NATIONAL HEALTHCARE SAFETY NETWORK

Pneumonia Event (PNEU)
Ventilator-Associated Event (VAE)
Pediatric VAE (PedVAE)

1

REFERENCE ACKNOWLEDGMENT

2024 NHSN ANNUAL TRAINING

- Patient Safety Component: Pneumonia(PNEU) Surveillance
- Pediatric Ventilator-associated event (PedVAE) Surveillance

Jennifer Watkins, RN, BSN, MPH
NHSN Protocol and Training Team

- Ventilator Associated Event (VAE)

Surveillance Guideline and Protocol Application (2024)
Emily Witt, MPH
NHSN Protocol and Training Team

2

MEETING PNEU (PNU1, PNU2, PNU 3)

- PNEU is comprised of:
  - PNU 1
  - PNU 2
  - PNU 3
- Each have their own algorithms
- Must meet all elements to the criterion
- **Must meet the footnote requirements**

The interpretation and guidance provided in the footnotes are an important part of the algorithms and must be incorporated into the decision-making process when determining if a PNEU definition is met

3

TABLE 1: SPECIFIC SITE ALGORITHMS for Clinically Defined Pneumonia (PNU1)

Imaging Test Evidence	Signs/symptoms
Two or more serial chest imaging test results with at least **one** of the following: New and persistent OR Progressive and persistent: • Infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤1 year old Note: In patients ***without*** underlying pulmonary or cardiac disease (for example respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), ***at least one definitive*** imaging test result is acceptable	For **ANY PATIENT**, at least one of the following: • Fever (>38.0°C or > 100.4°F) • Leukopenia (≤4000 WBC/mm³) or leukocytosis (≥12,000 WBC/mm³) • For adults ≥ 70 years old, altered mental status with no other recognized cause And at least ***two*** of the following: • New onset of purulent sputum or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea • Rales or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-PaO_2/FiO_2 ≤ 240), increased oxygen requirements or ventilator demand)

4

TABLE 1: SPECIFIC SITE ALGORITHMS for Clinically Defined Pneumonia (PNU1)

Imaging Test Evidence	Signs/symptoms
Two or more serial chest imaging test results with at least **one** of the following: New and persistent OR Progressive and persistent: • Infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤1 year old **Note**: In patients ***without*** underlying pulmonary or cardiac disease (for example respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), ***at least one definitive*** imaging test result is acceptable	**ALTERNATE CRITERIA**: for infants ≤ 1 year old: Worsening gas exchange (i.e., O_2 desaturation {for example pulse oximeter <94%}, increased oxygen requirements or ventilator demand) And at least **three** of the following: • Temperature instability • Leukopenia (≤4000 WBC/mm³) **or** leukocytosis (≥15,000 WBC/mm³) and left shift (≥ 10% band forms) • New onset of purulent sputum **or** change in character of sputum, or increased respiratory secretions, or increased suctioning requirements • Apnea, tachypnea nasal flaring with retraction of chest wall, or nasal flaring with grunting • Wheezing, rales or rhonchi • Cough • Bradycardia (<100 beats/min) or tachycardia (>170 beats/min)

5

TABLE 1: SPECIFIC SITE ALGORITHMS for Clinically Defined Pneumonia (PNU1)

Imaging Test Evidence	Signs/symptoms
Two or more serial chest imaging test results with at least **one** of the following[1,2,14]: New and persistent OR Progressive and persistent: • Infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤1 year old **Note**: In patients ***without*** underlying pulmonary or cardiac disease (for example respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), ***at least one definitive*** imaging test result is acceptable[1]	**ALTERNATE CRITERIA**: for child > 1 year old or ≤ 12 years old, at least ***three*** of the following: • Fever (>38.0°C or > 100.4°F) or hypothermia (< 36.0°C or <96.8°F) • Leukopenia (≤4000 WBC/mm³) **or** leukocytosis (≥15,000 WBC/mm³) • New onset of purulent sputum[3] **or** change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements • New onset of worsening cough, or dyspnea, or apnea, or tachypnea[5] • Rales[6] or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation {for example pulse oximeter <94%}, increased oxygen requirements or ventilator demand)

6

TABLE 2: SPECIFIC SITE ALGORITHM for Pneumonia with Common Bacterial or Filamentous Fungal Pathogens and Specific Laboratory Findings (PNU2)

Imaging Test Evidence	Signs/Symptoms	Laboratory
Two or more serial chest imaging test results with at least **one** of the following: New and persistent OR Progressive and persistent: • Infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤1 year old Note: In patients ***without*** underlying pulmonary or cardiac disease (for example respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), ***at least one definitive*** imaging test result is acceptable	At least ***one*** of the following: • Fever (38.0°C or >100.4°F) • Leukopenia (≤4000 WBC/mm³) or leukocytosis (≥12,000 WBC/mm³) • For adults ≥ 70 years old, altered mental status with no other recognized cause And at least ***one*** of the following: • New onset of purulent sputum or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea[5] • Rales or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-PaO_2/FiO_2 ≤ 240), increased oxygen requirements or ventilator demand)	At least ***one*** of the following: • Organism identified from blood • Organism identified from pleural fluid • Positive quantitative culture or corresponding semi-quantitative culture result, from minimally-contaminated LRT specimen (specifically, BAL, protected specimen brushing or endotracheal aspirate) • >5% BAL-obtained cells contain intracellular bacteria on direct microscopic exam (i.e., gram stain) • Positive quantitative culture or corresponding semi-quantitative culture result of lung tissue • Histopathologic exam shows at least ***one*** of the following evidences of pneumonia: *Abscess formation or foci of consolidation with intense PMN accumulation in bronchioles and alveoli* *Evidence of lung parenchyma invasion by fungal hyphae or pseudohyphae*

7

TABLE 2: SPECIFIC SITE ALGORITHM for Viral, Legionella and other Bacterial Pneumonias with Definitive Laboratory Findings (PNU2)

Imaging Test Evidence	Signs/Symptoms	Laboratory
Two or more serial chest imaging test results with at least ***one*** of the following: New and persistent OR Progressive and persistent: • Infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤1 year old Note: In patients ***without*** underlying pulmonary or cardiac disease (for example respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), ***at least one definitive*** imaging test result is acceptable[1]	At least ***one*** of the following: • Fever (38.0°C or >100.4°F) • Leukopenia (≤4000 WBC/mm³) or leukocytosis (≥12,000 WBC/mm³) • For adults ≥ 70 years old, altered mental status with no other recognized cause And at least ***one*** of the following: • New onset of purulent sputum or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea • Rales or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-PaO_2/FiO_2 ≤ 240), increased oxygen requirements or ventilator demand)	At least ***one*** of the following: • Virus, *Bordetella, Legionella, Chlamydia*, or *Mycoplasma* identified from respiratory secretions or tissue by a culture or non-culture based microbiologic testing method which is performed for purposes of clinical diagnosis or treatment (not Active Surveillance) • Fourfold rise in paired sera (IgG for pathogen (e.g., influenza virus, *Chlamydia*) • Fourfold rise in *Legionella pneumophila* serogroup 1 antibody titer to ≥1:128 in paired acute and convalescent sera by indirect IFA • Detection of *L. pneumophila* serogroup 1 antigens in urine by RIA or EIA

8

TABLE 3: SPECIFIC SITE ALGORITHM for Pneumonia in Immunocompromised Patients (PNU3)

