Use and Application of the Ventilator Associated Event (VAE) Protocol

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Objectives

- Understand the Ventilator Associated Events (VAE) surveillance algorithm
- Apply the VAE definitions
- Identify resources for VAE surveillance and reporting

VAE Surveillance

Ventilator Definition

- Ventilator is defined as 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 do surveillance for patients receiving mechanical ventilation?

- 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*

- Ventilator-associated pneumonia (VAP) is an important complication of mechanical ventilation, but other adverse events also happen to ventilated patients
  - Acute Respiratory Distress Syndrome (ARDS), sepsis, pulmonary embolism, barotrauma, and pulmonary edema, among other complications

*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.

VAE - Ventilator "Associated" Event

- **VAE Surveillance Working Group** convened in 2011
- **Currently** (as of January 2013)
  - Ventilator-Associated Event (VAE) is the only event available for *in-plan* surveillance in adult locations
    - Focus on objectivity, reliability and ability to automate
    - Identify a broad range of conditions and complications occurring in mechanically ventilated adult patients (pneumonia, ARDS, atelectasis, pulmonary edema) which may be preventable
    - Enhance ability to use surveillance data to drive improvements in patient care and safety

VAE - Ventilator “Associated” Event

- An 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 dispel the myth!

- VAE is designed to detect more than VAP

NOTE: Both VAE and PNEU are available for secondary BSI assignment when conducting BSI surveillance

Who is eligible for VAE surveillance?

- Inpatients of acute care hospitals, long term acute care hospitals, inpatient rehabilitation facilities
- Patients in **adult locations** are eligible for VAE surveillance
  - Pediatric patients in adult locations included in VAE surveillance
  - Adults in pediatric locations included in pedVAP surveillance
- Patients must be receiving support with mechanical ventilation
- Patients must be mechanically ventilated for more than 2 calendar days to be eligible for VAE

Note: It is NOT recommended to include in VAE surveillance young children housed in adult ICU locations who are not thought to be physiologically similar to the location's adult patient population (consider virtual location).

Who is NOT eligible for VAE surveillance?

- Patients who have been ventilated < 3 days are not eligible
- 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)

What about adjunct therapies or alternative modes of mechanical ventilation?

- **INCLUDE** patients who are receiving a conventional mode of mechanical ventilation and
  - Prone positioning
  - Nitric oxide therapy
  - Helium-oxygen mixture (heliox)
  - Epoprostenol therapy
- **INCLUDE** 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 Overview

Note that these are NOT clinical definitions and are not intended for use in the management of patients.

