North Carolina SPICE
Statewide Program for Infection Control & Epidemiology

NATIONAL HEALTHCARE SAFETY NETWORK

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

REFERENCE ACKNOWLEDGMENT

2023 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

PNEU SURVEILLANCE OPTIONS

- Available for **in-plan reporting** for mechanically ventilated patients in **pediatric locations only (pedVAP)**
- **Available for off-plan** reporting for **any patient** regardless of location, age, or ventilation status (for example a state reporting requirement, facility surveillance plan)
- **Available for secondary BSI assignment in any patient** regardless of location, age, or ventilation status.
  - Also, regardless of surveillance of VAE or PedVAE in the same location

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

PNU1 ALGORITHM (TABLE 1, PNEU PROTOCOL)

- PNU1 is 'clinically defined'-no laboratory test evidence required
- Required elements:
  - Imaging test evidence
  - Signs/symptoms
- 3 sets of criteria:
  - Any patient-patients of any age, including infants and children
  - Alternative criteria-infants $\leq$ 1 year old
  - Alternative criteria-child > 1 year or $\leq$ 12 years old
- Age-specific criteria apply to PNU1 ONLY (cannot be used for PNU2 or PNU3)

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), one definitive imaging test result is acceptable[1]	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[3] or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea[5] • Rales[6] or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-$PaO_2/FiO_2 \leq 240$)[7], increased oxygen requirements or ventilator demand)

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), one definitive imaging test result is acceptable[1]	**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[3] **or** change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements • Apnea, tachypnea[5] nasal flaring with retraction of chest wall, or nasal flaring with grunting • Wheezing, rales[6] or rhonchi • Cough • Bradycardia (<100 beats/min) or tachycardia (>170 beats/min)

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), 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/mm^3) **or** leukocytosis (≥15,000 WBC/mm^3) • 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)

PNU2 ALGORITHM (TABLE 2 AND TABLE 3, PNEU PROTOCOL)

- PNU2 is comprised of:
  - Imaging test evidence
  - Signs/symptoms
  - Laboratory evidence
- Split into 2 tables
  - Imaging test evidence and S/S are the same in both tables
  - Laboratory evidence is different, but all meet PNU2
- No age-specific criteria for S/S

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[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), 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[3] or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea[5] • Rales[6] or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-$PaO_2/FiO_2 \leq 240$)[7], increased oxygen requirements or ventilator demand)	At least ***one*** of the following: • Organism identified from blood[8],[13] • Organism identified from pleural fluid[9],[13] • 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 (i.e., gram stain) • Positive quantitative culture or corresponding semi-quantitative culture result[9] 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 alvelio* *Evidence of lung parenchyma invasion by fungal hyphae or pseudohyphae*

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[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), 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[3] or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea[5] • Rales[6] or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-$PaO_2/FiO_2 \leq 240$)[7], 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

PNU3 ALGORITHM (TABLE 4)

- PNU3 is for Immunocompromised patients
  - Immunocompromised definition in footnote #10 must be met in order to apply PNU3
- PNU3 is comprised of:
  - Imaging test evidence
  - S/S
  - Laboratory evidence
- No age-specific criteria for S/S

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[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), 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/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 • New onset or worsening cough, or dyspnea, or tachypnea[5] • Rales[6] or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-$PaO_2/FiO_2 \leq 240$)[7], 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[11,12,13] • 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***

KEY CONCEPTS

- Although 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
  - For example, an infant can meet PNU1, PNU2, or PNU3
  - Immunocompromised patient can meet PNU1 or PNU2
- There is a hierarchy for reporting if a patient meets more than one algorithm during the infection window period or the RIT-report at the higher level:
  - Meets both PNU1 and PNU2, report PNU2
  - Meets both PNU2 and PNU3, report PNU3

KNOWLEDGE CHECK # 1

- Which PNEU definition requires laboratory evidence?

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

IMAGING TEST EVIDENCE

Imaging Test Evidence

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 (such as respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), 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

Footnotes #1, #2, #14

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)

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

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 **only 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**

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.

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

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**

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 **<u>treatment for pneumonia</u>**
- If the imaging does not demonstrate findings of pneumonia, clinical correlation cannot be used

PNEUMONIA FOOTNOTE #14: EQUIVOCAL FINDINGS

14. If the imaging test result is equivocal for pneumonia, check to see if subsequent imaging tests are definitive. For example, if a chest imaging test result states infiltrate vs. atelectasis and a subsequent imaging test result is definitive for infiltrate, the initial imaging test would be eligible for use. In the absence of finding a subsequent imaging result that clarifies the equivocal finding, if there is clinical correlation (see Chapter 16) then the equivocal imaging test is eligible for use.