Imaging Test Evidence	Signs/Symptoms	Laboratory
Two or more serial chest imaging test results with at least **one** of the following: New and persistent OR Progressive and persistent: • Infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤1 year old Note: In patients ***without*** underlying pulmonary or cardiac disease (for example respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), ***at least one definitive*** imaging test result is acceptable	At least ***one*** of the following: • Fever (38.0°C or >100.4°F) • Leukopenia (≤4000 WBC/mm³) or leukocytosis (≥12,000 WBC/mm³) • For adults ≥ 70 years old, altered mental status with no other recognized cause And at least ***one*** of the following: • New onset of purulent sputum or change in character of sputum, or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea • Rales or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-PaO_2/FiO_2 ≤ 240), increased oxygen requirements or ventilator demand)	At least ***one*** of the following: • Identification of matching Candida spp. From blood and one of the following: sputum, endotracheal aspirate, BAL or protected specimen brushing • Evidence of fungi (excluding any Candida and yeast not otherwise specified) from minimally-contaminated LRT specimen (specifically BAL, protected specimen brushing or endotracheal aspirate) from one of the following: direct microscopic exam; positive culture of fungi; non-culture diagnostic laboratory test ***OR*** • Any of the following from: ***LABORATORY CRITERIA DEFINED UNDER PNU2***

9

FOOTNOTE #10: IMMUNOCOMPROMISED PATIENTS

10. Immunocompromised patients include only

- those with neutropenia defined as absolute neutrophil count or total white blood cell count (WBC) < 500/mm³
- those with leukemia, lymphoma, or who are HIV positive with CD4 count < 200
- those who have undergone splenectomy
- those who have a history of solid organ or hematopoietic stem cell transplant
- those on cytotoxic chemotherapy
- those on enteral or parenteral administered steroids (excludes inhaled and topical steroids) daily for > 14 consecutive days on the date of event

10

KEY CONCEPTS

- Specific criteria are included for infants and children under the PNU1 algorithm and PNU3 algorithm is specific to immunocompromised patients, all patients may meet any of the other pneumonia criteria
  - Ex: infant can meet PNU1, PNU2, or PNU3
  - Ex: Immunocompromised patient can meet PNU1 or PNU2
- Hierarchy for reporting if a patient meets more than one definition during the IWP or RIT
  - Meets both PNU1 and PNU2, report PNU2
  - Meets both PNU2 and PNU3, report PNU3

11

KNOWLEDGE CHECK # 1

- Which PNEU definition requires laboratory evidence?

1. PNU1
2. PNU2
3. PNU3
4. Both PNU2 and PNU3

12

IMAGING TEST EVIDENCE

Imaging Test Evidence
Two or more serial chest imaging test results with at least ***one*** of the following (1,2,13): New and persistent **or** Progressive and persistent • Infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤1 year old

Note: In patients ***without*** underlying pulmonary or cardiac disease (such as respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), at least one definitive chest imaging test result is acceptable. (1)

- Imaging requirement is the same for PNU1, PNU2, and PNU3
- New and persistent OR progressive and persistent
- Definitive findings

Reference Footnotes #1, #2, #13

13

IMAGING TEST EVIDENCE

- Evidence suggestive of pneumonia
  - **New or progressive finding** of infiltrate, consolidation, cavitation, pneumatoceles (infants <1 y/o)

AND

- Evidence of persistence
  - No indication of rapid resolution
  - No subsequent indication the finding is attributable to another condition (for example, 2 days later the opacity is now attributed to pulmonary edema)

14

IMAGING TEST EVIDENCE

- **New or Progressive** is determined in comparison to prior imaging test findings
- **New** findings-eligible findings were not present in prior imaging
  - 3/10 imaging findings: lungs are clear
  - 3/12 imaging findings: infiltrates
- **Progressive** findings-eligible findings are worse in comparison to prior imaging
  - 3/10 imaging findings: infiltrates present
  - 3/12 imaging findings: increasing (worsening) infiltrates

15

IMAGING TEST EVIDENCE

- **Persistence** of findings of pneumonia in subsequent imaging test results is required
  - For patients **with** underlying cardiac or pulmonary disease (serial imaging)
  - For **all patients** when multiple temporally related imaging test results are available
- If **at least one definitive** imaging test is available, it can satisfy the imaging requirement in the following situations only:
  - For POA determinations for all patients
  - For patients **without** underlying cardiac or pulmonary disease, when **no other imaging is available**

16

ELIGIBLE IMAGING FINDINGS

- Definitive findings listed in the PNEU algorithms:
  - Infiltrate
  - Consolidation
  - Cavitation
  - Pneumatoceles, in infants ≤1 year old
- Alternative findings-footnote #2
  - Opacities, airspace disease, densities

2. Note that there are many ways of describing the imaging appearance of pneumonia. Examples include, but are not limited to, "air-space disease," "focal opacification," "patchy areas of increased density." Although perhaps not specifically delineated as pneumonia by the radiologist, in the appropriate clinical setting these alternative descriptive wordings should be seriously considered as potentially positive findings. If provided and the findings are not documented as attributed to another issue (for example, pulmonary edema, chronic lung disease), they are eligible for meeting imaging test evidence of pneumonia.

17

WHAT IF IMAGING FINDINGS ARE EQUIVOCAL?

- Equivocal imaging: findings do not conclusively identify an infection or an infectious process
  - Examples: Infiltrate vs. atelectasis; opacity may represent pneumonia or CHF
- Look for further evidence that clarifies

18

CLARIFYING EQUIVOCAL IMAGING

- Subsequent imaging findings are definitive for pneumonia
  - Verifies the equivocal finding is **representative of pneumonia** and that there is **persistence**, making the equivocal finding **eligible for use**, **OR**
- Subsequent imaging findings no longer show pneumonia
  - Verifies the finding is **not representative of pneumonia**, making the equivocal finding **not eligible for use**

See Footnote #13 for more info

19

EQUIVOCAL IMAGING: CLINICAL CORRELATION

- In the absence of verification one way or the other ***THEN* and only then** can clinical correlation be used
  - Clinical correlation is specifically physician documentation of antimicrobial treatment for site-specific infection related to the equivocal imaging finding-in this case **treatment for pneumonia**
- If the imaging does not demonstrate findings of pneumonia, clinical correlation cannot be used

20

IMAGING REPORTS

- Documentation of the radiologist's review of the imaging test
- Imaging reports typically contain 'findings' and 'impressions'
  - Findings = what the radiologist saw
  - Impressions = the radiologist's assessment of what the findings represent
- Both the findings and impressions must be considered when determining if the imaging test results are eligible for use in meeting PNEU

21

PATHOGEN EXCLUSIONS

- All *Candida* species or yeast not otherwise specified
- All coagulase-negative *Staphylococcus* species
- All *Enterococcus* species

- Excluded as a site-specific pathogen **unless** isolated from *lung tissue or pleural fluid*
- If identified from ***blood***, the excluded pathogens can **only** be attributed as secondary to PNEU if PNU2 or PNU3 is met with a matching organism isolated from lung tissue or pleural fluid and the blood specimen is collected in the secondary BSI attribution period.

22

KNOWLEDGE CHECK

- The imaging requirement for PNEU is met with the following imaging test findings:
  - 3/14 – Lungs are clear bilaterally
  - 3/15 – Developing bibasilar and perihilar infiltrates
  - 3/18 – Perihilar infiltrates persist
  - 3/20 – Increasing bilateral infiltrates

1. New definitive finding
2. Persistent finding
3. Progressive & persistent

A. True
B. False

23

KEY POINTS ON SIGNS/SYMPTOMS

- Purulent sputum must meet definition in footnote #3. Documentation of "purulent" does not meet criteria. See Table on page 6-13 for guidance

3. Purulent sputum is defined as secretions from the lungs, bronchi, or trachea that contain ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per low power field (x100). Refer to the table below if your laboratory reports these data semi-quantitatively or uses a different format for reporting Gram stain or direct examination results (for example, "many WBCs" or "few squamous epithelial cells"). This laboratory confirmation is required since written clinical descriptions of purulence are highly variable.

