Ventilator-Associated Events: The Quest for Objectivity

Presented by: Matthew B. Crist, MD, MPH
Objectives

- Review ventilator-associated event (VAE) definitions
- Discuss tiers of VAE algorithm
- Demonstrate VAE surveillance methods
- Provide tips and tools for beginning VAE surveillance
Outline

• Background
• Definitions
• VAE Algorithms
• Ventilator-Associated Condition (VAC)
  ▪ Determination of Event Date
  ▪ Establish Window Period
• Infectious VAC (IVAC)
  ▪ Fever and white blood cell count
  ▪ Antibiotic start
• Possible or Probable Ventilator-Associated Pneumonia (VAP)
  ▪ Gram stains
  ▪ Culture results
• Denominator data
• Tips and tools for getting started
Ventilator-associated pneumonia is an important healthcare-associated infection with significant morbidity and mortality.

However, there has not been a valid, reliable surveillance definition.

NHSN pneumonia definitions are very subjective:
- Utility in monitoring within a facility
- Not well suited for comparisons between facilities
Subjectivity of NHSN- PNU 1, 2, 3

- Chest x-rays
  - Lack specificity
  - Interobserver variability

- Clinical signs and symptoms
  - Lack sensitivity and specificity
  - Depend on documentation

- Microbiological evidence
  - Lack sensitivity and specificity
  - Culturing practices vary by provider
  - Controversy regarding best practices
A New Approach

- Working group convened in 2011 to revamp VAP surveillance

- Finalized and implemented into NHSN in January 2013
  - Focus on objectivity, reliability, and more suitable for automated capture
  - Includes more general measures of ventilator-associated conditions and complications
VAE Working Group Members

- American Association of Critical Care Nurses
- American Association for Respiratory Care
- American College of Chest Physicians
- Association for Professionals in Infection Control and Epidemiology
- American Thoracic Society
- Council of State and Territorial Epidemiologists
- HICPAC Surveillance Working Group
- Infectious Disease Society of America
- Society of Critical Care Medicine
- Society for Healthcare Epidemiology of America
- US Department of Health and Human Services/Office of Disease Prevention and Health Promotion
- National Institute of Health
VAE Protocol

- VAE protocol went live in January 2013
  - VAP protocol also remained in-plan in 2013

- In January 2014 VAE became the only in-plan option available for ventilated patients
  - VAP is now only available for in-plan surveillance in pediatric locations
  - PNEU definitions are still available for off-plan surveillance in adult ICUs

- Will be required to be reported under HIDA in SC beginning January 2015
VAE Surveillance: Tiered Approach

- **Tiers 1 and 2**
  - **Objective Criteria:** Suitable for potential public reporting
    - Ventilator Support Settings
    - Fever: Temp > 100.4
    - WBC ≥ 12
    - Antibiotic start

- **Tier 3**
  - Better suited for internal monitoring
  - Incorporate microbiology criteria
Comparison to Prior Definitions

- Reasonable to expect that VAE rates will be higher than PNEU/VAP rates, using 2002 PNEU definitions

- Cannot benchmark/compare with the “old” VAP Rates
  \[ \text{PNEU/VAP} \neq \text{possible VAP + probable VAP} \]

- At least one year of data to establish a baseline period
VAE Definition Algorithm Summary

- Respiratory status component
  - Patient on mechanical ventilation > 2 days
  - Baseline period of stability or improvement, followed by sustained period of worsening oxygenation
  - Ventilator-Associated Condition (VAC)

- Infection / inflammation component
  - General evidence of infection/inflammation
  - Infection-Related Ventilator-Associated Complication (IVAC)

- Additional evidence
  - Positive results of microbiological testing
  - Possible or Probable VAP

No CXR needed!
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- **Additional evidence**
  - Positive results of microbiological testing

**Ventilator-Associated Condition (VAC)**

**Infection-Related Ventilator-Associated Complication (IVAC)**

**Temperature or WBC and New antimicrobial agent**

**Possible or Probable VAP**
VAE Definition Algorithm Summary

- **Respiratory status component**
  - Patient on mechanical ventilation > 2 days
  - Baseline period of stability or improvement, followed by sustained period of worsening oxygenation
  - **Ventilator-Associated Condition (VAC)**

- **Infection/inflammation component**
  - General evidence of infection/inflammation
  - **Infection-Related Ventilator-Associated Condition (IVAC)**

- **Additional evidence**
  - Positive results of microbiological testing
  - Possible or Probable VAP

- Purulent secretions and/or other positive laboratory evidence
Who is eligible?

