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Bacteriological profile and antimicrobial susceptibility patterns in ventilator- associated pneumonia (VAP): A Retrospective Study from a Tertiary Hospital in Navi Mumbai

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) is a major cause of morbidity and mortality among critically ill patients and is defined as pneumonia occurring ≥48 hours after initiation of mechanical ventilation via an endotracheal tube or tracheostomy. Gram-negative bacilli such as *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Acinetobacter baumannii* are commonly implicated. The emergence of multidrug-resistant (MDR) and extensively drug-resistant (XDR) pathogens poses significant therapeutic challenges.
Objectives: To determine the bacteriological profile and antimicrobial susceptibility pattern of pathogens causing VAP, identify associated risk factors, and estimate the VAP rate per 1000 ventilator days.
Methods: A retrospective study was conducted over one year (July 2024–July 2025) among 97 mechanically ventilated ICU patients at a tertiary care hospital in Navi Mumbai. VAP diagnosis was based on a Clinical Pulmonary Infection Score (CPIS) >6. Clinical samples were processed for bacterial identification and antimicrobial susceptibility testing according to CLSI guidelines.
Results: Five patients (5.1%) developed VAP, corresponding to a rate of 7.8 per 1000 ventilator days. Neurological disorders, respiratory failure, and sepsis were common indications for ventilation, while hypertension and diabetes mellitus were frequent comorbidities. Gram-negative bacilli predominated, with *Pseudomonas aeruginosa* (60%) as the most common isolate, followed by *Klebsiella pneumoniae* (20%) and *Acinetobacter baumannii* (20%). Overall, 60% isolates were MDR and 40% XDR, while all isolates remained susceptible to colistin.
Conclusion: A substantial burden of antimicrobial resistance was observed among VAP pathogens, highlighting the need for robust infection control practices and rational antibiotic stewardship in intensive care settings.

Keywords: Ventilator-associated pneumonia, Bacterial profile, Antibiotic susceptibility pattern, Intensive care unit; Antimicrobial resistance, Pseudomonas aeruginosa.

INTRODUCTION

Ventilator-associated pneumonia (VAP) is a type of hospital-acquired pneumonia (HAP) that develops in patients who have been on mechanical ventilation for more than two consecutive calendar days on the date of the event (with the day of ventilator placement being Day 1), and the ventilator was in place on the date of the event or the day before. (1,2). It is associated with longer periods of mechanical ventilation, extended ICU stays, and significant healthcare costs (3). The mortality rate associated with VAP is high, ranging from 24% to 76% (4,5).

Early and accurate diagnosis, coupled with appropriate antibiotic therapy, is crucial for improving patient outcomes and mitigating the development of multidrug-resistant (MDR) pathogens (2,6). Common causative agents include Pseudomonas aeruginosa, Acinetobacter baumannii, Klebsiella pneumoniae, and Staphylococcus aureus (7,8,9). The prevalence and resistance patterns of these pathogens vary significantly between hospitals, regions, and even within

different units of the same hospital (4,7). Inappropriate initial empirical antibiotic therapy is a consistent factor associated with increased mortality in patients with VAP (2,10).

Therefore, knowledge of the local bacteriological profile and antimicrobial susceptibility patterns is crucial for guiding appropriate empirical antibiotic selection, improving patient outcomes, and implementing effective antibiotic stewardship programs (2,11). This study aims to investigate the microbial etiology of VAP and the resistance patterns of the isolates in our ICU setting to formulate an evidence-based antibiotic policy.

MATERIAL AND METHODS:

A retrospective observational study was conducted over 1 year (1st July 2024–31st July 2025) after permission from the Institutional Ethics Committee (DYP/ IECBH/2025/243). Data were collected from case files of the medical records department corresponding to the clinical isolates identified and confirmed by the microbiology laboratory.

The study included 97 ventilated patients of both sexes, aged >18 years, who were admitted to ICUs. Clinical Pulmonary Infection Score (CPIS) >6 was used as the clinical criteria to determine Ventilator-associated pneumonia (12). Patients who received mechanical ventilation presenting with pneumonia before 48 hours of admission were excluded from this study. Study results were analyzed and presented descriptively.