24

PNU2-LABORATORY EVIDENCE

Table 5: Threshold values for cultured specimens used in the diagnosis of pneumonia

Specimen collection/technique	Values*
Lung tissue†	≥ 10^4 CFU/g tissue
Bronchoscopically (B) obtained specimens	
Bronchoalveolar lavage (B-BAL)	≥ 10^4 CFU/ml
Protected BAL (B-PBAL)	≥ 10^4 CFU/ml
Protected specimen brushing (B-PSB)	≥ 10^3 CFU/ml
Nonbronchoscopically (NB) obtained (blind) specimens	
NB-BAL	≥ 10^4 CFU/ml
NB-PSB	≥ 10^3 CFU/ml
Endotracheal aspirate (ETA)	≥ 10^5 CFU/ml

CFU = colony forming units, g = gram, ml = milliliter

*Consult with your laboratory to determine if reported semi-quantitative results match the quantitative thresholds. In the absence of additional information available from your laboratory, a semi-quantitative result of "moderate" or "heavy" or "many" or "numerous" growth, or 2+, 3+, or 4+ growth is considered to correspond.

†Lung tissue specimens obtained by either open or closed lung biopsy methods. For post-mortem specimens, only lung tissue specimens obtained by transthoracic or transbronchial biopsy that are collected immediately post-mortem are eligible for use.

25

KEY POINTS ON SIGNS/SYMPTOMS

- Tachypnea, footnote #5: documented respiratory rate must meet the age-based parameters; documentation of "tachypnea" **does not** meet the criteria

5. In adults, tachypnea is defined as respiration rate > 25 breaths per minute. Tachypnea is defined as > 75 breaths per minute in premature infants born at < 37 weeks gestation and until the 40th week; > 60 breaths per minute in patients < 2 months old; > 50 breaths per minute in patients 2-12 months old; and > 30 breaths per minute in children > 1 year old.

26

KNOWLEDGE CHECK # 3

- Within the 7-day IWP, there is :
  - definitive imaging test evidence suggestive of pneumonia,
  - the patient has leukocytosis,
  - there is documentation of dyspnea and rales, and
  - *E. faecalis* is identified from a BAL specimen

What is identified?

1. PNU1
2. PNU2
3. PNU3
4. None

27

PNEUMONIA & SECONDARY BSI

A PNEU site-specific definition must be met

AND

One of the following scenarios must be met:

Scenario 1:

- At least one organism from the blood specimen matches an organism identified from the site-specific infection that is used as an element to meet the **PNEU** criterion AND the blood specimen is collected during the secondary BSI attribution period, **OR**

Scenario 2:

- An organism identified in the blood specimen is an element that is used to meet PNEU criterion, and therefore is collected during the site-specific IWP.

28

Scenario 2 example

Table 2: Specific Site Algorithm for Pneumonia with Common Bacterial or Filamentous Fungal Pathogens and Specific Laboratory Findings (PNU2)

NOTE: The PNEU Algorithms (PNU1,2,3) and Flowcharts include FOOTNOTE references. The interpretation and guidance provided in the **FOOTNOTES** are an important part of the algorithms and must be incorporated into the decision-making process when determining if a PNEU definition is met.

Imaging Test Evidence	Signs/Symptoms	Laboratory
Two or more serial chest imaging test results with at least ***one*** of the following (1,2,13): New and persistent **or** Progressive and persistent • Infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤1 year old **Note**: In patients ***without*** underlying pulmonary or cardiac disease (such as respiratory distress syndrome,	At least ***one*** of the following: • Fever (> 38.0°C or > 100.4°F) • Leukopenia (≤ 4000 WBC/mm^3) or leukocytosis (≥ 12,000 WBC/mm^3) • For adults ≥ 70 years old, altered mental status with no other recognized cause And at least ***one*** of the following: • New onset of purulent sputum (3) or change in character of sputum (4), or increased respiratory secretions, or increased suctioning requirements • Dyspnea, or tachypnea (5), or new onset or worsening cough • Rales (6) or bronchial breath sounds • Worsening gas exchange (for	At least ***one*** of the following: • Organism identified from blood (8,12) • Organism identified from pleural fluid (9,12) • Positive quantitative culture or corresponding semi-quantitative culture result (9) from minimally contaminated LRT specimen (***specifically, BAL, protected specimen brushing, or endotracheal aspirate***) • ≥ 5% BAL-obtained cells contain intracellular bacteria on direct microscopic exam (for example, Gram's stain) • Positive quantitative culture or corresponding semi-quantitative culture result (9) of lung tissue

29

- PNU1 *does not have* a site-specific specimen or a blood culture as part of the criterion
  - **Therefore, a BSI cannot be secondary to PNU1**
- Pathogens can be reported for PNU2 and PNU3 events
  - Therefore, secondary BSIs can be attributed to PNU2 and PNU 3
- PNU1, PNU2, PNU3 events create a PNEU RIT
  - If PNU2 or PNU3 can be met in the PNEU RIT using the blood specimen as an element in the PNEU IWP, the BSI can be determined secondary to PNEU

30

KNOWLEDGE CHECK #4

- The PNEU definition can be used as a site-specific infection for secondary BSI attribution when conducting CLABSI surveillance

1. True
2. False

31

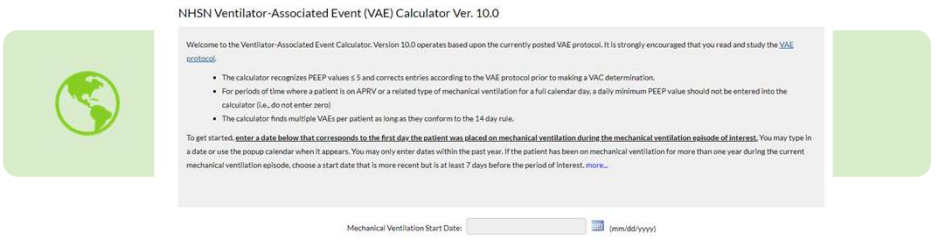
NATIONAL HEALTHCARE SAFETY NETWORK

Ventilator-Associated Event (VAE)

32

VAE TOOLS

VAE Calculator and Worksheets



33

WHY PERFORM VAE SURVEILLANCE

- 2015 CDC point-prevalence survey determined that of the 427 healthcare– associated infections identified in a sample of acute care hospitals in the U.S., pneumonia was the most common infection, with 35% of those being ventilator associated*
- The VAE surveillance definition algorithm implemented by NHSN in January 2013 is based on objective, streamlined, and potentially automatable criteria that identify a broad range of conditions and complications occurring in mechanically-ventilated adult patients
- Other adverse events may occur to ventilated patients: Acute Respiratory Distress Syndrome (ARDS), sepsis, pulmonary embolism, barotrauma, pulmonary edema

*Magill SS, O'Leary E, Janelle SJ, et al. Changes in prevalence of healthcare-associated infections in US hospitals. New England Journal of Medicine 2018; 379:1732-1744.