- Inpatients of:
  - Acute care hospitals
  - Long term acute care (LTAC) hospitals
  - Inpatient rehabilitation facilities (IRFs)
- Patients receiving mechanical ventilation
- Patients in adult locations
  - Includes patients <18 years old in adult locations

* Not recommended that young children in adult locations who are not thought to be physiologically similar to the location’s adult patient population be included in VAE surveillance
Who is not eligible?

- Patients who have been ventilated for <3 days
- Patients on high frequency ventilation or extracorporeal life support (during the time they are receiving those therapies)
- Patients in locations other than NHSN adult locations
  - Adult patients in pediatric locations are included in PED-VAP surveillance
Ventilator

- Device to assist or control respiration continuously, inclusive of the weaning period, through a tracheostomy or endotracheal tube

- Respiratory support not considered mechanical ventilation unless delivered via tracheostomy or endotracheal tube:
  - Intermittent positive-pressure breathing (IPPB)
  - Nasal positive end-expiratory pressure (nasal PEEP)
  - Continuous nasal positive airway pressure (CPAP)

- No change from previous definition
Modes of Ventilation

- **Excluded** from VAE surveillance
  - High frequency ventilation
  - Extracorporeal life support

- **Included** in VAE surveillance
  - Prone position
  - Nitric oxide or epoprostenol therapy
  - Airway Pressure Release Ventilation (APRV)
Episode of Mechanical Ventilation

- A period of days during which the patient was mechanically ventilated for some portion of each consecutive day.

- A break in mechanical ventilation of at least one full calendar day followed by reintubation and reinitiation of mechanical ventilation is a new episode.
Tier 1: VAC

Patient has a baseline period of stability or improvement on the ventilator, defined by ≥ 2 calendar days of stable or decreasing daily minimum FiO₂ or PEEP values. The baseline period is defined as the two calendar days immediately preceding the first day of increased daily minimum PEEP or FiO₂.

AND

After a period of stability or improvement on the ventilator, the patient has at least one of the following indicators of worsening oxygenation:

1) Increase in daily minimum FiO₂ of ≥ 0.20 (20 points) over the daily minimum FiO₂ in the baseline period, sustained for ≥ 2 calendar days.

2) Increase in daily minimum PEEP values of ≥ 3 cmH₂O over the daily minimum PEEP in the baseline period, sustained for ≥ 2 calendar days.
Positive End Expiratory Pressure (PEEP)

- Pressure at the end of exhalation that is above atmospheric pressure
- PEEP decreases the work of breathing and improves oxygenation
- An increase in PEEP provides more ventilator support for the patient
Fraction of Inspired Oxygen (FiO₂)

- Fraction of oxygen in inspired gas
- FiO₂ of ambient air is 0.21
- FiO₂ can be increased on the ventilator to better oxygenate the patient
Daily Minimum FiO\(_2\) and PEEP

- Choose the lowest FiO\(_2\) and PEEP settings during the calendar day that were maintained for at least 1 hour
- Daily minimum PEEP values of 0-5 cmH\(_2\)O are considered equivalent (=5) for the purpose of VAE surveillance
- Include values recorded during spontaneous breathing trials or other forms or weaning
- Do not include periods of time when:
  - the patient is on an excluded mode of ventilation
  - the patient is not on mechanical ventilation (T-piece trial or trach collar trial)
Airway Pressure Release Ventilation

- Included in VAE surveillance
- VAC determined by changes in FIO$_2$ only
- Changes in PEEP in the algorithm may not be applicable to APRV
- Leave PEEP blank in VAE calculator (do not enter 0)

- If patient is on APRV part of the day and a conventional mode for part of the day the PEEP values while on the conventional mode can be used to determine a minimal PEEP for VAC determination
Period of Stability or Improvement

- Defined as ≥2 calendar days of stable or decreasing daily minimum FiO$_2$ or PEEP values
- The baseline period is defined as the 2 calendar days immediately preceding the first day of increased daily minimum PEEP or FiO$_2$
Evidence of Worsening Oxygenation