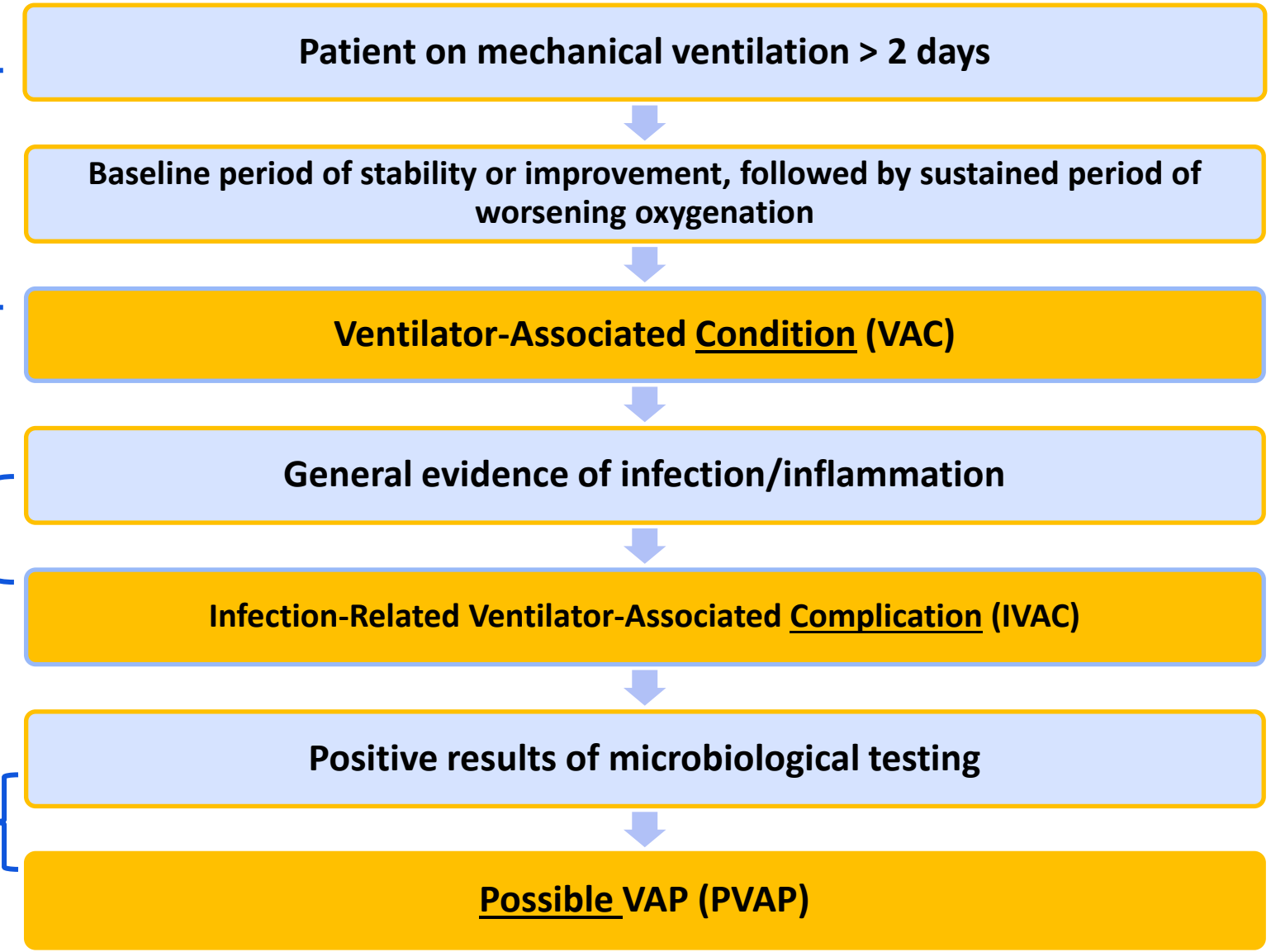
NHSN Chapter 2 Definitions - Identifying Healthcare-associated Infections (HAI) for NHSN Surveillance

Do not apply to VAE

	SSI*	LabID*	VAE*	PedVAE*
Infection Window Period	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Date of Event				
POA				
HAI				
Repeat Infection Timeframe (RIT)				
Secondary BSI Attribution Period				