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

IMAGING EVIDENCE OF PNEUMONIA SUMMARY

- Findings must be new **and** persistent OR progressive **and** persistent
- Simply finding words such as infiltrate, consolidation, opacity, or airspace disease in an imaging test report is not enough
- Unlike imaging for other NHSN events, due to the persistence requirement, all available imaging findings that are temporally related must be considered
- Only definitive and equivocal findings are eligible for consideration
- Additional guidance can be found in the PNEU protocol (p. 6-3) under “Guidance for Determination of Eligible Imaging Test Evidence”

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

Signs/symptoms

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[3] or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements
- New onset or worsening cough, or dyspnea, or tachypnea[5]
- Rales[6] or bronchial breath sounds
- Worsening gas exchange (i.e., O_2 desaturation- $PaO_2/FiO_2 \leq 240$)[7], increased oxygen requirements or ventilator demand)

PNU1-ANY PATIENT-SIGNS/ SYMPTOMS

At least 2 of these s/s must be from different bullet points

SPICE

PNU1-INFANTS ≤ 1YEAR OLD

Signs/symptoms

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[3] **or** change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements
- Apnea, tachypnea[5] nasal flaring with retraction of chest wall, or nasal flaring with grunting
- Wheezing, rales[6] or rhonchi
- Cough
- Bradycardia (<100 beats/min) or tachycardia (>170 beats/min)

At least 3 of these s/s must be from different bullet points

Signs/symptoms

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)

PNU1-CHILD
> 1 YEAR OLD
OR
≤12 YEARS OLD

At least 3 of these s/s must be from different bullet points

Signs/Symptoms	Laboratory
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[3] or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea[5] • Rales[6] or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-$PaO_2/FiO_2 \leq 240$)[7], increased oxygen requirements or ventilator demand)	At least ***one*** of the following: • Organism identified from blood[8,13] • Organism identified from pleural fluid[9,13] • 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 (i.e., gram stain) • Positive quantitative culture or corresponding semi-quantitative culture result[9] 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 alvelio* *Evidence of lung parenchyma invasion by fungal hyphae or pseudohyphae*

TABLE 2: PNU2 S/S AND Specific Laboratory Findings (PNU2)

Signs/Symptoms	Laboratory
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[3] or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea[5] • Rales[6] or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-$PaO_2/FiO_2 \leq 240$)[7], 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

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

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

Signs/Symptoms	Laboratory
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[3] or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements • New onset or worsening cough, or dyspnea, or tachypnea[5] • Rales[6] or bronchial breath sounds • Worsening gas exchange (i.e., O_2 desaturation-$PaO_2/FiO_2 \leq 240$)[7], 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[11,12,13] • 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***

FOOTNOTE #10: IMMUNOCOMPROMISED PATIENTS

10. Immunocompromised patients include only

- those with neutropenia defined as absolute neutrophil count or total white blood cell count (WBC) < $500/mm^3$
- 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

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.

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.

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.

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.

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

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.

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 (1,2,14): New and persistent **or** Progressive and persistent • Infiltrate • Consolidation • Cavitation • Pneumatoceles, in infants ≤1 year old **Note**: In patients ***without***	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	At least ***one*** of the following: Organism identified from blood (8,13) • Organism identified from pleural fluid (9,13) • 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

- 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

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

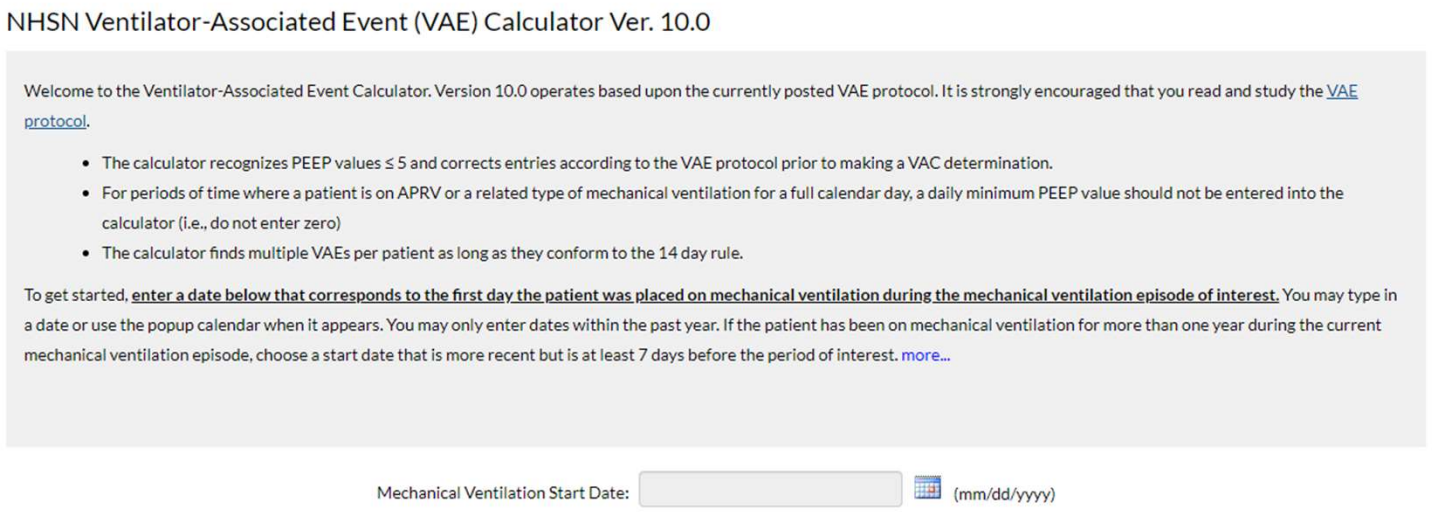
North Carolina SPICE
Statewide Program for Infection Control & Epidemiology

