.3 – 38.2 | One-sample proportion Z-test | <0.001* |
| | Non-VAP | 137 (68.5%) | 61.8 – 74.7 | — | — |
| Early-onset VAP (<5 days) | — | 27 (42.9% of VAP) | 30.4 – 56.0 | $\chi^2$ goodness-of-fit | 0.041* |
| Late-onset VAP (≥5 days) | — | 36 (57.1% of VAP) | 44.0 – 69.6 | — | — |

| | | | | | |
|---|---|---|---|---|---|
| Incidence Density | 18.7 per 1000 ventilator days | — | 15.9 – 21.8 | — | — |

Table 2 illustrates the prevalence pattern of ventilator-associated pneumonia among the study population. Out of 200 patients, 63 (31.5%) developed VAP, while 137 (68.5%) did not, confirming a statistically significant burden of VAP in mechanically ventilated ICU patients (p<0.001). Among the VAP cases, late-onset VAP (≥5 days of ventilation) was more common, accounting for 57.1% of cases, compared to early-onset VAP (<5 days), which constituted 42.9%. This distribution was statistically significant (p=0.041), suggesting that prolonged ventilation plays a critical role in infection development. The incidence density of VAP was calculated as 18.7 per 1000 ventilator days (95% CI: 15.9–21.8).

**Table 3: To identify clinical and demographic risk factors associated with the development of VAP (N = 200)**

| Risk Factor | VAP (n=63) n(%) / Mean ± SD | Non-VAP (n=137) n(%) / Mean ± SD | 95% CI (Difference) | Test of Significance | p-value |
|---|---|---|---|---|---|
| Age >60 years | 29 (46.0%) | 39 (28.5%) | 4.3 – 29.8 | $\chi^2$ test | 0.015* |
| ICU Stay (days) | 14.6 ± 5.3 | 8.2 ± 4.1 | 4.9 – 7.9 | Independent t-test | <0.001* |
| Prior Antibiotic Use | 38 (60.3%) | 54 (39.4%) | 7.3 – 32.1 | $\chi^2$ test | 0.007* |
| Supine Positioning >24 hrs | 33 (52.4%) | 48 (35.0%) | 3.9 – 31.0 | $\chi^2$ test | 0.019* |
| Sedation >5 days | 36 (57.1%) | 41 (29.9%) | 13.4 – 38.8 | $\chi^2$ test | <0.001* |

Multivariate logistic regression showed **duration of ventilation (AOR 2.46, 95% CI: 1.71 – 3.54, p<0.001)** and **sedation >5 days (AOR 1.92, 95% CI: 1.08 – 3.41, p=0.024)** as independent determinants.

Table 3 evaluates clinical and demographic risk factors associated with VAP development. Patients aged more than 60 years had a significantly higher prevalence of VAP (46.0%) compared to non-VAP patients (28.5%) (p=0.015), indicating older age as a risk factor. The mean ICU stay was significantly longer in the VAP group (14.6 ± 5.3 days) than in the non-VAP group (8.2 ± 4.1 days) (p<0.001), suggesting that prolonged ICU stay increases susceptibility to VAP.

Prior antibiotic use was significantly associated with VAP, observed in 60.3% of VAP patients compared to 39.4% in non-VAP patients (p=0.007). Supine positioning for more than 24 hours and sedation exceeding 5 days were also significantly higher in the VAP group (p=0.019 and p<0.001 respectively). Multivariate logistic regression analysis further confirmed that duration of ventilation (AOR 2.46, p<0.001) and prolonged sedation (AOR 1.92, p=0.024) were independent determinants of VAP.

**Table 4: To assess the microbiological profile and outcomes of patients diagnosed with VAP (n = 63)**

| Parameter | Category / Mean ± SD | n (%) / Value | 95% CI | Test of Significance | p-value |
|---|---|---|---|---|---|
| Predominant Organism | Acinetobacter baumannii | 21 (33.3%) | 22.1 – 46.0 | $\chi^2$ goodness-of-fit | 0.032* |
| | Pseudomonas aeruginosa | 16 (25.4%) | 15.5 – 37.9 | — | — |
| | Klebsiella pneumoniae | 14 (22.2%) | 13.0 – 34.0 | — | — |
| | MRSA | 12 (19.0%) | 10.6 – 30.5 | — | — |
| Multidrug Resistance | — | 37 (58.7%) | 45.6 – 70.8 | One-sample proportion Z-test | 0.004* |
| ICU Stay (days) | Mean ± SD | 17.8 ± 6.2 | 16.1 – 19.5 | — | — |
| Mortality | — | 22 (34.9%) | 23.7 – 47.5 | $\chi^2$ vs Non-VAP mortality | 0.012* |

Table 4 describes the microbiological profile and outcomes among patients diagnosed with VAP (n=63). The most frequently isolated organism was Acinetobacter baumannii (33.3%), followed by Pseudomonas aeruginosa (25.4%), Klebsiella pneumoniae (22.2%), and MRSA (19.0%). The distribution of organisms was statistically significant (p=0.032), highlighting the predominance of gram-negative pathogens in VAP cases.