A total of 97 clinical samples of endotracheal aspirates were received and processed as per standard microbiological techniques. Clinical and microbiological criteria are the two important features for the diagnosis of VAP and non-VAP cases. Samples were collected aseptically by standard methods and transported immediately.

Smear examination, bacterial isolation, morphology, and colony characteristics were studied according to standard microbiological procedures. The isolates were tested by the Kirby–Bauer disk diffusion method on Mueller–Hinton agar using commercially prepared antibiotic discs (HiMedia Laboratories, Mumbai). Antibiotic susceptibility testing was performed according to The Clinical and Laboratory Standards Institute (CLSI) guidelines (12,13).

Age	Male	Female
15-40	13 (13.4%)	4 (4.1%)
41-60	33(34%)	11(11.3%)
>61	22 (22.6%)	14 (14.4%)
Total (97)	**68**	**29**

Colistin susceptibility was determined using the automated broth microdilution method with the BD Phoenix™ automated identification and susceptibility testing system, and minimum inhibitory concentration (MIC) values were interpreted according to CLSI guidelines.

Table 1: Clinical pulmonary infection scoring criteria and scoring

CPIS Criteria	0	1	2
Tracheal secretions	Rare	Abundant	Purulent
Leukocyte count	>4000 and <11,000	<4000 and >11,000	<4000 or >11,000+ band forms
Temperature (°C)	>36.5 and <38.4	>38.5 and 38.9	>39 or <36
PaO_2/FiO_2 ratio (mmHg)	>240 or ARDS	-	≤240 and no ARDS
Chest radiograph	No infiltrate	Diffuse infiltrate	Localized infiltrate
Culture of tracheal aspirate	Negative	-	Positive

ARDS=Acute respiratory distress syndrome, CPIS=Clinical pulmonary infection score, PaO_2=Partial pressure of oxygen in blood, FiO_2=Fraction of oxygen in the inhaled air

RESULTS:

The study included a total of 97 ventilated patients who met the inclusion criteria. In the age group of 41–60 years, there were 44 patients constituting 45.4% of all ventilated patients. A total of 36 patients belonged to the age group above 60 years (37.1%), while 17 patients were in the 15–40 years age group (17.5%).

Among the ventilated patients, the most common indication for mechanical ventilation was CNS disorders (28.6%), including stroke, intracranial bleed, subdural hematoma, hypoxic brain injury, and status epilepticus. Sepsis (23.8%) formed the next major group, followed by respiratory causes (14.3%) such as pneumonia, Acute Respiratory Distress Syndrome (ARDS) and respiratory failure. Metabolic/systemic disorders (14.3%), including metabolic and hepatic

encephalopathy, Chronic kidney disease with fluid overload, and multi-organ dysfunction, were also frequent. Malignancy (9.5%) and trauma/post-operative conditions (9.5%) were less common.

Most ICU patients were from the Medical ICU (n = 62, 63.9%), followed by the Surgical ICU (n = 26, 26.8%) and Emergency ICU (n = 2, 2.1%). All patients on ventilators, except 39, had pre-existing comorbidities such as hypertension, diabetes, COPD, cardiovascular diseases, and malignancies.

Patients were categorized as having VAP or non-VAP based on Clinical Pulmonary Infection Score (CPIS) scoring. A total of 5 patients developed VAP. The total number of ventilator days was 633. With 5 VAP cases, the VAP rate was calculated as 7.8 per 1000 ventilator days according to CDC criteria (14).

Monomicrobial infections (79.6%) were more common than polymicrobial infections (20.4%). Bacteriological analysis revealed exclusively Gram-negative bacilli, with *Pseudomonas aeruginosa* (n = 3, 60%) as the predominant pathogen, followed by *Klebsiella pneumoniae* (n = 1, 20%) and *Acinetobacter baumannii* (n = 1, 20%).
Pseudomonas aeruginosa showed highest susceptibility to colistin (100%), followed by amikacin, meropenem, piperacillin–tazobactam, and cefepime (66.7% each), gentamicin (50%), and ceftazidime, ciprofloxacin, and imipenem (33.3% each). Both *Klebsiella pneumoniae* and *Acinetobacter baumannii* were susceptible only to colistin. Overall, 60% (3/5) of isolates were MDR, while 40% (2/5) were XDR.

