ORIGINAL RESEARCH

# Concordance between the National Healthcare Safety Network (NHSN) Surveillance Criteria and Clinical Pulmonary Infection Score (CPIS) Criteria for Diagnosis of Ventilator-associated Pneumonia (VAP)

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## Abstract

**Background:** Ventilator-associated pneumonia (VAP) is one of the most common hospital-acquired infections among mechanically ventilated patients and the incidence rates are widely used as an index of quality of care given in an ICU. Since there is no gold standard method available to diagnose VAP, the incidence rate varies based on different criteria used for calculation. Therefore, we conducted a study to determine the concordance between the National Healthcare Safety Network (NHSN) surveillance criteria and clinical pulmonary infection score (CPIS) criteria for the diagnosis of VAP.

**Materials and methods:** This was a prospective study that evaluated patients in the medical intensive care units (MICUs) of a tertiary care hospital, India, who were intubated for >48 hours between October 2018 and September 2019. All the patients (n = 273) were followed up daily and assessed using both CPIS and NHSN surveillance criteria for diagnosing VAP.

**Results:** Of these 273 patients, 93 patients (34.1%) had VAP according to CPIS criteria as compared with 33 patients (12.1%) using the NHSN criteria. The corresponding rates of VAP were 39.59 vs 11.53 cases per 1,000 ventilator days, respectively. The agreement of the two sets of criteria was fairly good (kappa statistics, 0.42)

**Conclusion:** The NHSN surveillance criteria have a lower sensitivity in detecting VAP cases and have to be modified to achieve better results.

**Keywords:** Anesthesia and intensive care, Clinical pulmonary infection score, Ventilator-associated pneumonia, National Healthcare Safety Network.

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## Introduction

Ventilator-associated pneumonia (VAP) is a frequent complication of mechanical ventilation (MV). The incidence of VAP is not known precisely and ranges from 13–51 per 1,000 ventilator days.[1,2] It varies among different studies because of the lack of uniformity in the diagnostic criteria and it also depends on the type of ICU and the population studied. Following VAP at the national level is challenging, because of the absence of substantial and solid definitions. To overcome this, the Centers for Disease Control and Prevention (CDC) held a meeting to help build up another way to deal with observation in mechanically ventilated patients. This new methodology, called "ventilator-associated event" (VAE) surveillance, was executed in CDC's National Healthcare Safety Network (NHSN), in January 2013.[3] These surveillance criteria were created to expand the reliability and to upgrade the utility of these surveillance data for improving patient security.[4] Despite these efforts, several studies have shown that NHSN surveillance criteria have a very low sensitivity in detecting VAP cases leading to underestimation of actual VAP rate and there was low agreement between the clinical criteria and the surveillance criteria used for diagnosis of VAP.[5,6]

In this context, the present study aimed to determine the concordance between NHSN surveillance criteria and clinical pulmonary infection score (CPIS) criteria for the diagnosis of VAP.

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## Materials and Methods

All hospitalized adult patients on MV > 48 hours in the medical intensive care unit (MICU) for one year from October 2018 to September 2019 were included while those admitted to MICU with pneumonia or with a diagnosis of VAP from other hospitals were

**Table 1:** Clinical pulmonary infection score calculation

| *Assessed parameter* | *Result* | *Score* |
|---|---|---|
| Temperature (°C) | 36.5–38.4 °C | 0 |
| | 38.5–38.9 °C | 1 |
| | ≤36 or ≥39 °C | 2 |
| Leukocytes in blood (cells/mm$^3$) | 4,000–11,000/mm$^3$ | 0 |
| | <4,000 or > 11,000/mm$^3$ | 1 |
| | ≥ 500 band cells | 2 |
| Tracheal secretions (subjective visual scale) | None | 0 |
| | Mild/non-purulent | 1 |
| | Purulent | 2 |
| Radiographic findings (on chest radiography, excluding CHF and ARDS) | No infiltrate | 0 |
| | Diffuse/patchy infiltrate | 1 |
| | Localized infiltrate | 2 |
| Culture results (endotracheal aspirate) | No or mild growth | 0 |
| | Moderate or florid growth | 1 |
| | Moderate or florid growth and pathogen consistent with Gram stain | 2 |
| Oxygenation status (defined by $PaO_2$:$FiO_2$) | > 240 or ARDS | 0 |
| | ≤ 240 and absence of ARDS | 2 |