34

VAE ≠VAP(PNEU) & PVAP ≠VAP(PNEU)

- VAE and PNEU protocols detect two separate and distinct events.
  - It is possible to meet VAE and PNEU
  - It is possible to meet VAE and not PNEU
  - It is possible to meet PNEU and not VAE
  - May not meet either!
- VAE is designed to detect more than VAP

VAP –Ventilator-associated Pneumonia (PNEU definition)
PVAP–Possible Ventilator-associated Pneumonia (VAE definition)
NOTE:
Both VAE and PNEU are available for secondary BSI assignment when conducting BSI surveillance

SPICE

35

VAE surveillance inclusion/exclusion criteria

Inclusion criteria:

- Inpatient locations eligible to participate in VAE surveillance are those **adult locations** in acute care hospitals, long term acute care hospitals, and inpatient rehabilitation facilities where denominator data (ventilator days and patient days) can be collected for patients.
- Pediatric patients in adult locations are included in VAE surveillance

Exclusion criteria:

- Patients on high frequency ventilation (HFV), paracorporeal membrane oxygenation, or extracorporeal life support (ECLS) are not eligible for VAE surveillance (during the time they are receiving those therapies for the entire calendar day)
- Patients in non-acute care locations in an acute care setting (such as a chronic care unit)
- Adults in pediatric locations are included in pedVAP surveillance

SPICE

36

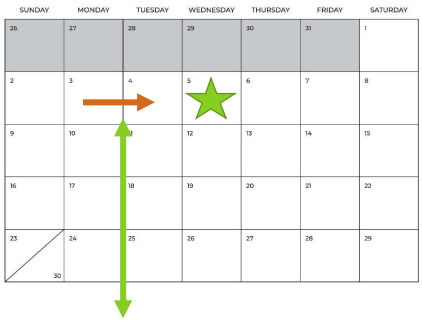
ADJUNCT THERAPIES & ALTERNATIVE MODES OF MECHANICAL VENTILATION

- VAE surveillance
  - Includes patients who are receiving a conventional mode of mechanical ventilation:
    - While in the prone position
    - While receiving nitric oxide therapy, helium-oxygen mixtures (heliox), or epoprostenol therapy
  - Includes patients on Airway Pressure Release Ventilation (APRV) or related modes
    - A mode of mechanical ventilation characterized by continuous application of positive airway pressure with an intermittent pressure release phase
    - Other names: BiLevel, Bi Vent, BiPhasic, PCV+, DuoPAP

37

WHO MEETS VAE CRITERIA?

- Patients must be mechanically ventilated for more than 2 calendar days to be **eligible** for VAE
- The first two days of ventilation can be used to establish the baseline period of stability or improvement, ***but the earliest date of event for VAE is day 3 of mechanical ventilation***



Can be used to establish baseline

38

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/or re-initiation of mechanical ventilation during the same hospitalization, defines a new episode of mechanical ventilation.

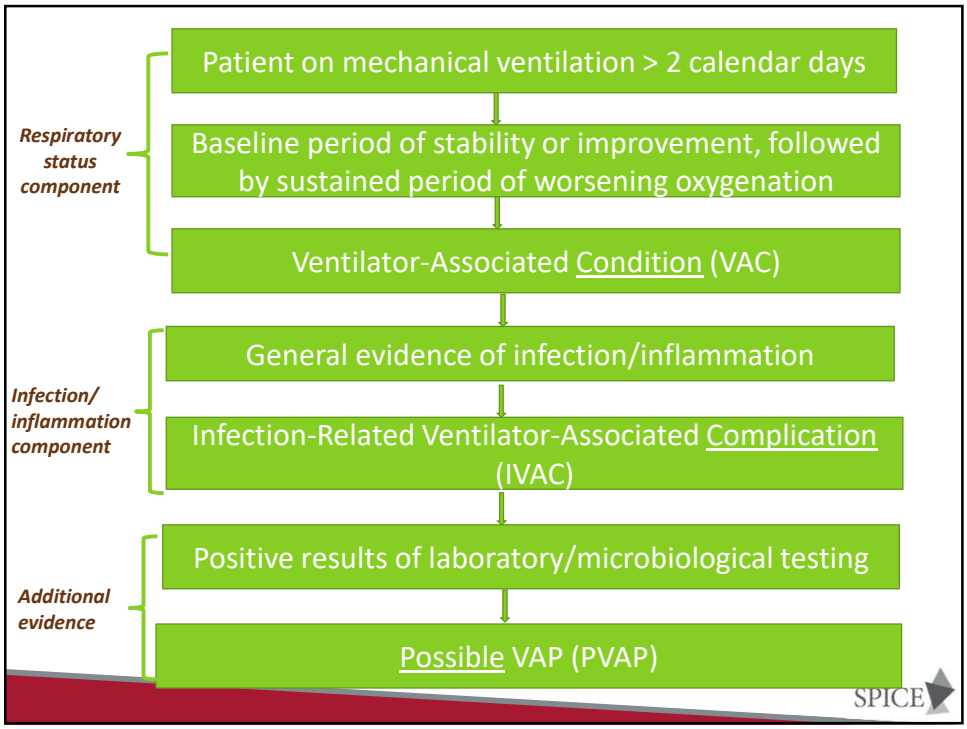
39

VAE ALGORITHM

- VAE is ***NOT*** a clinical definition and ***NOT*** intended for use in the management of patients
- NHSN Chapter 2 Definitions on identifying HAIs **do not apply to VAE**

Concept	SSI	LabID	VAE	PedVAE
Infection Window Period	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Date of Event				
Present on Admission				
Healthcare-associated Infection				
Repeat Infection Timeframe				
Secondary BSI Attribution Period				

40



41

VAE ALGORITHM

- Algorithm is progressive in terms of criteria to be met
- VAC → IVAC → PVAP
- Each subsequent tier is not more significant than the one before it
- All events start with VAC
  - IVAC is not necessarily "worse" than having VAC
  - PVAP is not necessarily worse than having IVAC

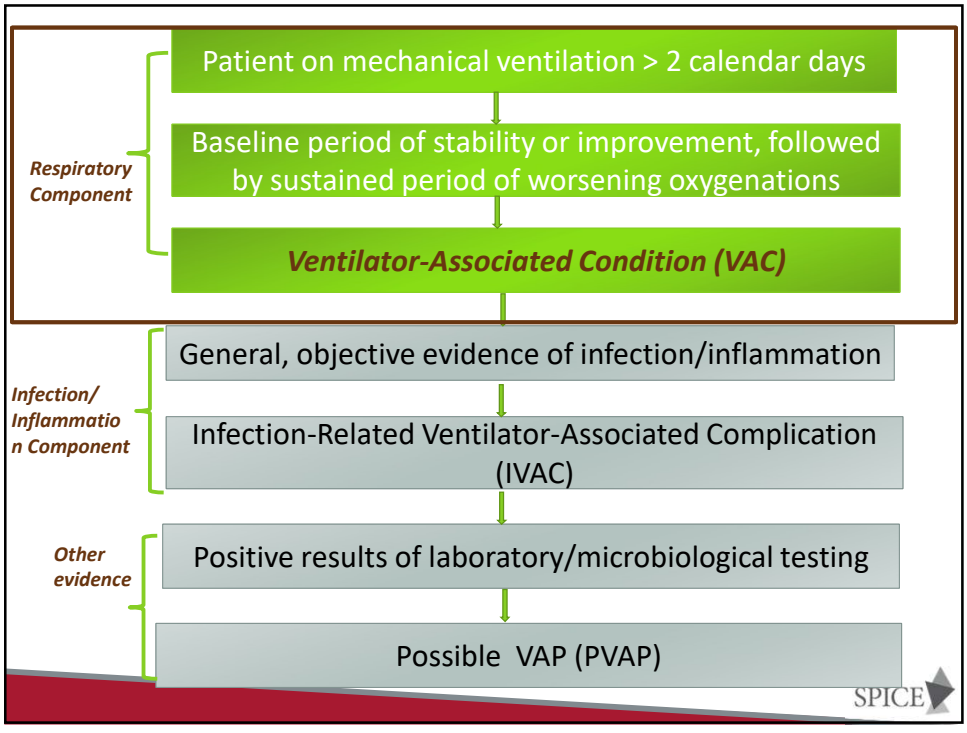
SPICE

42

VAE ALGORITHM

- The fundamental definition within the algorithm is the **VAC**, which is defined on the basis of respiratory deterioration
  - All events start with **VAC** - evidence of respiratory deterioration
  - **IVAC** -additional evidence that the event may be infectious vs. non-infectious
  - **PVAP** -additional evidence the infection may be respiratory related
- ***The VAE is reported at the highest tier of the algorithm that is met***

43



44

OXYGENATION

- Patient's oxygenation needs can be addressed by adjusting the FiO_2 and/or PEEP settings on the ventilator
- **FiO_2**: fraction of oxygen in inspired air
  - Ex: FiO2 of room air is 0.21
  - Oxygenation concentration of room air is 21%
  - 0.21 = 21%
- **PEEP**: positive end-expiratory pressure
  - PEEP is the alveolar pressure above atmospheric pressure at the end of exhalation
  - Achieved by introduction of mechanical impedance to exhalation
  - Expressed in cmH_2O

45

TIER 1: VAC

Figure 1: Ventilator-Associated Events (VAE) Surveillance Algorithm

Patient has a baseline period of stability or improvement on the ventilator, defined by ≥ 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.