NATIONAL HEALTHCARE SAFETY NETWORK

Ventilator-Associated Event (VAE)

VAE TOOLS

VAE Calculator and Worksheets



INTRODUCTION

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

There are three definition tiers within the VAE algorithm:

Ventilator-Associated Condition (VAC)	Infection-related Ventilator-Associated complication (IVAC	Possible VAP (PVAP)

DEFINITIONS

- **Ventilator:** a device used to support, assist, or control respiration (inclusive of the weaning period) through the application of positive pressure to the airway when delivered via an artificial airway, specifically oral/nasal endotracheal or tracheostomy tube.
- **Note:** *Ventilation and lung expansion devices that deliver positive pressure to the airway (for example, CPAP, BiPAP, Bi-level, IPPB, and PEEP) via non-invasive means (for example, nasal prongs, nasal mask, full face mask, total mask, etc.) are not considered ventilators unless positive pressure is delivered via an artificial airway (oral/nasal endotracheal or tracheostomy tube).*

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*

- 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.

VENTILATOR ASSOCIATED EVENT (VAE)

- An adverse event “associated” with the use of a mechanical ventilator
- Detection of VAE may be related to:
  - Infection -respiratory or another site
  - Fluid overload
  - ARDS
  - Atelectasis
  - Provider preference in adjusting settings
  - Other
- ***“Surveillance is information for action”***
  - Address duration of mechanical ventilation
  - Address issues found to be “associated” with VAE detection

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!
- Educate your clinicians to dispel the myth!
- 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

VAE SURVEILLANCE INCLUSION CRITERIA-SETTINGS

- 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

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)
- 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