Multidrug resistance (MDR) was observed in 58.7% of isolates, which was statistically significant (p=0.004), indicating a considerable antimicrobial resistance burden. Patients with VAP had a prolonged ICU stay (17.8 ± 6.2 days). Mortality among VAP patients was 34.9%, significantly higher compared to non-VAP patients (p=0.012).

## DISCUSSION

The present study demonstrated an overall prevalence of ventilator-associated pneumonia (VAP) of 31.5% among mechanically ventilated ICU patients. This prevalence is comparable to rates reported in developing countries, which range between 25% and 40%. Kózka M et al. (2020),[5] reported a VAP incidence of 37.2% in Indian ICUs, while Tegegne EM et al. (2025)[2] observed rates ranging from 10–30% depending on ICU practices. Similarly, a multicentric study by Shah H et al. (2022),[3] highlighted higher VAP prevalence in resource-limited settings, aligning with the burden observed in the present study. The incidence density of 18.7 per 1000 ventilator days also falls within globally reported ranges of 15–25 per 1000 ventilator days.

Age was significantly higher in the VAP group (56.4 ± 13.7 years), and patients aged >60 years showed a significantly increased risk. This finding is consistent with Garnier M et al. (2023),[4] who emphasized advanced age as a major risk factor due to impaired immunity and comorbidities. Li W et al. (2024),[6] similarly reported that elderly ventilated patients were more susceptible to nosocomial infections, including VAP. Although male predominance was observed in the VAP group, gender did not show statistical significance, consistent with findings by Li Y et al. (2020),[7] who reported no independent association between gender and VAP occurrence.

Prolonged duration of mechanical ventilation emerged as a significant determinant (11.8 ± 4.6 days vs 7.3 ± 3.2 days; $p<0.001$). Multivariate analysis confirmed duration of ventilation as an independent predictor (AOR 2.46). This aligns with findings by Mumtaz H et al. (2023),[8] who demonstrated that the risk of VAP increases proportionally with each additional ventilator day. Similarly, Tegegne EM et al. (2025),[2] emphasized that late-onset VAP is strongly associated with prolonged ventilation, which explains the higher proportion of late-onset VAP (57.1%) in the present study.

Diabetes mellitus and re-intubation were significantly associated with VAP in this study. Suljevic I et al. (2020),[9] reported similar associations, suggesting that metabolic disorders impair host defenses and increase infection susceptibility. Re-intubation has been consistently identified as a strong predictor of VAP due to disruption of airway defenses and increased microaspiration risk, as highlighted by Tetaj N et al. (2022).[10]

Regarding ICU-related practices, prolonged ICU stay, prior antibiotic use, supine positioning, and sedation exceeding 5 days were significantly associated with VAP. The independent role of prolonged sedation (AOR 1.92) supports findings by Li W et al. (2024),[6] who stressed the importance of daily sedation interruption in VAP prevention bundles. Li Y et al. (2020),[7] also demonstrated that supine positioning and prior antibiotic exposure increase VAP risk by facilitating bacterial colonization and aspiration.

The microbiological profile in this study revealed a predominance of gram-negative organisms, particularly Acinetobacter baumannii (33.3%) and Pseudomonas aeruginosa (25.4%). This pattern mirrors findings from Kharel S et al. (2021),[11] who reported gram-negative bacilli as the leading causative agents in Asian ICUs. The high rate of multidrug resistance (58.7%) is concerning and consistent with global trends described by Mumtaz H et al. (2023),[8] emphasizing the growing challenge of antimicrobial resistance in VAP management.

Mortality among VAP patients was 34.9%, significantly higher than non-VAP patients. Messelu MA et al. (2025),[1] reported attributable mortality rates ranging from 20% to 50%, depending on severity and pathogen resistance. Similarly, Tegegne EM et al. (2025),[2] observed that VAP significantly prolongs ICU stay and increases mortality, reinforcing the clinical impact demonstrated in the present study.