*Daily minimum defined by lowest value of FiO_2 or PEEP during a calendar day that is maintained for > 1 hour.

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* FiO_2 of ≥ 0.20 (20 points) over the daily minimum FiO_2 of the first day in the baseline period, sustained for ≥ 2 calendar days.
2) Increase in daily minimum* PEEP values of ≥ 3 cmH_2O over the daily minimum PEEP of the first day in the baseline period†, sustained for ≥ 2 calendar days.

*Daily minimum defined by lowest value of FiO_2 or PEEP during a calendar day that is maintained for > 1 hour.

†Daily minimum PEEP values of 0-5 cmH_2O are considered equivalent for the purposes of VAE surveillance.

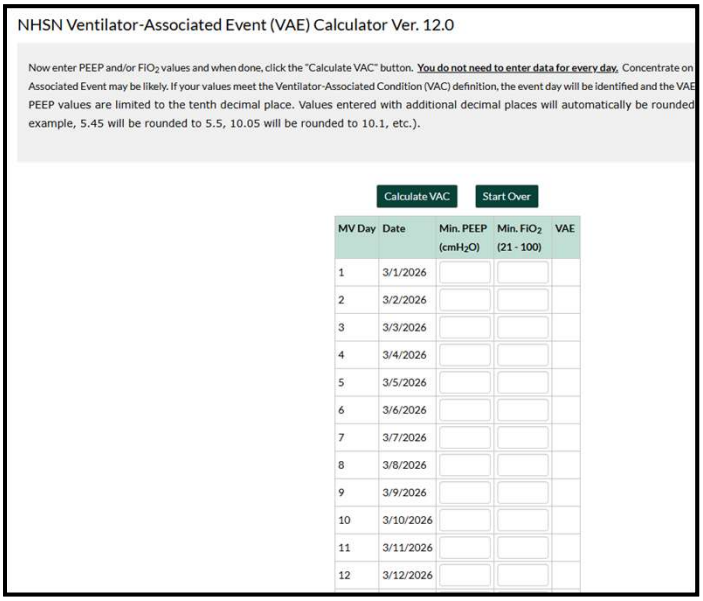
Ventilator-Associated Condition (VAC)

46

DAILY MINIMUM FIO_2 & PEEP

- Daily minimum FiO_2: lowest value of FiO2 during a calendar day that is set on the ventilator and *maintained for > 1 hour*
- Daily minimum PEEP: lowest value of PEEP during a calendar day that is set on the ventilator and *maintained for > 1 hour*
  - Daily minimum PEEP values of 0-5 cmH2O are considered equivalent (equal to 5 cmH2O) for the purposes of VAE surveillance.

47



48

ELIGIBLE FiO_2 & PEEP SETTINGS

- The daily minimum FiO_2 and PEEP values are determined using all eligible FiO_2 and PEEP settings that are documented throughout the calendar day during times when the patient is receiving support from **an eligible mode of mechanical ventilation** in an **inpatient location**
- All conventional mechanical ventilation settings are to be used
  - Include settings collected during weaning/mechanical ventilation liberation trials if the patient is receiving ventilator support during those trials
  - Include conventional MV settings during times when a patient is intermittently on an excluded mode of ventilation or support throughout a calendar day
  - Do NOT include settings from the Emergency Department or other prehospital/pre-inpatient locations

49

DETERMINING DAILY MINIMUM FIO_2 AND PEEP

- From the eligible documented settings, use the lowest FiO_2 and PEEP setting during the calendar day that was maintained for greater than 1 hour
- In the event there is no value that has been maintained for greater than 1 hour, then select the lowest value available regardless of the period of time in which the setting was maintained
- When might there be no FiO2 and PEEP setting during the calendar day that was maintained for greater than 1 hour?
  - Ventilation initiated late in the calendar day
  - Ventilation discontinued early in the calendar day
  - Ventilator settings very unstable throughout the day

50

GUIDANCE FOR DETERMINING DAILY MINIMUM PEEP AND FIO2- WHEN SETTINGS ARE RECORDED EVERY HOUR OR MORE FREQUENTLY

Specific guidance is found in the protocol

- There must be sufficient documentation of consecutive recordings to meet the minimum required duration of > 1 hour
  - If tracking every 15 minutes, 5 consecutive recordings at the same setting would be needed (e.g., at 09:00, 09:15, 09:30, 09:45 and 10:00)
  - If tracking every 30 minutes, 3 consecutive recordings at the same setting would be needed (e.g., at 09:00, 09:30, and 10:00)
  - If tracking every hour, 2 consecutive recordings at the same setting would be needed (e.g., at 09:00 and 10:00)
- Provides standardization

51

BASELINE PERIOD

- A baseline period of stability or improvement is defined by ≥ 2 calendar days of stable or decreasing daily minimum FiO2 values or stable or decreasing daily minimum PEEP values.
- The baseline period is defined as the two calendar days immediately preceding the first day of increased daily minimum FiO2 or PEEP (or, evidence of worsening oxygenation)

52

EVIDENCE OF WORSENING OXYGENATION

- After an identified period of stability or improvement there is evidence of worsening oxygenation in the **same parameter**
- Increase in daily minimum* FiO2of ≥ 0.20 (20 points) over the daily minimum FiO2 of the first day in the baseline period, sustained for ≥ 2 calendar days.

OR

- Increase in daily minimum* PEEP values of ≥ 3 cmH2O over the daily minimum PEEP of the first day in the baseline period†, sustained for ≥ 2 calendar days

*Daily minimum defined by lowest value of FiO2or PEEP during a calendar day that is maintained for > 1 hour.
†Daily minimum PEEP values of 0-5 cmH2O are considered equivalent for the purposes of VAE surveillance.

53

DATE OF EVENT

- The date of onset of worsening oxygenation (day 1 of the required ≥ 2-day period of worsening oxygenation following a ≥ 2-day period of stability or improvement on the ventilator).
  - ***It is not the date on which all VAE criteria are met.***
  - ***It is not the date of the first day of the baseline period.***
- Earliest date of event for VAE is mechanical ventilation day 3 (first day of worsening oxygenation)
- First possible day that VAC criteria can be fulfilled is mechanical ventilation day 4

54

VAE WINDOW PERIOD

- This is the period of days around the Date of Event (specifically, the day of onset of worsening oxygenation) within which other VAE criteria must be met.