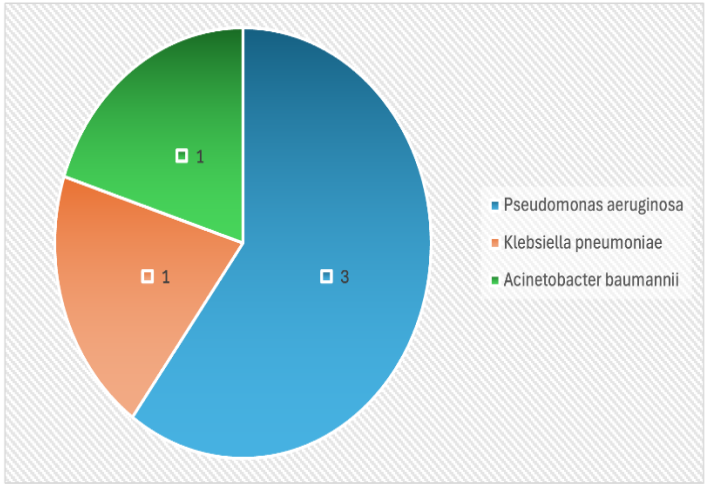

Figure 1: organism distribution

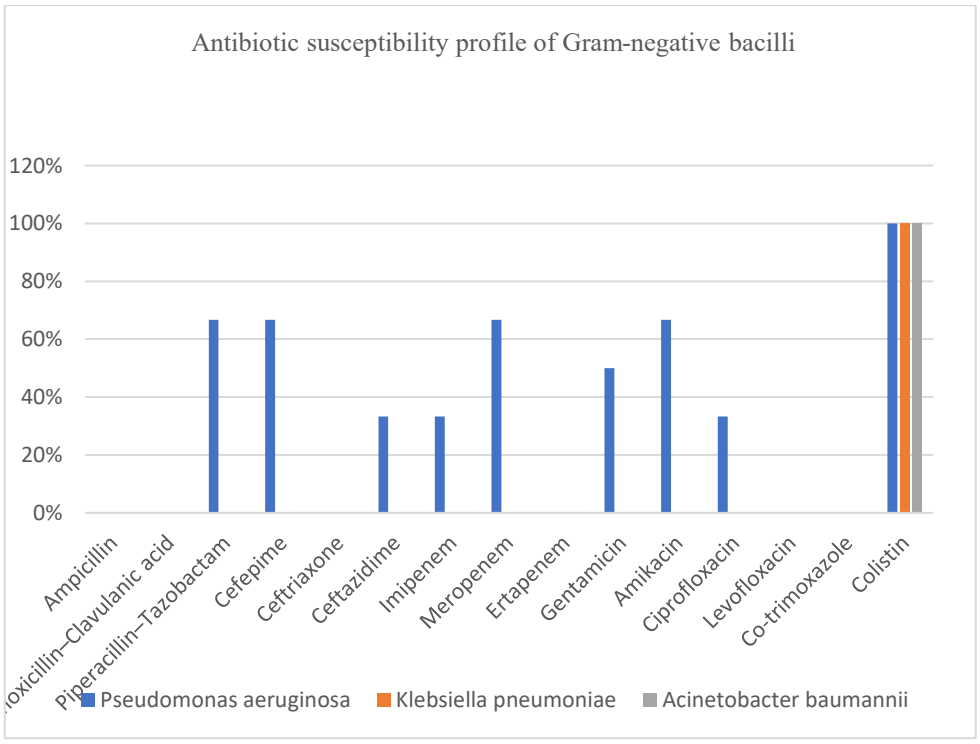

Figure 2: Antibiotic susceptibility profile of Gram- negative bacilli

Comorbidities associated with ventilated patients (97)	n (%)
Hypertension	35 (36.1)
Diabetes	25 (25.8)
Chronic Kidney disease	10 (10.3%)
Carcinoma	7 (7.2%)
Cardiovascular disease	6 (6.2%)
COPD	4 (4.1%)
Hypothyroidism	3 (3.1%)
None	39 (40.2%)
Table 2:	

DISCUSSION:

VAP is one of the most common hospital-acquired infections among critically ill patients receiving mechanical ventilation. It represents a significant public health issue with high morbidity, mortality, and increased healthcare costs (11,15).