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

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

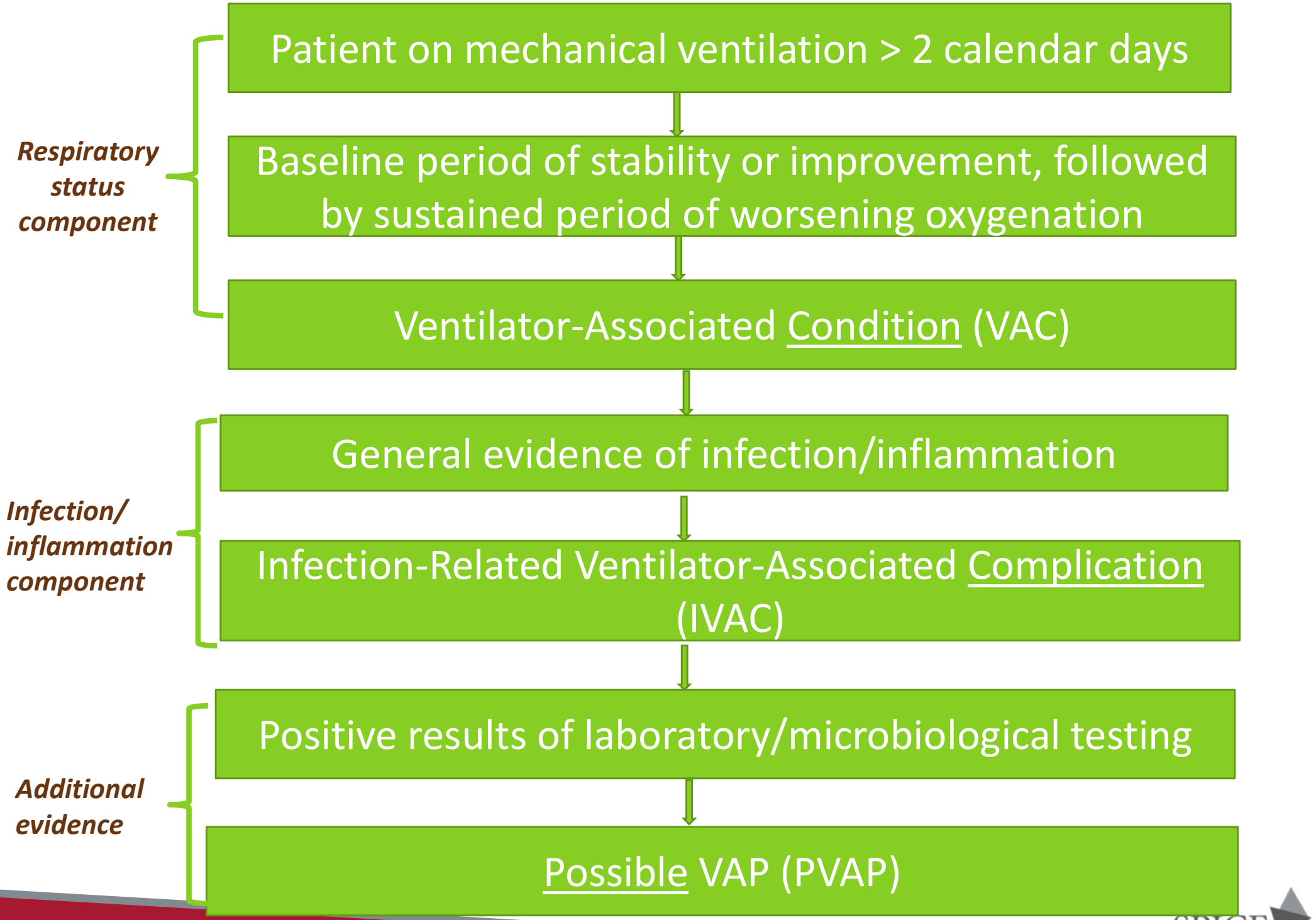
EPISODE OF MECHANICAL VENTILATION

- 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.

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				

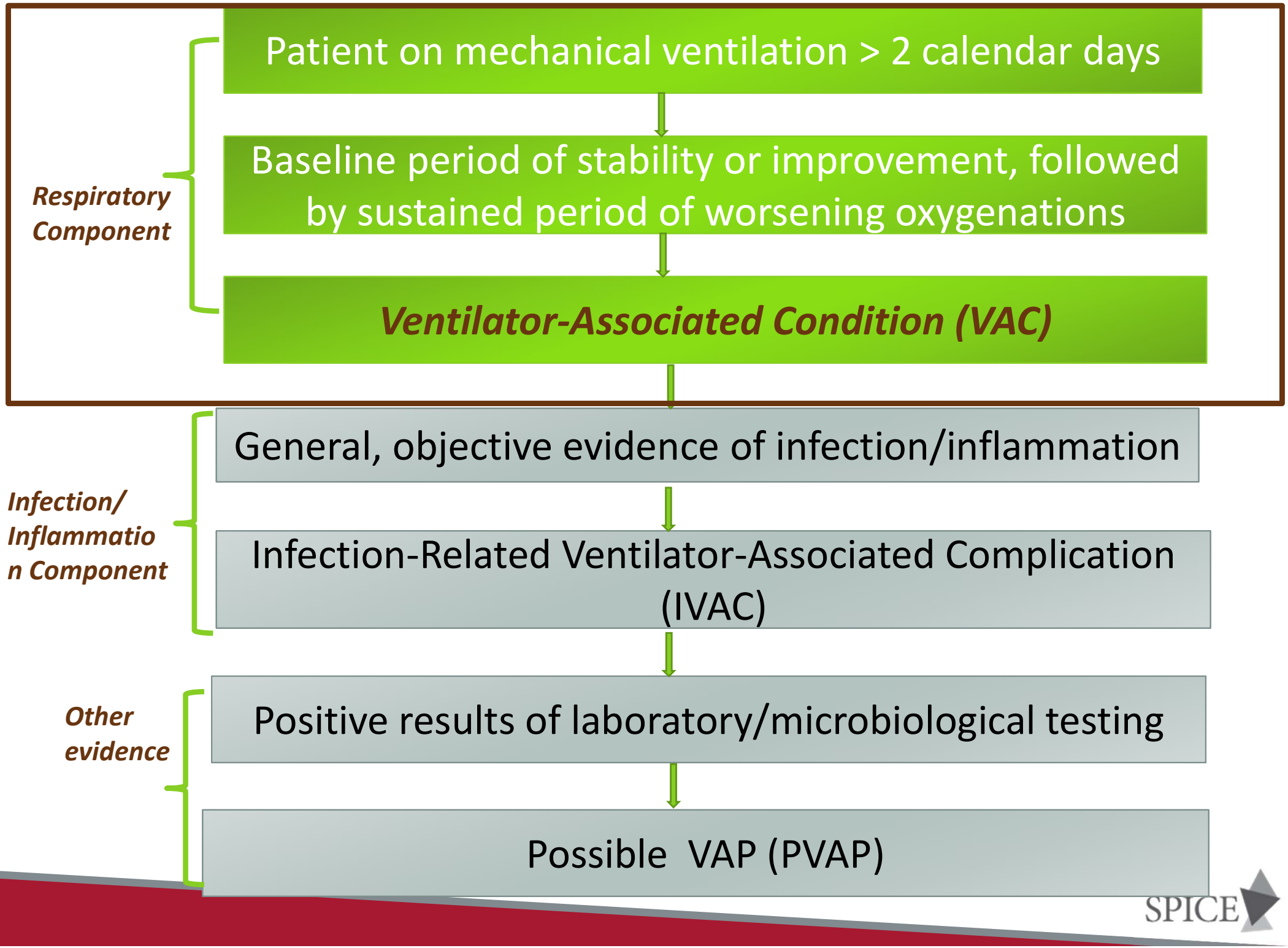

Patient on mechanical ventilation > 2 calendar days
Baseline period of stability or improvement, followed by sustained period of worsening oxygenation
Ventilator-Associated Condition (VAC)
General evidence of infection/inflammation
Infection-Related Ventilator-Associated Complication (IVAC)
Positive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

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

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***


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

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

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)

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.