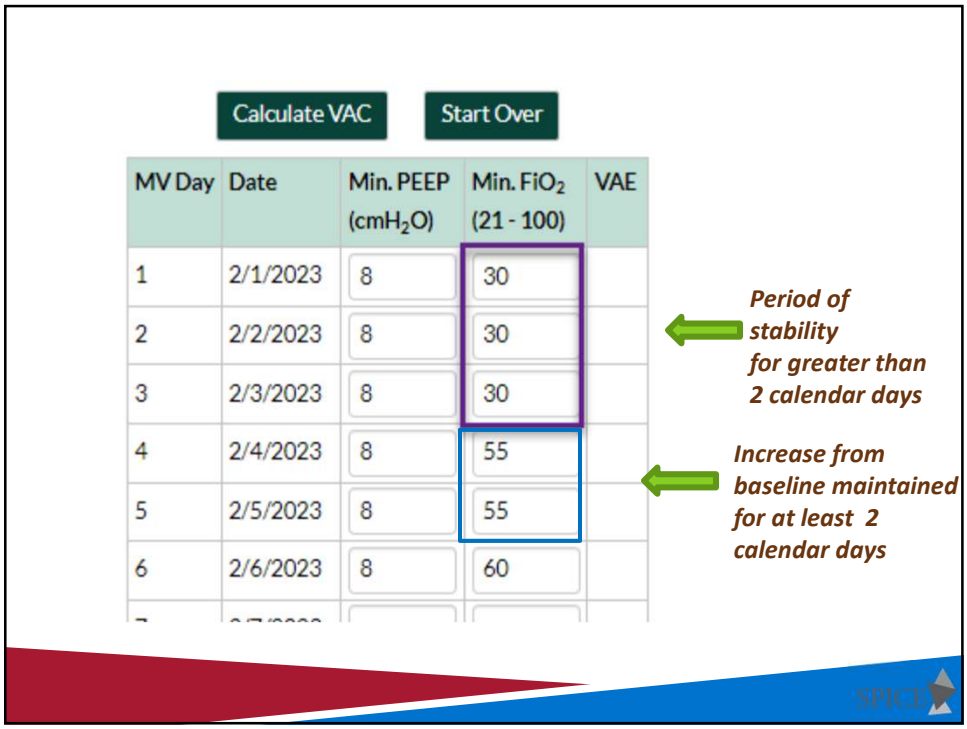
- It is usually a ***5-day period*** and includes the **2 days before**, **the day of**, and the **2 days after** the VAE date of event.

55

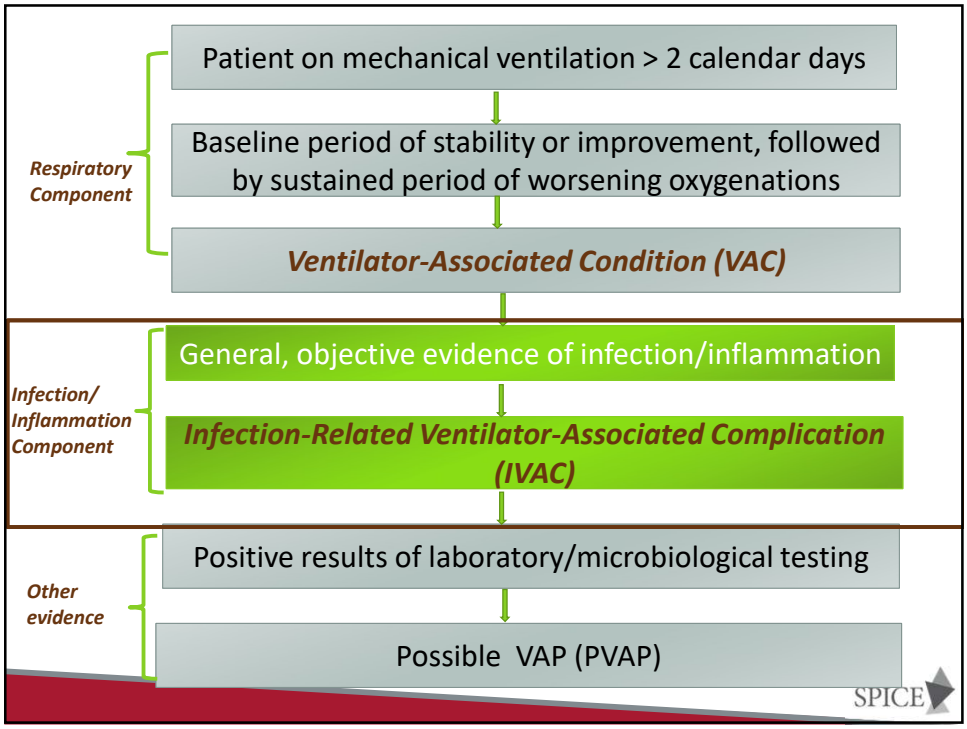
VAE WINDOW PERIOD: IMPORTANT NOTE

- There is an exception in which the VAE Window Period is only 3 or 4 days
- In cases where the VAE event date corresponds to mechanical ventilation (MV) day 3 or day 4, the VAE Window Period may only be a 3-day or a 4-day window, because it can NOT include any days before the 3rd day of MV
  - If the VAE event date is MV day 3, then the window period includes only the day of VAE onset and the 2 days after VAE onset (because the 2 days before VAE onset are before the 3rd day of MV).
  - If the VAE event date is MV day 4, then the window period includes only the day before, the day of, and the 2 days after the day of VAE onset

56

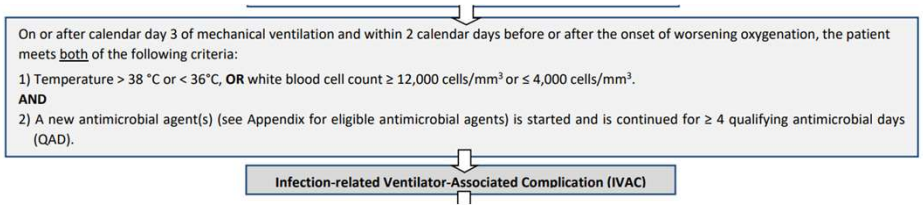

Calculate VAC
Start Over
MV Day
Date
Min. PEEP (cmH_2O)
Min. FiO_2 (21 - 100)
VAE
1 2/1/2023 8 30
2 2/2/2023 8 30
3 2/3/2023 8 30
4 2/4/2023 8 55
5 2/5/2023 8 55
6 2/6/2023 8 60
Period of stability for greater than 2 calendar days
Increase from baseline maintained for at least 2 calendar days
SPICE

57


Patient on mechanical ventilation > 2 calendar days
Baseline period of stability or improvement, followed by sustained period of worsening oxygenations
Ventilator-Associated Condition (VAC)
Respiratory Component
General, objective evidence of infection/inflammation
Infection-Related Ventilator-Associated Complication (IVAC)
Infection/ Inflammation Component
Positive results of laboratory/microbiological testing
Possible VAP (PVAP)
Other evidence
SPICE

58

TIER 2: IVAC



59

KEY DEFINITIONS

- **New antimicrobial agent:** any agent listed in Appendix A (List of Antimicrobial Agents eligible for IVAC, PVAP) that is initiated on or after the third calendar day of mechanical ventilation **AND** in the VAE window period.
  - Agent is considered new if it was **NOT** given to the patient on either of the 2 days preceding the current start date
  - New agent must be administered IV, IM, or via digestive tract or respiratory tract
  - New agent must be continued for ≥ 4 qualifying antimicrobial days

60

QUALIFYING ANTIMICROBIAL DAY (QAD)

- QAD: a day on which the patient was administered an antimicrobial agent that was determined to be "new" within the VAE Window Period.
- Four consecutive QADs are needed to meet the IVAC antimicrobial criterion
  - Days between administrations of a new antimicrobial agent also count as QADs as long as there is a gap of no more than 1 calendar day between administrations.
  - There is no requirement that the same antimicrobial agent be given on the 4 qualifying antimicrobial days
  - QADs can accrue outside the VAE window period (after date of event)

61

FAQ: Do you count an antimicrobial agent as "new" if it is new as a result of de-escalation or simply a switch from one agent to another in the same drug class?