ARDS, acute respiratory distress syndrome; CHF, congestive heart failure; $PaO_2$:$FiO_2$, a ratio of arterial oxygen partial pressure to fractional inspired oxygen

excluded from this study. The estimated sample size was 273 using Open Epi software, with a 95% confidence interval, assuming alpha error of 5%, and absolute precision of 5%. All patients who were mechanically ventilated >48 hours, were followed up daily and the different criteria (CPIS and surveillance criteria) (Tables 1 and 2) needed for diagnosing VAP were employed. When there was a clinical suspicion of VAP, endotracheal aspirates (EA) were collected and subjected to Gram's stain and semi-quantitative culture.

The data were entered into Epicollect software. Continuous variables like age, duration of MV, the onset of VAP were expressed as mean with standard deviation. Incidence of VAP was expressed as incidence proportion with a 95% confidence interval and also as incidence density of VAP per ventilator days. The etiology was summarized as percentages. Kappa statistics were calculated to assess the concordance between NHSN surveillance criteria and CPIS for diagnosis of VAP.

## Results

Out of 273 patients who met inclusion criteria, 93 (34.1%) patients developed VAP using CPIS criteria, and 33 (12.1%) developed VAP according to NHSN surveillance criteria resulting in a VAP rate of 39.5 per 1000 ventilator days and 11.5 per 1000 ventilator days, respectively. In our study, 16 (5.9%) patients met VAC criteria, 1 (0.4%) patient met IVAC criteria, and 16 (5.9%) met PVAP criteria using NHSN surveillance criteria. All the patients who were diagnosed to have VAP by NHSN surveillance criteria had CPIS > 6. The demographic details of patients developing VAP are shown in Table 3. Using CPIS as a gold standard, the sensitivity and specificity of NHSN surveillance criteria for detecting VAP were found to be 35.5% and 100%, respectively (Table 4). There was a fairly good agreement between CPIS and NHSN criteria with a kappa factor of 0.42 with a *p*-value < 0.001.

**Table 2:** Ventilator-associated events (VAE) surveillance algorithm

| | |
|---|---|
| MV criteria | Patient has MV in place for 2 days or more or if removed, MV was in place on the day of sample collection or the day before |
| Baseline period | Patient should have a baseline period of stability which is defined as ≥2 days of stable or decreasing daily minimum $FiO_2$ or PEEP (positive end-expiratory pressure) |
| Ventilator-associated condition (VAC) | After a baseline period, the patient should have at least one of the following criteria of worsening of oxygenation<br>• Increase in daily minimum $FiO_2$ of ≥0.20 sustained for ≥2 days or<br>• Increase in daily minimum PEEP values ≥ 3 cm $H_2O$ sustained for ≥2 days |
| Infection-related ventilator-associated complications (IVAC) | During the infection window period of VAC, patient should have both<br>• Temperature > 100.4 °F or WBC count ≥ 12,000 or ≤4,000 cells/mm$^3$ and<br>• A new antimicrobial agent is started and continued for ≥4 days |
| Possible ventilator-associated pneumonia (PVAP) | Criterion 1 Positive quantitative/ semi-quantitative culture<br>ET aspirate ≥ $10^5$ CFU/mL; BAL (bronchoalveolar lavage) ≥ $10^4$ CFU/mL; lung tissue ≥ $10^5$ CFU/g; protected specimen brushing ≥ $10^3$ CFU/mL<br>Criterion 2 Qualitative culture plus Gram stain: Gram stain shows purulent respiratory secretions plus a positive culture of any growth (Criterion-1 specimens and sputum)<br>Criterion 3 One of the following positive tests:<br>• Organism identified from pleural fluid<br>• Lung histopathology<br>• Diagnostic test for *Legionella* species<br>• Diagnostic test for respiratory viruses |