- After the period of stability or improvement on the ventilator, the patient has at least one of the following indicators of worsening oxygenation:
  - Increase in daily minimum PEEP of $\geq 3$ cmH$_2$O, over the daily minimum PEEP in the baseline period, sustained for $\geq 2$ calendar days
  - Increase in daily minimum FiO$_2$ of $\geq 0.20$, over the daily minimum FiO$_2$ in the baseline period, sustained for $\geq 2$ calendar days
Date of Event

- The date of onset of worsening oxygenation
- Day 1 of the ≥ 2 day period of worsening oxygenation
- Not the date on which all VAE criteria are met
VAE Window Period

- This is the period of days around the event date (i.e., the day of onset of worsening oxygenation) within which other VAE criteria must be met.

- Usually 5-day period:
  - The 2 days before the VAE event date
  - The event date
  - The 2 days after the event date

- Does not include ventilator days 1 and 2
- Will be < 5 days if event date is on mechanical ventilation day 3 or 4
## VAE Window Period

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When is the VAE window period <5 days?

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Can’t count data in 1st 2 days of MV for IVAC, Poss/Prob VAP

Event Date

2 days after Event Date
### VAE Surveillance: Table

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<th>Vent Day</th>
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## Determine Event Date

### 2-day period of stability (PEEP or FiO₂)

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### Columns
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- **FiO₂ min**
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2-day period of worsening, based on PEEP or FiO₂
## VAE Surveillance: Determine Event Date

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<th>PEEP (min)</th>
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Establish the VAE Window Period

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In this case—there is only 1 day before onset of worsening (because cannot count 1st 2 days of MV)

Event Date, day 1 of worsening

2-day period after onset of worsening
Next Step

- What definition has been met at this point?
Next Step

- What definition has been met at this point?
  - Ventilator-Associated Condition (VAC)
Next Step

- What definition has been met at this point?
  - Ventilator-Associated Condition (VAC)

- Since VAC definition was met proceed to Tier 2 and determine if IVAC definition is met

- If the criteria for VAC is not met, you do not need to proceed further
Tier 2: IVAC

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, the patient meets both of the following criteria:

1) Temperature > 38 °C or < 36°C, OR white blood cell count ≥ 12,000 cells/mm³ or ≤ 4,000 cells/mm³.

2) A new antimicrobial agent(s)* is started, and is continued for ≥ 4 calendar days.

*See Appendix for eligible agents.
Temperature or WBC Criteria

- As long as the abnormal temperature or WBC is documented to have occurred during the window period the criteria is met.

- Does not matter if it was present prior to the window period.
Temperature or WBC Criteria

Look for abnormal temp or white count during VAE Window Period

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<tr>
<th>Vent Day</th>
<th>PEEP min</th>
<th>FiO₂ min</th>
<th>Temp min</th>
<th>Temp max</th>
<th>WBC min</th>
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New Antimicrobial Agent

- Any agent listed in the protocol Appendix that is initiated in the **VAE Window Period**

- Considered new if NOT given in the 2 days preceding the current start date

- Must be continued for ≥ 4 consecutive days

- Must be administered IV, IM, via digestive tract, or via respiratory tract
New Antimicrobial Agent

- No requirement that the same antimicrobial agent be given on the 4 consecutive days

- However, if antibiotic is changed after the window period, it does not count as a new agent or contribute to the 4 consecutive days

- Days between administrations of a new antimicrobial agent count if there is a gap of no more than 1 calendar day between administrations of the same drug
### Qualifying Antimicrobial Days (QADs)

#### Same agent, given every other day = 7 consecutive QADs

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<tr>
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#### Vs

#### Different agents, with gap between agents: only 2 consecutive QADs

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**Key:**
- **Abx:** Antibiotic
- **QAD:** Qualifying Antimicrobial Days
- **Levo:** Levo,
- **Mero:** Mero,
New Antibiotic Start

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New antimicrobial agent started and continued for 4 days

= IVAC
Tier 3: Possible VAP

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, ONE of the following criteria is met:

1) Purulent respiratory secretions (from one or more specimen collections)
   - Defined as secretions from the lungs, bronchi, or trachea that contain >25 neutrophils and <10 squamous epithelial cells per low power field [lpf, x100].
   - If the laboratory reports semi-quantitative results, those results must be equivalent to the above quantitative thresholds.