Yes

To avoid additional substantial complexity, there are not rules or exceptions for changes that represent narrowing of spectrum/de-escalation, switches to other agents in the same class, etc. These kinds of situations are very difficult to operationalize in a way that is understandable, standardized, and implementable by any facility that might decide to do VAE surveillance.

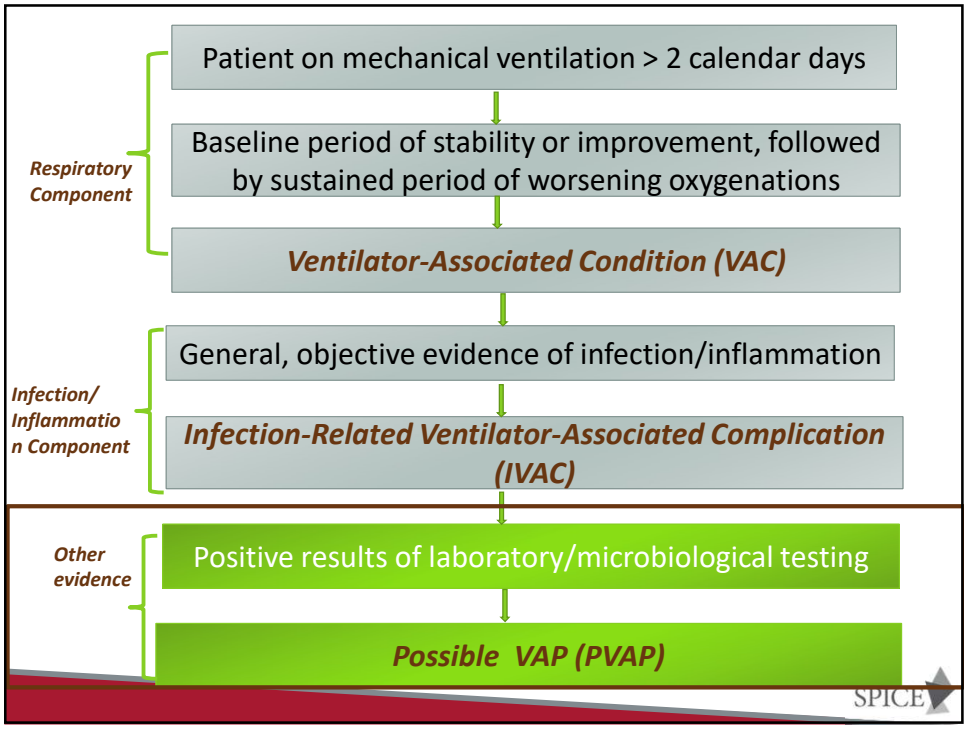
62

IVAC AND ANTIMICROBIAL AGENTS

- Meeting the IVAC definition does not mean that the "infection related" event is necessarily respiratory in origin
- The IVAC antimicrobial list was refined by removing selected antimicrobial agents that would not be used, or would be unlikely to be used, in treating a lower respiratory infection in a critically ill patient
  - It is still possible that an existing agent may have dual purposes and not necessarily be used to treat a respiratory infection
- No need to discern the reason for the administration of the antimicrobial
  - Prophylaxis, de-escalation, change within a class of antimicrobials, etc. is not a reason for exclusion

SPICE

63



64

TIER 3: PVAP

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 (**taking into account organism exclusions specified in the protocol**):

1) Criterion 1: Positive culture of one of the following specimens, meeting quantitative or semi-quantitative thresholds† as outlined in protocol, without requirement for purulent respiratory secretions:
   - Endotracheal aspirate, ≥ 10^5 CFU/ml or corresponding semi-quantitative result
   - Bronchoalveolar lavage, ≥ 10^4 CFU/ml or corresponding semi-quantitative result
   - Lung tissue, ≥ 10^4 CFU/g or corresponding semi-quantitative result
   - Protected specimen brush, ≥ 10^3 CFU/ml or corresponding semi-quantitative result
2) Criterion 2: Purulent respiratory secretions (defined as secretions from the lungs, bronchi, or trachea that contain ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per low power field [lpf, x100])† **PLUS** organism identified from one of the following specimens (to include qualitative culture, or quantitative/semi-quantitative culture without sufficient growth to meet Criterion #1):
   - Sputum
   - Endotracheal aspirate
   - Bronchoalveolar lavage
   - Lung tissue
   - Protected specimen brush
3) Criterion 3: One of the following positive tests:
   - Organism identified from pleural fluid (where specimen was obtained during thoracentesis or within 24 hours of chest tube placement; pleural fluid specimens collected after a chest tube is repositioned or from a chest tube in place > 24 hours are not eligible for PVAP)
   - Lung histopathology, defined as: 1) abscess formation or foci of consolidation with intense neutrophil accumulation in bronchioles and alveoli; 2) evidence of lung parenchyma invasion by fungi (hyphae, pseudohyphae, or yeast forms); 3) evidence of infection with the viral pathogens listed below based on results of immunohistochemical assays, cytology, or microscopy performed on lung tissue
   - Diagnostic test for *Legionella* species
   - Diagnostic test on respiratory secretions for influenza virus, respiratory syncytial virus, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus, coronavirus

† If the laboratory reports semi-quantitative results, those results must correspond to the quantitative thresholds. Refer to Table 2 and 3.

Possible Ventilator-Associated Pneumonia (PVAP)

65

PVAP – CRITERION 1

Positive culture of one of the following specimens, meeting quantitative or semi-quantitative thresholds as outlined in protocol, without requirement for purulent respiratory secretions:

- Endotracheal aspirate (ETA), ≥ 10_5 CFU/ml or corresponding semi-quantitative result
- Bronchoalveolar lavage (BAL) ≥10_4 CFU/ml or corresponding semi-quantitative result
- Lung tissue, ≥10_4 CFU/g or corresponding semi-quantitative result
- Protected specimen brush (PSB), ≥10_3 CFU/ml or corresponding semi-quantitative result

66

SEMI-QUANTITATIVE CULTURE RESULTS

- **FAQ**: How do I relate my lab's semi-quantitative culture result reporting to the quantitative thresholds in the algorithm?
- Ask your laboratory manager/director – they may be able to provide guidance
- If your lab does not have this information:
  - For the purposes of this surveillance, and in the absence of additional information available from your laboratory, a semi-quantitative result of "moderate" "many" "numerous" or "heavy" growth, or 2+, 3+ or 4+ growth, meets the PVAP definition (Criterion 1).
  - See FAQ no. 20 in VAE Protocol

67

PVAP – CRITERION 2

Purulent respiratory secretions (defined as secretions from the lungs, bronchi, or trachea that contain $\geq$ 25 neutrophils and $\leq$ 10 squamous epithelial cells per low power field [lpf, x100])

AND

A positive culture of one of the following specimens (qualitative culture, or quantitative/semi-quantitative culture without sufficient growth to meet criterion #1):

- Sputum
- Endotracheal aspirate
- Bronchoalveolar lavage
- Lung Tissue
- Protected specimen brush

68

GRAM STAINS

- FAQ: What if my lab reports Gram stain/direct exam results in a manner that doesn't quantitate neutrophils and squamous epithelial cells as the definition is written?
  - Check with the lab for direction in interpreting your facility's reporting method
  - If your lab cannot provide guidance, use the following direct examination results to meet the purulent respiratory secretions criterion: many, heavy, numerous, 4+, or ≥ 25 neutrophils per low power field (lpf) [x100], AND no, rare, occasional, few, 1+ or 2+, or ≤ 10 squamous epithelial cells per lpf [x100]

See Table 2, Ch. 10, pg. 15 for more details on lab report

69

PVAP – CRITERION 3

One of the following positive tests:

- Pleural fluid culture (where specimen was obtained during thoracentesis or initial placement of chest tube and NOT from an indwelling chest tube)
- Lung histopathology, defined as:
  - 1) abscess formation or foci of consolidation with intense neutrophil accumulation in bronchioles and alveoli
  - 2) evidence of lung parenchyma invasion by fungi
  - 3) evidence of infection with viral pathogens listed below based on results of immunohistochemical assays, cytology, or microscopy performed on lung tissue

70

PVAP – CRITERION 3, CONT.