VAE Definition Algorithm Summary

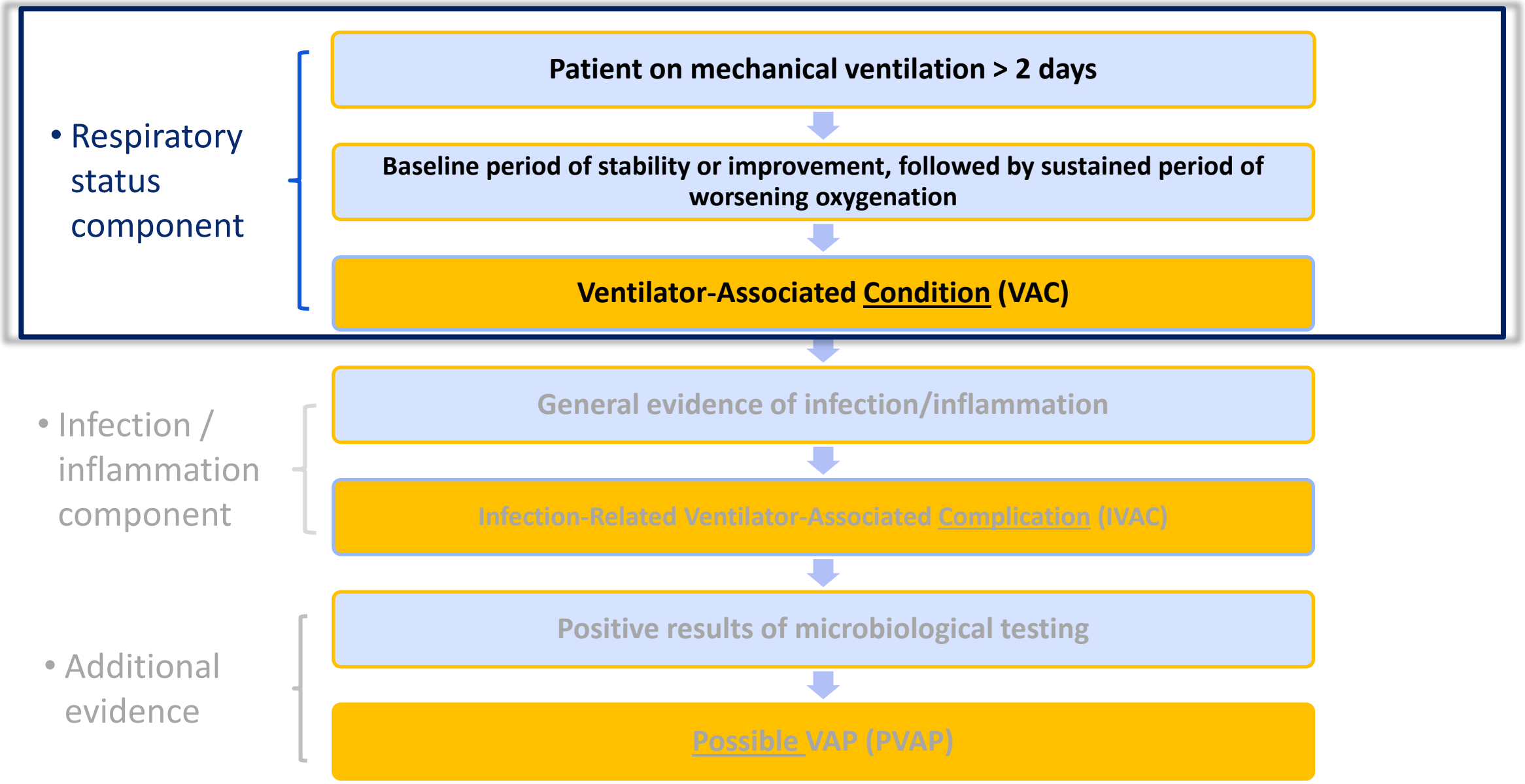
- Respiratory status component
- Infection / inflammation component
- Additional evidence



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
  - All events start with VAC
    - IVAC is not necessarily “worse” than having VAC
    - PVAP is not necessarily “worse” than having IVAC
- 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

Respiratory Status Component of VAE Algorithm



Oxygenation – FiO_2 and PEEP

- A patient's oxygenation needs can be addressed by adjusting the FiO_2 and PEEP settings on the ventilator
- **FiO_2** – the fraction of oxygen in inspired air
  - For example, the FiO_2 of room air is 0.21
  - The oxygen concentration of room air is 21%
  - 0.21 is equivalent to 21%
- **PEEP** – positive end-expiratory pressure – the alveolar pressure above atmospheric pressure at the end of exhalation
  - Achieved by the introduction of mechanical impedance to exhalation
  - Expressed in cmH_2O

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 and PEEP

- **Daily Minimum FiO_2** – the lowest value of FiO_2 during a calendar day that is set on the ventilator and *maintained for > 1 hour*

- **Daily Minimum PEEP** – the lowest value of PEEP during a calendar day that is set on the ventilator and *maintained for > 1 ho*ur
  - Daily minimum PEEP values of 0-5 cmH_2O are considered equivalent (equal to 5 cmH_2O) for the purposes of VAE surveillance.

Eligible FiO_2 and PEEP Setting

- The daily minimum FiO_2 and PEEP values are determined using all **eligible** FiO_2 and PEEP **settings** that are recorded throughout the **calendar day** during times when the patient is **receiving support from an eligible mode of mechanical ventilation**
  - 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

Ineligible FiO_2 and 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)
    - Only review FiO_2 data (PEEP settings are not eligible for use).

Determining Daily Minimum FiO_2 and PEEP

- From the eligible documented settings, choose 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 FiO_2 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

Identifying the Daily Minimum FiO_2 and PEEP

(Select the lowest value recorded for each calendar day that is maintained for > one hour)

	Monday 12am	3am	6am	9am	12pm	3pm	6pm	9pm
MV mode	ACV	ACV	ACV	ACV	ACV	ACV	ACV	ACV
FiO_2	1.0	1.0	0.80	0.70	0.70	0.75	0.70	0.70
PEEP	8	8	8	8	8	5	5	8

Note: FiO_2 and PEEP values are maintained for > 1 hour

Guidance for determining daily minimum PEEP and FiO_2 when settings are recorded every hour or more frequently