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

INELIGIBLE FIO_2 & PEEP SETTINGS

- Settings not eligible for use
  - Periods of time when the patient is on high frequency ventilation, extracorporeal life support or paracorporeal membrane oxygenation.
  - Periods of time when the patient is not receiving mechanical ventilation support (for example, a T-piece trial, or a trach collar trial, where the patient continues to receive supplemental oxygen, but is receiving no additional support from the mechanical ventilator).
  - Periods of time when the patient is being mechanically-ventilated using APRV or a related strategy (for example, BiLevel, BiVent, BiPhasic, PCV+ and DuoPAP)
    - In these cases, only review FiO2 data (PEEP settings are not eligible for use).

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

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

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)

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* 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.

OR

- 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.

KEY POINTS FOR MEETING VAC DEFINITION

- Use the daily minimum FiO2 and PEEP values when assessing for both the period of stability or improvement and the period that indicates worsening oxygenation
- Do not compare values that occur within a calendar day to determine stability, improvement, or worsening.
- The baseline period and the evidence of worsening oxygenation must occur in the same parameter
- Each parameter is assessed independently of the other – VAC may be met in the FiO2 parameter, or in the PEEP parameter, or in both parameters

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

WHY IS THE DATE OF EVENT IMPORTANT?

- Defines the **VAE Window Period**
  - Period during which criteria for other events—IVAC, PVAP—must be met
- Sets the **VAE 14-day Event Period**
  - Day 1 is the Date of Event—so if June 1 is date of onset of worsening oxygenation and a VAC is reported, a second VAE cannot be detected and reported until June 15.
  - May not "upgrade" a VAE based on data collected outside the VAE Window Period but within the 14-day event period.
  - May not report a new VAE until that 14-day period has elapsed (keep in mind that 14-day period is event date to event date—so baseline period can occur during previous event period).
  - Blood cultures must be collected within the 14-day event period for a BSI to be secondary to VAE

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.

VAE WINDOW PERIOD: IMPORTANT NOTE

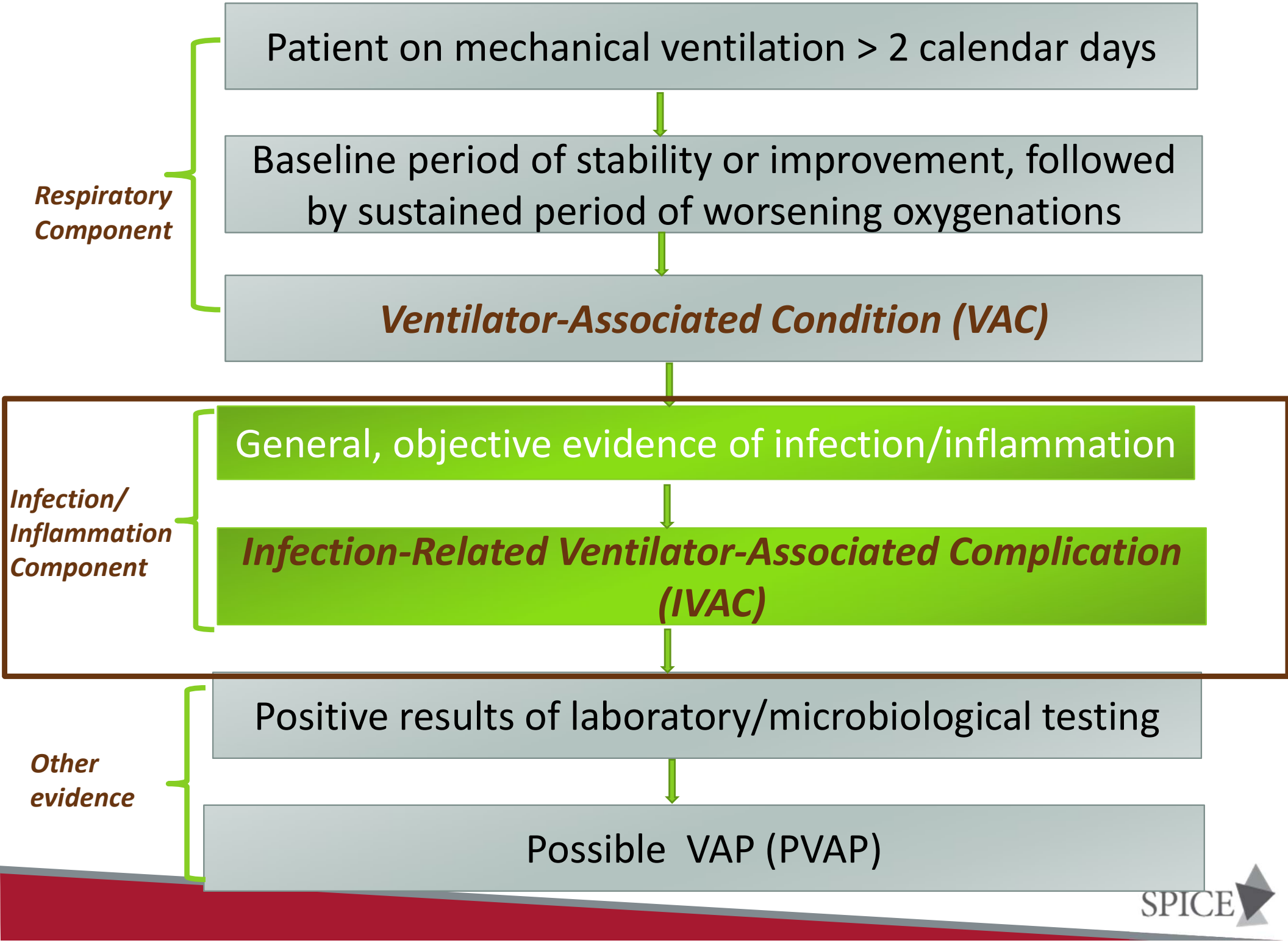
- There is an exception in which the VAE Window Period is only 3 or 4 days
- In cases where the VAE event date corresponds to mechanical ventilation (MV) day 3 or day 4, the VAE Window Period may only be a 3-day or a 4-day window, because it can NOT include any days before the 3rd day of MV
  - If the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