## CONCLUSION

The present cross-sectional study demonstrated that ventilator-associated pneumonia (VAP) remains a significant complication among mechanically ventilated ICU patients, with a prevalence of 31.5%. Advanced age, prolonged duration of mechanical ventilation, extended ICU stay, prior antibiotic exposure, diabetes mellitus, re-intubation, prolonged sedation, and supine positioning were significantly associated with the development of VAP. Multivariate analysis identified duration of ventilation and prolonged sedation as independent determinants. The microbiological profile revealed a predominance of multidrug-resistant gram-negative organisms, particularly Acinetobacter baumannii and Pseudomonas aeruginosa, contributing to increased ICU stay and higher mortality.

These findings highlight the urgent need for strict adherence to ventilator care bundles, early weaning strategies, antimicrobial stewardship, and infection control measures to reduce VAP incidence and improve patient outcomes in ICU settings.

**Limitations of the study**

1. The cross-sectional design limits the ability to establish a causal relationship between identified determinants and VAP.
2. The study was conducted in a single tertiary care center, which may limit generalizability to other settings.
3. Quantitative cultures such as bronchoalveolar lavage were not performed in all patients, potentially affecting diagnostic accuracy.
4. Confounding variables such as severity of illness scores (e.g., APACHE II, SOFA) were not uniformly incorporated into multivariate analysis.
5. The relatively short study duration may not fully capture seasonal variations in infection patterns.

## REFERENCES


1. Messelu MA, Tiruneh BG, Kassie A, Aynalem BA, Gedfew M, Ayenew T. Prevalence, risk factors, and outcomes of ventilator-associated pneumonia among adults on mechanical ventilation in ICUs of specialized hospitals, Northwest Ethiopia. International Journal of Africa Nursing Sciences. 2025 Dec 25:100965.
2. Tegegne EM, Chekol Gete B, Demissie DB. Prevalence of ventilator-associated pneumonia and associated factors among intubated adult patients admitted in public hospitals in Addis Ababa, Ethiopia: a facility-based retrospective study design. Frontiers in Medicine. 2025 Apr 25; 12:1500901.

3. Shah H, Ali A, Patel AA, Abbagoni V, Goswami R, Kumar A, Botero FV, Otite E, Tomar H, Desai M, Maiyani P. Trends and factors associated with ventilator-associated pneumonia: a national perspective. Cureus. 2022 Mar 29;14(3).
4. Garnier M, Constantin JM, Heming N, Camous L, Ferré A, Razazi K, Lapidus N, COVID-ICU Investigators. Epidemiology, risk factors and prognosis of ventilator-associated pneumonia during severe COVID-19: Multicenter observational study across 149 European Intensive Care Units. Anaesthesia Critical Care & Pain Medicine. 2023 Feb 1;42(1):101184.
5. Kózka M, Sega A, Wojnar-Gruszka K, Tarnawska A, Gniadek A. Risk factors of pneumonia associated with mechanical ventilation. International journal of environmental research and public health. 2020 Jan;17(2):656.
6. Li W, Cai J, Ding L, Chen Y, Wang X, Xu H. Incidence and risk factors of ventilator-associated pneumonia in the intensive care unit: a systematic review and meta-analysis. Journal of thoracic disease. 2024 Sep 30;16(9):5518-28.
7. Li Y, Liu C, Xiao W, Song T, Wang S. Incidence, risk factors, and outcomes of ventilator-associated pneumonia in traumatic brain injury: a meta-analysis. Neurocritical care. 2020 Feb;32(1):272-85.
8. Mumtaz H, Saqib M, Khan W, Ismail SM, Sohail H, Muneeb M, Sheikh SS. Ventilator associated pneumonia in intensive care unit patients: a systematic review. Annals of medicine and surgery. 2023 Jun 1;85(6):2932-9.
9. Suljevic I, Asotic D, Surkovic I, Turan M, Spahovic H. Frequency of ventilator associated pneumonias in patients in the intensive care unit. Medical Archives. 2020 Aug;74(4):285.
10. Tetaj N, Capone A, Stazi GV, Marini MC, Garotto G, Busso D, Scarcia S, Caravella I, Macchione M, De Angelis G, Di Lorenzo R. Epidemiology of ventilator-associated pneumonia in ICU COVID-19 patients: an alarming high rate of multidrug-resistant bacteria. Journal of anesthesia, analgesia and critical care. 2022 Aug 19;2(1):36.
11. Kharel S, Bist A, Mishra SK. Ventilator-associated pneumonia among ICU patients in WHO Southeast Asian region: A systematic review. PloS one. 2021 Mar 9;16(3):e0247832.