2) Positive culture (qualitative, semi-quantitative or quantitative) of sputum*, endotracheal aspirate*, bronchoalveolar lavage*, lung tissue, or protected specimen brushing*

*Excludes the following:
   - Normal respiratory/oral flora, mixed respiratory/oral flora or equivalent
   - Candida species or yeast not otherwise specified
   - Coagulase-negative Staphylococcus species
   - Enterococcus species
Tier 3: Probable VAP

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, ONE of the following criteria is met:

1) Purulent respiratory secretions (from one or more specimen collections—and defined as for possible VAP)

AND one of the following (see Table 2):
- Positive culture of endotracheal aspirate*, ≥ 10^5 CFU/ml or equivalent semi-quantitative result
- Positive culture of bronchoalveolar lavage*, ≥ 10^4 CFU/ml or equivalent semi-quantitative result
- Positive culture of lung tissue, ≥ 10^4 CFU/g or equivalent semi-quantitative result
- Positive culture of protected specimen brush*, ≥ 10^3 CFU/ml or equivalent semi-quantitative result

*Same organism exclusions as noted for Possible VAP.

2) One of the following (without requirement for purulent respiratory secretions):
- Positive pleural fluid culture (where specimen was obtained during thoracentesis or initial placement of chest tube and NOT from an indwelling chest tube)
- Positive lung histopathology
- Positive diagnostic test for *Legionella* spp.
- Positive diagnostic test on respiratory secretions for influenza virus, respiratory syncytial virus, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus, coronavirus
Possible VAP

- Purulent respiratory secretions
  - Secretions from the lungs, bronchi, or trachea
  - $\geq 25$ neutrophils (polys, PMNs) per low power field
  - $\leq 10$ squamous epithelial cells per low power field
  
or

- Positive lower respiratory tract cultures
  - Sputum
  - Endotracheal aspirate
  - Bronchoalveolar lavage
  - Protected specimen brushing
  - Lung tissue
Probable VAP

- Purulent respiratory secretions (same as for possible VAP) and
- Positive lower respiratory tract cultures (does not include sputum culture)
  or
- Other criteria for Probable VAP (does not require purulent respiratory secretions)
  - Positive pleural fluid culture
  - Positive lung histopathology
  - Positive tests for Legionella or
  - Respiratory virus infection
Semi-Quantitative Gram stains

- Ask your laboratory manager/director first
- If your lab does not have this information, use the following:
  - 1+ = occasional or rare = <1 cell per lpf, x100)
  - 2+ = few = 1-9 cells per lpf, x100
  - 3+ = moderate = 10-25 cells per lpf, x100
  - 4+ = heavy = >25 cells per lpf, x100
- Thus, without information from your lab, “purulent respiratory secretions” are defined by:
  - ≥25 neutrophils per lpf, x100 = “heavy” or 4+
  - ≤10 squamous epithelial cells per lpf, x100 = “rare”, “occasional”, “few”, 1+ or 2+
Lower Respiratory Cultures

- Exclude the following as a pathogen unless isolated from lung tissue or pleural fluid:
  - Candida species or yeast not otherwise specified
  - Coagulase negative Staphylococcus species
  - Enterococcus species

- Positive pleural fluid culture meets criteria for probable VAP without purulent respiratory secretions

- Exclude the following culture results (or similar):
  - Normal respiratory flora / Normal oral flora
  - Mixed respiratory flora / Mixed oral flora
  - Altered oral / respiratory flora
Non-Culture Based Results: Probable VAP only

- Positive diagnostic test for *Legionella*
- Positive diagnostic test for respiratory viruses
  - Influenza
  - Parainfluenza
  - RSV
  - Human metapneumovirus
  - Adenovirus
  - Rhinovirus
  - Coronavirus

- Other pathogens that may be detected with non-culture-based techniques are not currently included in probable VAP criteria
Histopathology (Lung) Results

- Identification of abscess formation or foci of consolidation with intense neutrophil accumulation in bronchioles and alveoli
- Evidence of lung parenchyma invasion by fungi (hyphae, pseudohyphae, or yeast forms)
- Evidence of infection with viral pathogens (immunohistochemical assays, cytology, microscopy)
Possible or Probable VAP

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Purulent respiratory secretions AND positive quantitative or semi-quantitative ETA culture (meeting specified threshold)

= Probable VAP
Tiered Approach

1. For most patients only need to record daily minimum PEEP and FiO$_2$ while on ventilator

2. Only need to assess temperature and white blood cell count for patients who fulfill VAC criteria and only for VAE Window Period

3. Only need to look at antimicrobial administrations for patients with VAC who meet temp or WBC criteria

4. Only need lab/microbiology/pathology data for patients with IVAC and only during the VAE Window Period
Can the same patient have multiple VAEs?