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


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

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 <u>both</u> of the following criteria:

1) Temperature > 38 °C or < 36°C, **OR** white blood cell count ≥ 12,000 cells/mm^3 or ≤ 4,000 cells/mm^3.

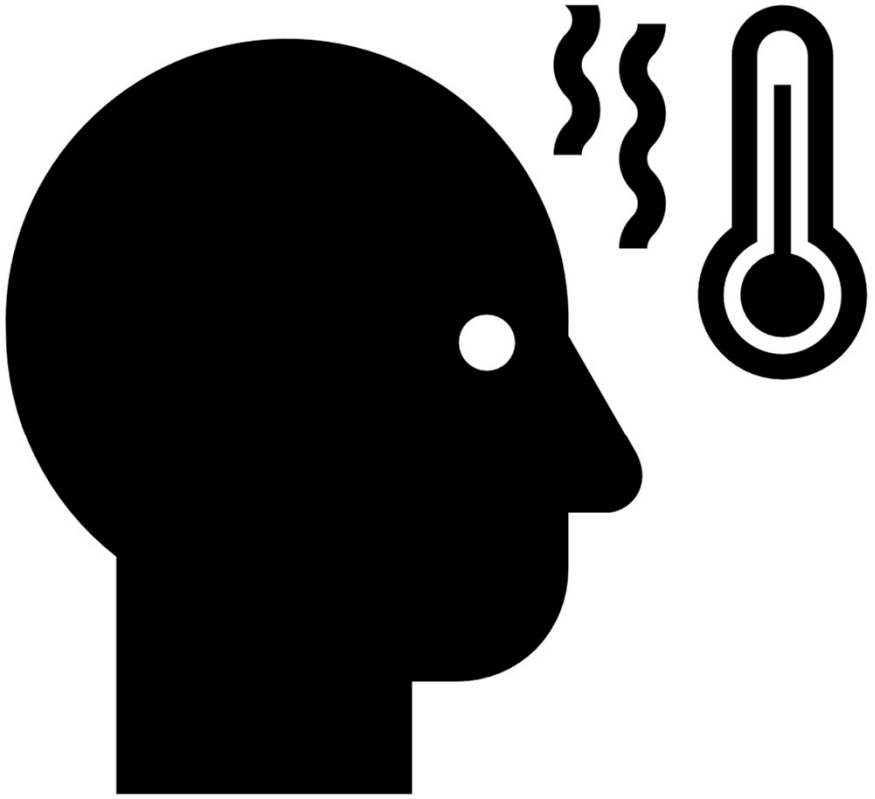
AND

2) A new antimicrobial agent(s) (see Appendix for eligible antimicrobial agents) is started and is continued for ≥ 4 qualifying antimicrobial days (QAD).

Infection-related Ventilator-Associated Complication (IVAC)

TEMPERATURE AND WHITE BLOOD CELL COUNT (WBC)

If there is an abnormal temperature (> 38 °C or < 36°C) **OR** abnormal WBC count (≥ 12,000 or ≤ 4,000 cells/mm3) documented during the VAE Window Period, it should be used in determining whether the patient meets the IVAC definition, **regardless** of whether an abnormal temperature or abnormal WBC count was also present on admission or outside the VAE Window Period.