Incidence Rates and Comparative Benchmarks

The observed VAP rate of 7.8 per 1,000 ventilator days is encouraging when compared with global and regional data. It is lower than the global rate of 13.6 reported by the International Nosocomial Infection Control Consortium (INICC) and aligns closely with a recent large-scale Indian network pilot study which identified an overall rate of 6.4 per 1,000 ventilator days (6,16). Other Indian single-center studies have reported higher rates, indicating effective infection control practices in the present setting (5,17). VAP typically affects 9–27% of intubated patients (1,18).

Clinical Indications and Comorbidities

Neurological disorders, respiratory failure, and **sepsis** were the predominant indications for mechanical ventilation among the VAP cases identified in this setting (4,18). Neurological impairment increases VAP risk significantly by predisposing patients to an impaired cough reflex and microaspiration, which are the primary pathogenic mechanisms for the entry of bacteria into the lower respiratory tract (1,3,9).

Diabetes mellitus and hypertension were the most frequent comorbidities observed in clinical cohorts (9,17) Diabetes is a known risk factor for nosocomial infections including pneumonia (1,4). Similar findings regarding the high prevalence of these comorbidities in VAP patients have been reported in Indian studies (9,17).

Bacteriological Profile and Pathogen Distribution

The study demonstrated exclusive Gram-negative bacilli (GNB), which is consistent with global ICU trends where GNB account for the vast majority of VAP cases, (8,18,17). *Pseudomonas aeruginosa* (60%) was the predominant pathogen, followed by *Klebsiella pneumoniae* (20%) and *Acinetobacter baumannii* (20%) These organisms are well-recognized as major multidrug-resistant (MDR) pathogens in ICU settings due to their ability to form biofilms on the inner surfaces of endotracheal tubes and their various intrinsic resistance mechanisms, such as the expression of multiple efflux pumps and porin channel downregulation (1,11,6).

Antimicrobial Susceptibility Patterns

In contrast to the total susceptibility observed for colistin, other antimicrobial classes in this study showed high rates of resistance, a trend reflective of the growing challenge of multidrug-resistant (MDR) and extensively drug-resistant (XDR) pathogens in Indian tertiary care settings (5,16,17). *Pseudomonas aeruginosa* isolates in our setting remained 100% susceptible to colistin, but demonstrated significantly reduced susceptibility to other first-line agents: 66.7% for amikacin, meropenem, and cefepime, and even lower rates of 33.3% for ciprofloxacin and imipenem. This high level of resistance is mirrored in other regional studies, such as one from a Syrian university hospital where *Pseudomonas* was 100% resistant to carbapenems and fluoroquinolones (18).

The profiles of *Acinetobacter baumannii* and *Klebsiella pneumoniae* in our study are particularly concerning, showing near-total resistance to all tested antimicrobials except colistin. This extreme resistance aligns with broader national trends; for instance, a large-scale Indian network pilot study recently reported carbapenem resistance in 98% of *Acinetobacter* isolates and 85.5% of Enterobacterales (16). Similarly, in a tertiary hospital in Odisha, *Acinetobacter* species showed 100% resistance to ceftazidime, amikacin, and ciprofloxacin (20).

The most vital therapeutic finding is the 100% susceptibility to colistin across all isolates. This mirrors observations in other high-resistance settings, such as a study from Saudi Arabia where no colistin-resistant isolates were identified among MDR Gram-negative bacilli (19). In many contemporary ICUs, the rise of XDR strains has left colistin and polymyxin B as the only viable "last-resort" antimicrobials. (2,11) Our study's 100% sensitivity results confirm that a reliable rescue therapy remains effective at our centre, which is crucial for managing the most difficult cases of late-onset VAP (20)

CONCLUSION:

Conclusion and Clinical Implications

These findings reinforce the recommendations of the American Thoracic Society (ATS) and Infectious Diseases Society of America (IDSA) guidelines, which advocate for tailoring empirical therapy to the local ICU antibiogram (1,2).

The low VAP rate suggests effective implementation of ventilator care bundles, including head-of-bed elevation, sedation protocols, and secretion management (3,13).

Continued antimicrobial stewardship is essential to preserve colistin efficacy, as emerging resistance has already been reported large-scale Indian hospital networks (16).

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