- Each VAE is 14 days in duration

- Day 1 is the Event Date—so if June 1 is date of onset of a second VAE cannot be detected until June 15

- Period is event date to event date—so baseline period can occur during previous event period

- May not “upgrade” a VAE based on data collected outside the VAE Window Period but in the 14-day event period
Pathogen Reporting

- Pathogens reported for Possible VAP and Probable VAP, according to usual pathogen and antimicrobial susceptibility reporting methods utilized in NHSN for other events

- Pathogens NOT reported for VAC or for IVAC
Secondary Bloodstream Infections

- Secondary BSI may be reported for Possible and Probable VAP
  - At least one organism from the blood culture matches an organism from an appropriate respiratory tract specimen collected during the VAE Window Period
  - The blood culture was collected within the 14 day event period
- Secondary BSI may NOT be reported for Possible and Probable VAP if no respiratory culture performed
  - Possible VAP met with purulent respiratory secretions
  - Probable VAP met with histopathology criterion
- Secondary BSIs NOT reported for VAC or IVAC

BSI cannot be attributed to VAC or IVAC or a possible or probable VAP without a culture
Can a BSI still be attributed to a PNEU or LRI?

- If Possible or Probable VAP is met but a positive blood culture cannot be attributed to Possible or Probable VAP a BSI cannot be secondary to PNEU or LRI
  - Not a matching pathogen
  - Respiratory culture was not performed

- If only VAC or IVAC are met or if no VAE definition is met a positive blood culture can potentially be secondary to PNEU or LRI if NHSN definition is met
Location of Attribution

- Defined as the inpatient location where the patient was assigned on the VAE event date (the date of onset of worsening oxygenation)

- Transfer Rule: If VAE develops on the day of transfer or the day following transfer from one inpatient location to another, the VAE is attributed to the transferring location
Denominator Data

- Device (ventilator) days and patient days
- Collect data at the same time each day
- Daily counts are summed and only the total for the month is reported in NHSN

- Ventilator days – number of patients in location who are managed with a ventilatory device
Denominator Data

- Ventilator days for all patients are counted including:
  - Ventilator < 3 days
  - Those receiving excluded therapies
  - Pediatric patients housed in adult locations

- Number of patients on APRV mode of ventilation or related modes included in total and also indicated separately

- Patient days = number of patients in chosen location
Tips for Getting Started

1. Get familiar with the NHSN protocol and review FAQs
2. Establish relationships with Respiratory Therapy and/or Critical Care:
   – Share the Protocol
   – Discuss options for collection of minimum daily PEEP and FiO2 for each
   – MV day (IP, RT, electronically generated)
   – Inquire about frequency with which excluded therapies (HFV, extracorporeal support) are used, and APRV
3. Determine your lab’s approach to Gram stain and culture result reporting
4. Explore tools for data collection and for learning the definitions and making VAE determinations
VAE Tools

- VAE protocols

- VAE calculator

- Tennessee checklists
  - http://health.state.tn.us/ceds/hai/
Take-Home Points

- Patient must be ventilated >2 calendar days
- Earliest VAE event date is day 3 of mechanical ventilation
- Patient must have ≥2 calendar days of stability or improvement followed by ≥2 calendar days of worsening oxygenation
- Date of Event is the 1st day of worsening oxygenation
- VAE Window Period:
  - 2 days before, the day of, and 2 days after the VAE Event Date
  - Does not include mechanical ventilation days 1 and 2
- All criteria must be identified in the VAE Window Period
Acknowledgements

- Shelley MaGill, CDC DHQP
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- VAE Working Group
- CDC Prevention Epicenters
- Other Subject Matter Experts
Questions?

Matthew B. Crist, MD, MPH
Medical Consultant
South Carolina Department of Health and
Environmental Control
Division of Acute Disease Epidemiology
2100 Bull St. Columbia, SC 22901
803-898-2110 (p)
cristmb@dhec.sc.gov