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

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)

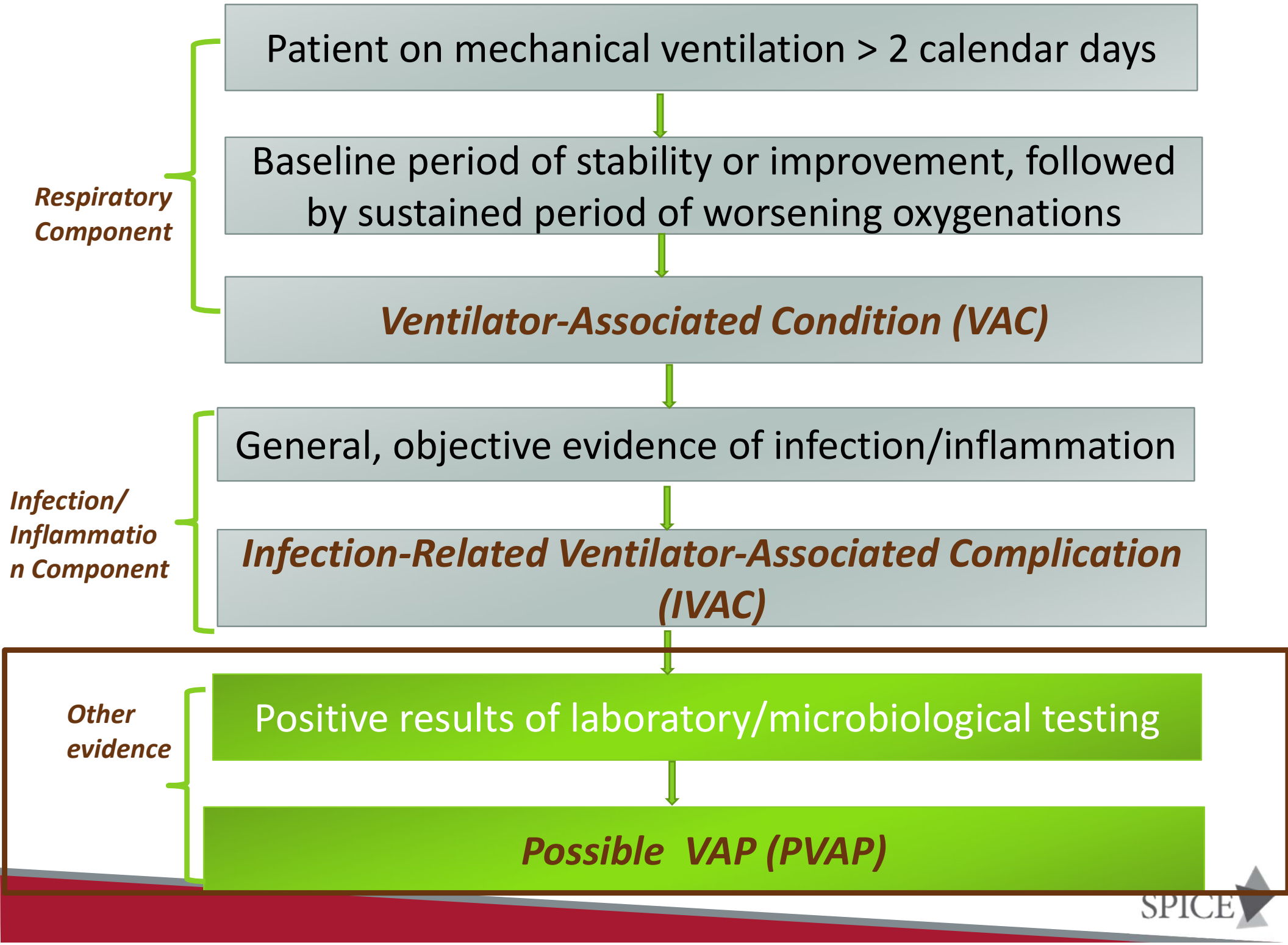
FAQ: Do you count an antimicrobial agent as "new" if it is new as a result of de-escalation or simply a switch from one agent to another in the same drug class?

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.

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


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

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, <u>without</u> 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])[†] **<u>PLUS</u>** 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)

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), $\geq 10^5$ CFU/ml or corresponding semi-quantitative result
- Bronchoalveolar lavage (BAL) $\geq 10^4$ CFU/ml or corresponding semi-quantitative result
- Lung tissue, $\geq 10^4$ CFU/g or corresponding semi-quantitative result
- Protected specimen brush (PSB), $\geq 10^3$ CFU/ml or corresponding semi-quantitative result

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 you lab does not have this information:
  - For the purposes of VAE surveillance, 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. 24** in the VAE Protocol

PVAP – 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])

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

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, refer to Table 2 or FAQ no. 19 in the VAE protocol

Table 2: Instructions for using the purulent respiratory secretions criterion, based on laboratory reporting of respiratory secretion direct examination results.