- Specific guidance is found in the protocol
- 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 a certain level 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 a certain level would be needed (e.g., at 09:00, 09:30, and 10:00)
  - If tracking every hour, 2 consecutive recordings at a certain level (e.g., at 09:00 and 10:00)
- Standardization

Identifying the Daily Minimum FiO_2 and PEEP

(Select the lowest value recorded for each calendar day that is maintained for >1 hour)

	Monday 12am	3am	4am	6am	9am	12pm	3pm	9pm
MV mode	ACV	ACV	ACV	ACV	ACV	ACV	ACV	ACV
FiO_2	0.80	0.70	0.90	0.80	0.80	0.75	0.75	0.75
PEEP	8	8	8	8	8	8	8	8

0.70 is the lowest value for the calendar day - but it was not maintained for > 1 hour

Identifying the Daily Minimum FiO_2 and PEEP

(Ventilation is initiated late in the calendar day)

	Monday 2300	2330	Tuesday 2400 (midnight)	0100	0300	0600	0900	1200…
MV mode	ACV	ACV	ACV	ACV	ACV	ACV	ACV	ACV
FiO_2	0.80	0.70	0.80	O.80	0.80	0.75	0.75	0.75
PEEP	8	5	8	8	8	8	8	8

0.70 is the lowest value for Monday because no value was maintained for > 1 hour

Baseline Period of Stability or Improvement

- A period of stability or improvement, defined by ≥ 2 calendar days of stable or decreasing daily minimum FiO_2 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 FiO_2 or PEEP (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 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 FiO_2 or 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.

Meeting the VAC Definition

- Use the daily minimum FiO_2 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 FiO_2 parameter, or in the PEEP parameter, or in both parameters

Meeting VAC – Baseline Period of Stability

MV Day	Daily minimum PEEP	Daily minimum FiO_2
1	8	30
2	8	30
3	8	30
4	8	55
5	8	55
6	8	60

≥ 2 calendar days of stable daily minimum FiO_2 values

Meeting VAC – Baseline Period of Improvement

MV Day	Daily minimum PEEP	Daily minimum FiO_2
1	8	35
2	8	35
3	8	30
4	8	55
5	8	55
6	8	60

≥ 2 calendar days of improving daily minimum FiO_2 values

2-day period of stability (FiO_2)

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Polys/E pis	Org
1	10	60								
2	5	40								
3	5	40								
4	8	60								
5	8	50								
6	7	40								
7	5	40								
8	5	40								

2-day period of worsening (PEEP parameter)

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Polys/ Epis	Org
1	10	60								
2	5	40								
3	5	40								
4	8	60								
5	8	50								
6	7	40								
7	5	40								
8	5	40								

VAC is met in the PEEP parameter

Vent Day	PEEP min	FiO_2	Temp	Temp	WBC in	WBC max	Abx	Spec	Polys/E pis	Org
1	10									
2	5									
3	5									
4	8									
5	8									
6	7									
7	5									
8	5	40								

Baseline period of ≥ 2 calendar days of stable daily minimum PEEP values

Increase in daily minimum PEEP values of ≥ 3 cmH_2O over the daily minimum PEEP of the first day in the baseline period

VAC is NOT met in the FiO_2 parameter

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Polys/E pis	Org
1	10	60								
2	5	40								
3	5	40								
4	8	60								
5	8	50								
6	7	40								
7	5	40								
8	5	40								

Baseline period of ≥ 2 calendar days of stable daily minimum FiO_2 values

However, the increase in daily minimum FiO_2 values of ≥ 0.20 (20 points) over the daily minimum FiO_2 of the first day in the baseline period is NOT sustained at the required threshold for at least 2 days (50 on MV day 5).

VAC is NOT met in the PEEP parameter

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Polys/E pis	Org
1	10									
2	7									
3	5									
4	8									
5	8									
6	7									
7	5	40								
8	5	40								

Baseline period of ≥ 2 calendar days of improving daily minimum PEEP values

Increase in daily minimum PEEP values does not meet worsening oxygenation criteria of ≥ 3 cmH_2O over the daily minimum PEEP of the <u>first day</u> in the baseline period.