**Table 3:** Baseline characteristics of patients developing VAP

| *Parameters* | *CPIS (n = 93)* | *NHSN (n = 33)* |
|---|---|---|
| Age | 45.2 ± 15.9 | 40.36 ± 13.98 |
| Gender | | |
| Male | 62 (66.7%) | 22 (66.7%) |
| Female | 31 (33.3%) | 11 (33.3%) |
| Duration of MV (days) | 8.44 ± 3 | 9.06 ± 3.96 |
| Onset of VAP (days) | 4.7 ± 1.81 | 4.48 ± 1.48 |

## Discussion

Ventilator-associated pneumonia is one of the most common hospital-acquired infections among mechanically ventilated patients. The incidence of VAP in our study was 39.59 episodes per 1,000 ventilator days according to CPIS criteria, which is similar to other Indian studies where the incidence of VAP ranged from 8.9–46 episodes per 1,000 ventilator days.[7] This high incidence rate may be due to inadequate nursing staff in the ICU (ideally 1:1 ratio) which would indirectly have a negative impact on the care conferred to the patients.

Our study was conducted only in MICU, therefore the difference in the occurrence of VAP between different ICUs was not studied. A

**Table 4:** Test characteristics of NHSN surveillance criteria for the diagnosis of VAP

| *VAC criteria* | *IVAC criteria* | *PVAP criteria* | *No. of patients fulfilling the criteria* | *Diagnosis by NHSN criteria* |
|---|---|---|---|---|
| ✓ | – | – | 16 | VAE |
| ✓ | ✓ | – | 1 | VAE |
| ✓ | ✓ | ✓ | 16 | VAE |
| ✓ | – | ✓ | 16 | No VAE |
| – | ✓ | – | 0 | No VAE |
| – | ✓ | ✓ | 44 | No VAE |
| – | – | ✓ | 42 | No VAE |
| – | – | – | 138 | No VAE |

study by Song et al. showed that there was no significant difference in the incidence of VAP between MICU and surgical intensive care unit (SICU).[8] However, a study by Dallas showed that the incidence of VAP was higher in SICU (13.6 per 1,000 ventilator days) when compared to MICU (4.8 per 1000 ventilator-days).[9] A study done by Joseph et al. showed that there was no significant change in the incidence of VAP between MICU and critical care unit (CCU) ($p$-value = 0.0976).[10]

Our study results proved that the NHSN surveillance scoring system had a weakened ability to recognize patients with a clinical suspicion of VAP, indicating a huge disparity in deciding the VAP occurrence rates. In the present study, out of 273 who were included in the study period, only 33 (12.08%) patients had ventilator-associated events using the NHSN surveillance scoring system proposed by CDC resulting in a VAP rate of 11.53 per 1,000 ventilator days. Our finding was similar to those of Skrupky et al. who found that only 14.5% of clinically diagnosed VAP cases were identified using NHSN surveillance criteria.[11] Similar studies conducted by Lilly et al. and Waltrick et al. showed that the sensitivity of NHSN surveillance criteria in diagnosing VAP was 32% and 37%, respectively.[6,12] A study conducted by Miller et al. in 2006 in trauma ICU showed that there was less precision when surveillance criteria were utilized at the bedside to settle on treatment choices and resulted in non-treatment in 16% of VAP cases.[5]

Numerous patients who satisfied the VAP definition (CPIS) and had VAP with elevated levels of clinical suspicion were not recognized using the NHSN surveillance criteria basically on the grounds that they did not meet the stable baseline necessities of ventilator settings or did not have worsening of gas exchange indicated by an increase in $FiO_2$ or PEEP (positive end-expiratory pressure) for 2 days which cannot be seen in all the patients. Another possible reason for the reduced sensitivity of the NHSN surveillance criteria is that it did not utilize the most delicate variable for pathologically analyzed VAP that is the chest radiograph.

Our study has a few drawbacks, such as a small sample size and involving only one ICU (MICU) that limited the study power.

## Conclusion

To conclude, clinicians and the hospital infection control committee should be careful while interpreting the data on VAP detailed to them using surveillance criteria, as they tend to have lower sensitivity in predicting the infection and may under-report the occurrence of these infections.

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**Ethical statement:** This study received ethical approval from the institute ethics committee JIPMER—JIP/IEC/2018/0142.

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