How do I use the purulent respiratory secretions criterion if …	Instruction
My laboratory reports counts of "white blood cells" or "polymorphonuclear leukocytes" or "leukocytes" rather than counts of "neutrophils"?	Assume that counts of cells identified by these other descriptors (for example, "white blood cells") are equivalent to counts of neutrophils, unless the laboratory tells you this is not the case.
My laboratory reports semi-quantitative results (not quantitative results) for numbers of neutrophils and squamous epithelial cells?	Check with the laboratory to get information about what quantitative ranges the semi-quantitative reports correspond to.
My laboratory cannot provide additional information on how its semi-quantitative reporting corresponds to quantitative reporting ranges for neutrophils and squamous epithelial cells?	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] [20].
My laboratory reports only the numbers of neutrophils present, without reporting the number of squamous epithelial cells?	In this situation, the purulent secretions criterion may be met using the specified quantitative and semi-quantitative thresholds for neutrophils alone (specifically many, heavy, numerous, 4+, or ≥ 25 neutrophils per lpf [x100]).
My laboratory uses different reporting thresholds for neutrophils and squamous epithelial cells (for example, maximum report of ≥ 20 neutrophils per low power field [x100], or minimum report of ≤ 15 squamous epithelial cells per low power field [x100])?	In this situation, the purulent secretions criterion may be met using the laboratory's specified maximum quantitative threshold for neutrophils, and/or minimum quantitative threshold for squamous epithelial cells.
My laboratory processes respiratory specimens such as bronchoalveolar lavage fluid using a centrifugation procedure (for example, "cytospin"), and there is no quantitation or semi-quantitation of neutrophils or white blood cells in the direct examination report?	In this situation, a report indicating the presence of white blood cells, without quantitation, is sufficient to meet the purulent secretions criterion.

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 fung
  - 3) evidence of infection with viral pathogens listed below based on results of immunohistochemical assays, cytology, or microscopy performed on lung tissue

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

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

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)

PEDVAE SURVEILLANCE

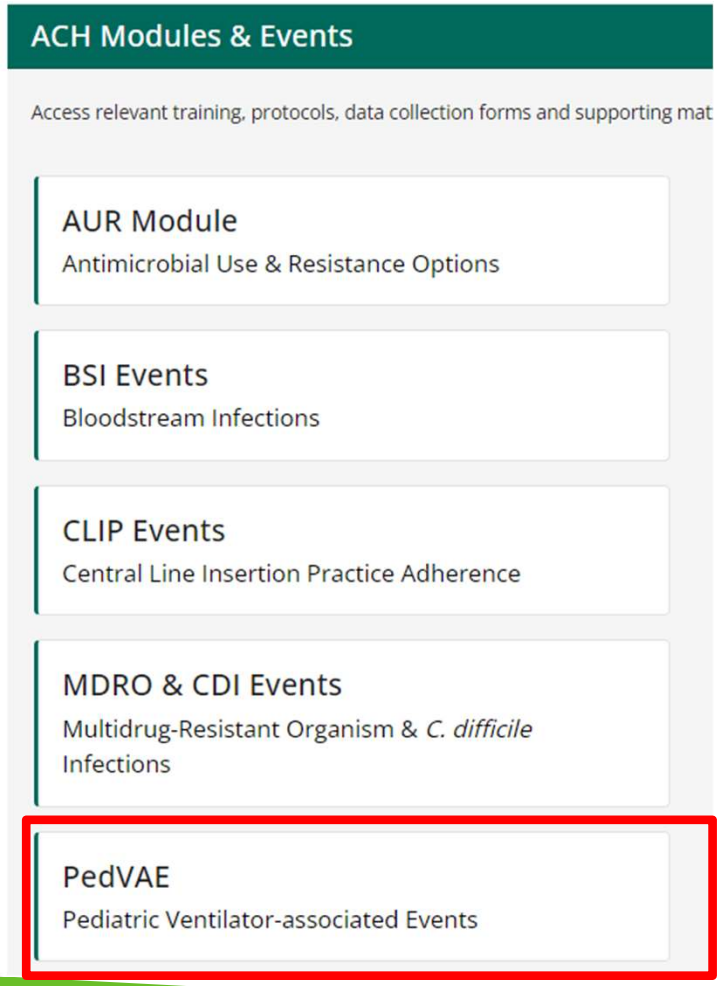
- In mid-2013, working group determined that there were insufficient data to inform development of a pediatric VAE definition.
- Further working group discussions were postponed until 2015, following publication of the results of a study on pediatric VAE definition criteria.
- This study demonstrated that events defined by changes in the fraction of inspired oxygen (FiO2) and Mean Airway Pressure (MAP) were associated with increases in patient length of stay as well as mortality.

PEDVAE SURVEILLANCE

- After additional discussion with the working group, CDC decided to move forward with pediatric VAE (PedVAE) development and implementation in NHSN.
- PedVAE field testing conducted in 2017
- PedVAE made available as an NHSN surveillance event starting in Jan. 2019

PEDVAE RESOURCES

- NHSN resources



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

PEDVAE: ELIGIBLE PATIENTS

- Ventilated inpatients in acute care hospitals, long term acute care hospitals, inpatient rehabilitation facilities
- **Patients in neonatal and pediatric** locations where denominator data (ventilator and patient days) can be collected
  - Ventilated adults in pediatric locations are included in PedVAE surveillance – regardless of age

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

PEDVAE: INELIGIBLE PATIENTS

- Patients on extracorporeal life support or paracorporeal membrane oxygenation are not eligible for VAE surveillance
  - Ineligibility only applies to periods of time while receiving this form of support
- Patients in non-acute care locations in acute care facilities (such as a chronic care unit)
- Pediatric patients in adult inpatient locations
  - Ventilated pediatric patients in adult locations are included in adult VAE surveillance

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)

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)

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

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

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

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

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 $\geq$ 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

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

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


Any
Questions