VAC is met in the PEEP parameter

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Polys/E pis	Org
1	10									
2	5									
3	5									
4	10									
5	8									
6	7									
7	5	40								
8	5	40								

Baseline period of ≥ 2 calendar days of stable daily minimum PEEP values

Increase in daily minimum PEEP values of ≥ 3 cmH_2O over the daily minimum PEEP of the first day in the baseline period is maintained for at least 2 days

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

Date of Event = Vent Day 4 (first day of worsening oxygenation)

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Poly/ Epis	Org
1	10	60								
2	5	40								
3	5	40								
4	8	60								
5	8	50								
6	7	40								
7	5	40								
8	5	40								

Why is the Date of Event important?

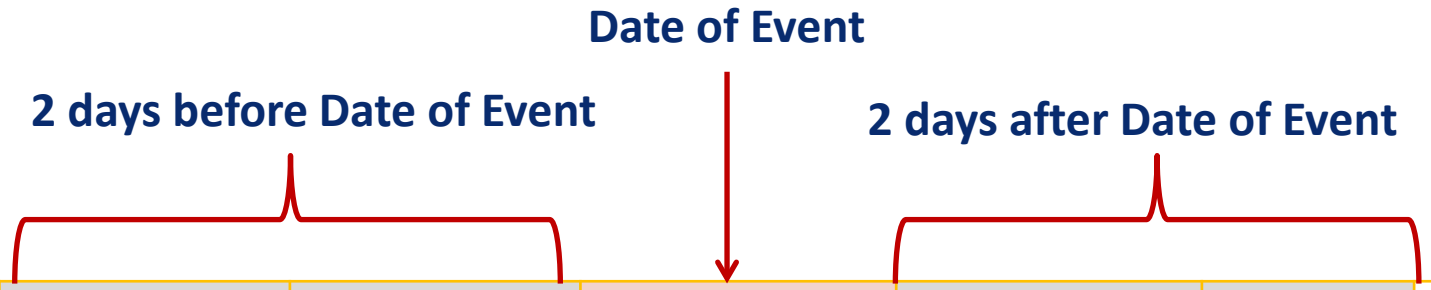
- Defines the “VAE Window Period”
  - Period during which criteria for other events—IVAC, PVAP—must be met
- Sets the 14-day VAE Event Period
  - Day 1 is the Date of Event—so if June 1 is date of onset of worsening oxygenation and a VAC is reported, a second VAE cannot be detected and reported until 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 all 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



MV Day	10	11	12	13	14	15	16
VAE Day	-3	-2	-1	1	2	3	4
Worsening oxygenation	--	Day 1 of Stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation		
Temperature or WBC abnormality		←Documented within this shaded period→					
Antimicrobial agent		←Started on within this shaded period, and then continued for at least 4 days→					
Purulent respiratory secretions, positive culture, positive histopathology		←Collected within this shaded period→					