One of the following positive tests:

- Diagnostic test for *Legionella* species
- Diagnostic test on respiratory secretions for influenza virus, RSV, adenovirus, parainfluenza virus, rhinovirus, human metapneumonovirus, coronavirus

71

PATHOGEN EXCLUSIONS

- "Normal respiratory flora," "normal oral flora," "mixed respiratory flora," "mixed oral flora," "altered oral flora" or other similar results indicating isolation of commensal flora of the oral cavity or upper respiratory tract
- *Candida* species or yeast not otherwise specified, coagulase-negative *Staphylococcus* species, and *Enterococcus* species only available for use as PVAP pathogens when isolated from **lung tissue** or **pleural fluid**
  - Cannot be used to meet PVAP definition when identified from sputum, endotracheal aspirates, bronchoalveolar lavage, or protected specimen brushings

72

Table 3: Threshold values for cultured specimens used in the PVAP definition

Specimen collection/technique	Values
Lung tissue	≥ 10^4 CFU/g tissue*
Bronchoscopically (B) obtained specimens	
Bronchoalveolar lavage (B-BAL)	≥ 10^4 CFU/ml*
Protected BAL (B-PBAL)	≥ 10^4 CFU/ml*
Protected specimen brushing (B-PSB)	≥ 10^3 CFU/ml*
Nonbronchoscopically (NB) obtained (blind) specimens	
NB-BAL	≥ 10^4 CFU/ml*
NB-PSB	≥ 10^3 CFU/ml*
Endotracheal aspirate (ETA)	≥ 10^5 CFU/ml*

CFU = colony forming units, g = gram, ml = milliliter

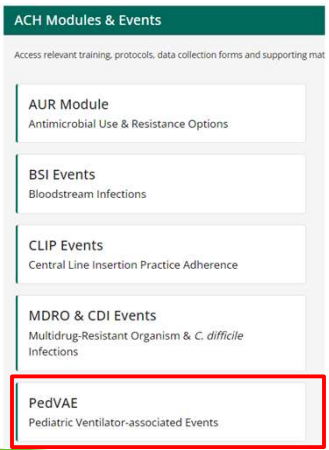
*Or corresponding semi-quantitative result (see FAQ no. 24 at the end of this protocol)

SPICE

73

PEDVAE RESOURCES

- NHSN resources



- PedVAE webpage
  - Protocol
  - Calculator
  - Training
  - FAQS
  - Forms
  - More!

SPICE

74

OTHER INCLUSION CRITERIA

- Includes patients on
  - High Frequency Oscillatory or Jet Ventilation
  - Airway Pressure Release Ventilation (APRV)
- Includes patients who are receiving mechanical ventilation while also receiving
  - Proning
  - Surfactant
  - Corticosteroids
  - Nitric oxide therapy
  - Helium-oxygen mixture (heliox)
  - Epoprostenol therapy

75

PEDVAE ALGORITHM

Figure 1: Pediatric Ventilator-Associated Events (PedVAE) Surveillance Algorithm

Patient has a baseline period of stability or improvement on the ventilator, defined by ≥ 2 calendar days of stable or decreasing daily minimum* FiO_2 or MAP values. The baseline period is defined as the 2 calendar days immediately preceding the first day of increased daily minimum FiO_2 or MAP.

*Daily minimum FiO_2 is defined as the lowest value of FiO_2 documented during a calendar day that is maintained for > 1 hour.
Daily minimum MAP is the lowest value documented during the calendar day.
For patients < 30 days old, daily minimum MAP values 0-8 cm H_2O are considered equal to 8 cmH_2O for the purposes of surveillance.
For patients ≥ 30 days old, daily minimum MAP values 0-10 cmH_2O are considered equal to 10 cmH_2O for the purposes of surveillance.

⇩

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 FiO_2 of ≥ 0.25 (25 points) over the daily minimum FiO_2 of the first day in the baseline period, sustained for ≥ 2 calendar days.
2) Increase in daily minimum MAP values of ≥ 4 cmH_2O over the daily minimum MAP of the first day in the baseline period, sustained for ≥ 2 calendar days.

⇩

Pediatric Ventilator-Associated Event (PedVAE)

76

PEDVAE DETERMINATION

- ▪ PedVAEs are determined by identification of deterioration in respiratory status after a period of stability or improvement on the ventilator
- Assessed by monitoring two key parameters that reflect oxygenation status in neonatal and pediatric ventilated patients:
  - Fraction of Inspired Oxygen - FiO_2
  - Mean Airway Pressure(MAP): average pressure exerted on the airway and lungs from the beginning of inspiration until the beginning of the next inspiration (inspiratory cycle)

77

MAP: MEAN AIRWAY PRESSURE

- MAP is a measured/calculated value (not a ventilator setting) that is determined by
  - PEEP - Positive End-Expiratory Pressure
  - PIP - Peak Inspiratory Pressure
  - Inspiratory time
  - Frequency

78

MEETING PEDVAE DEFINITION

- Patients must be mechanically ventilated for some portion of the day for at least 4 consecutive calendar days to fulfill PedVAE criteria (where the day of intubation or initiation of mechanical ventilation is day 1)
  - At least 2 days of stability or improvement
  - At least 2 days of evidence of worsening oxygenation
- The period of stability or improvement and the evidence of worsening oxygenation must occur in the same parameter
  - Each parameter is assessed independently of the other – PedVAE may be met only in the FiO2 parameter, only in the MAP parameter, or in both parameters

79

PEDVAE DETERMINATION: FIO_2

- A baseline period of stability or improvement in the FiO_2 parameter is immediately followed by an increase in the daily minimum **FiO2 of ≥ 0.25 (25 points)** over the daily minimum FiO2 of the first day in the baseline period that is sustained for ≥ 2 calendar days

80

PEDVAE DETERMINATION: MAP

- A baseline period of stability or improvement in the MAP parameter is immediately followed by an increase in the daily minimum **MAP of ≥ 4 cmH_2O** over the daily minimum MAP of the first day in the baseline period that is sustained for ≥ 2 calendar days

81

IMPORTANT NOTES ON MAP AND AGES

- In patients <30 days old, MAP values of 0-8 cmH_2O are considered equivalent, therefore would be assigned a daily minimum values of 8
  - An increase in the daily minimum MAP to at least 12, sustained for 2 calendar days, would be needed to meet the PedVAE definitions
- Patients ≥ 30 days old, MAP values of 0-10 cmH_2O are considered equivalent, therefore would be assigned a daily minimum value of 10
  - An increase to at least 14, sustained for 2 calendar days would be needed to meet the PedVAE definition

82

DATE OF EVENT

- The date of onset of worsening oxygenation (day 1 of the required ≥ 2-day period of worsening oxygenation following a ≥ 2-day period of stability or improvement on the ventilator)
  - Earliest date of event for PedVAE is mechanical ventilation day 3 (first day of worsening oxygenation)
  - The first two days of mechanical ventilation can establish the baseline period

83

14 DAY EVENT PERIOD

- PedVAEs are defined by a 14-day period
- The Date of Event is day 1 of the 14-day Event Period
  - A new PedVAE cannot be reported until the 14-day period has elapsed
  - For example, if a PedVAE is reported with a date of event March 1, this sets a 14-day event period March 1 - 14, and the earliest date a new PedVAE can be detected and reported is March 15
  - The 2 days of stability or improvement for a new PedVAE can occur during the previous 14-day event period

84

SPICE

85