VAE Window Period: Important Note

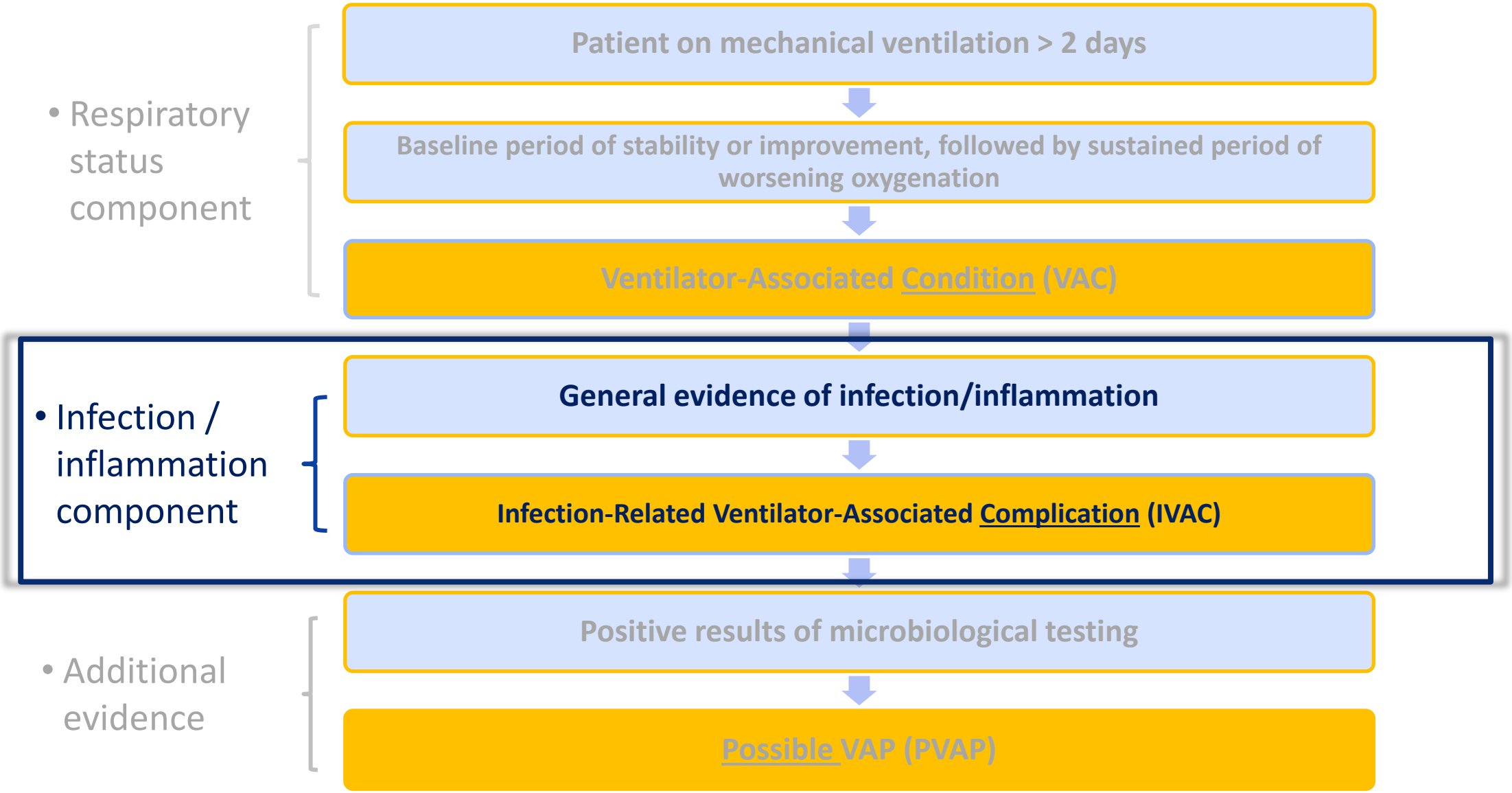
- There is an exception in which the VAE Window Period is only 3 or 4 days
- In cases where the VAE event date corresponds to MV day 3 or day 4, the VAE Window Period may only be a 3-day or a 4-day window, because it can NOT include any days before the 3rd day of MV.
  - If the VAE event date is MV day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

Exception to VAE Window Period

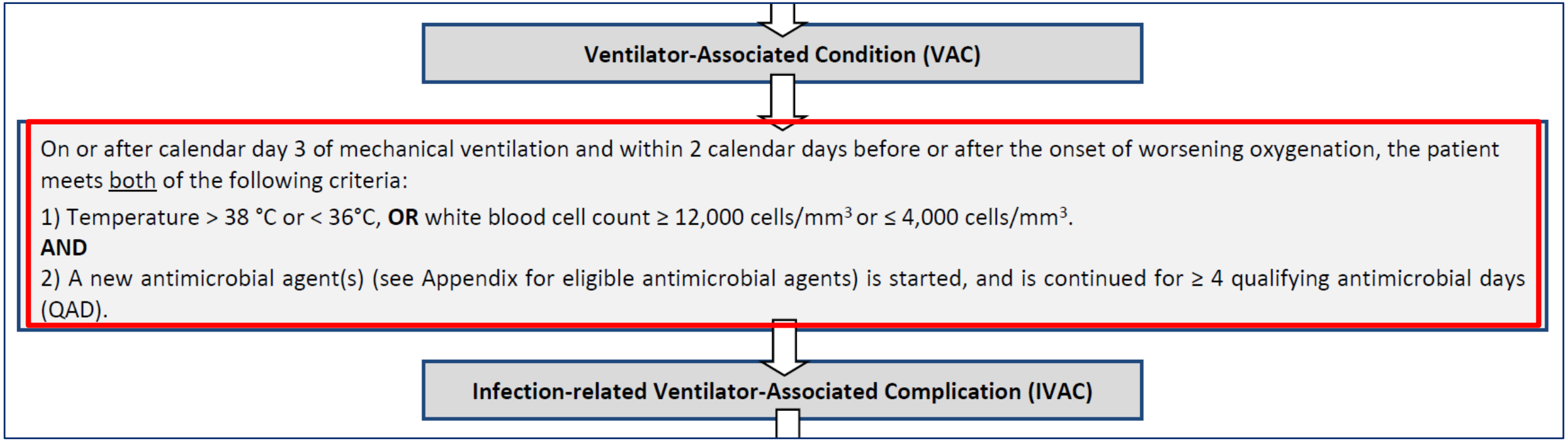
Date of Event is MV day 3, so MV Day 1 and 2 are not included in the VAE Window Period. VAE Window Period is MV Days 3-5.

MV Day No.	1	2	3	4	5	6	7
VAE Day	-2	-1	1	2	3	4	5
Worsening oxygenation	Day 1 of Stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation			
Temperature or WBC abnormality			←Documented within this shaded period→				
Antimicrobial agent			←Started on within this shaded period, and then continued for at least 4 days→				
Purulent respiratory secretions, positive culture, positive histopathology			←Collected within this shaded period→				

Infection/Inflammation Component of VAE Algorithm



Tier 2: IVAC


Ventilator-Associated Condition (VAC)
On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, the patient meets both of the following criteria:
1) Temperature > 38 °C or < 36°C, OR white blood cell count ≥ 12,000 cells/mm3 or ≤ 4,000 cells/mm3.
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 (WBC) Count

As long as there is an abnormal temperature (> 38 °C or < 36°C) OR 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 WBC count was also present on admission or outside the VAE Window Period.

Look for abnormal temperature or WBC count during VAE Window Period

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Polys/ Epis	Org
1	10	60								
2	5	40								
3	5	40	35.8	37.6	7.1	10.3				
4	5	60	36.1	39.2	3.6	4.2				
5	8	50	38.4	38.9	12.6	15.9				
6	8	40	36.5	37.8	11.1	13.6				
7	8	40	36.6	37.7	5.6	8.0				
8	5	40								

What is a “new” antimicrobial agent:

- **New antimicrobial agent**: Defined as any agent listed in the protocol Appendix that is initiated on or after the third calendar day of mechanical ventilation AND in the VAE Window Period
  - The agent is considered “new” if it was NOT given to the patient on either of the 2 days preceding the current start date
  - The new agent must be administered IV, IM, via digestive tract or via respiratory tract
  - A new agent must be continued for ≥ 4 qualifying antimicrobial days

Qualifying Antimicrobial Days (QAD)

- QAD is 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

Qualifying Antimicrobial Days

MV Day	Date	Hide... Min. PEEP (cmH_2O)	Hide... Min. FiO_2 (21 - 100)	VAE	T<36° or T>38°	WBC≤ 4,000 or WBC≥ 12,000 cells/mm^3	Add... Remove... Choose a Drug: CEFTAZIDIME	QAD
2	3/2/2019	5 (2)*	40				☐	
3	3/3/2019	5 (2)*	40				☐	
† 4	3/4/2019	5	40		☑	☐	☐	
† 5	3/5/2019	5	40		☐	☐	☑	¶ yes
† 6	3/6/2019	10	40	‡ IVAC	☑	☐	☑	¶ yes
† 7	3/7/2019	10	40		☐	☐	☑	¶ yes
† 8	3/8/2019				☐	☐	☑	¶ yes
9	3/9/2019						☑	¶ yes

NEW: Initiated on or after the third calendar day of mechanical ventilation and in the VAE Window Period

QADs: Same Agent

- Days between administrations of the **SAME** new antimicrobial agent also count as QADs as long as there is a gap of **no more than 1 calendar day** between administrations of the **same drug**.

MV Day	Date	Hide... Min. PEEP (cmH_2O)	Hide... Min. FiO_2 (21 - 100)	VAE	T<36° or T>38°	WBC ≤ 4,000 or WBC ≥ 12,000 cells/mm^3	Add... Remove... Choose a Drug: CEFTAZIDIME	QAD
2	3/2/2019	5 (2)*	40				☐	
3	3/3/2019	5 (2)*	40				☐	
† 4	3/4/2019	5	40		☑	☐	☐	
† 5	3/5/2019	5	40		☐	☐	☑	¶ yes
† 6	3/6/2019	10	40	‡ IVAC	☑	☐	☐	¶ yes
† 7	3/7/2019	10	40		☐	☐	☑	¶ yes
† 8	3/8/2019				☐	☐	☐	¶ yes
9	3/9/2019						☑	¶ yes

- Ceftazidime is administered on MV days 5, 7, 9 but not MV days 6 and 8. This represents 5 consecutive QADs.

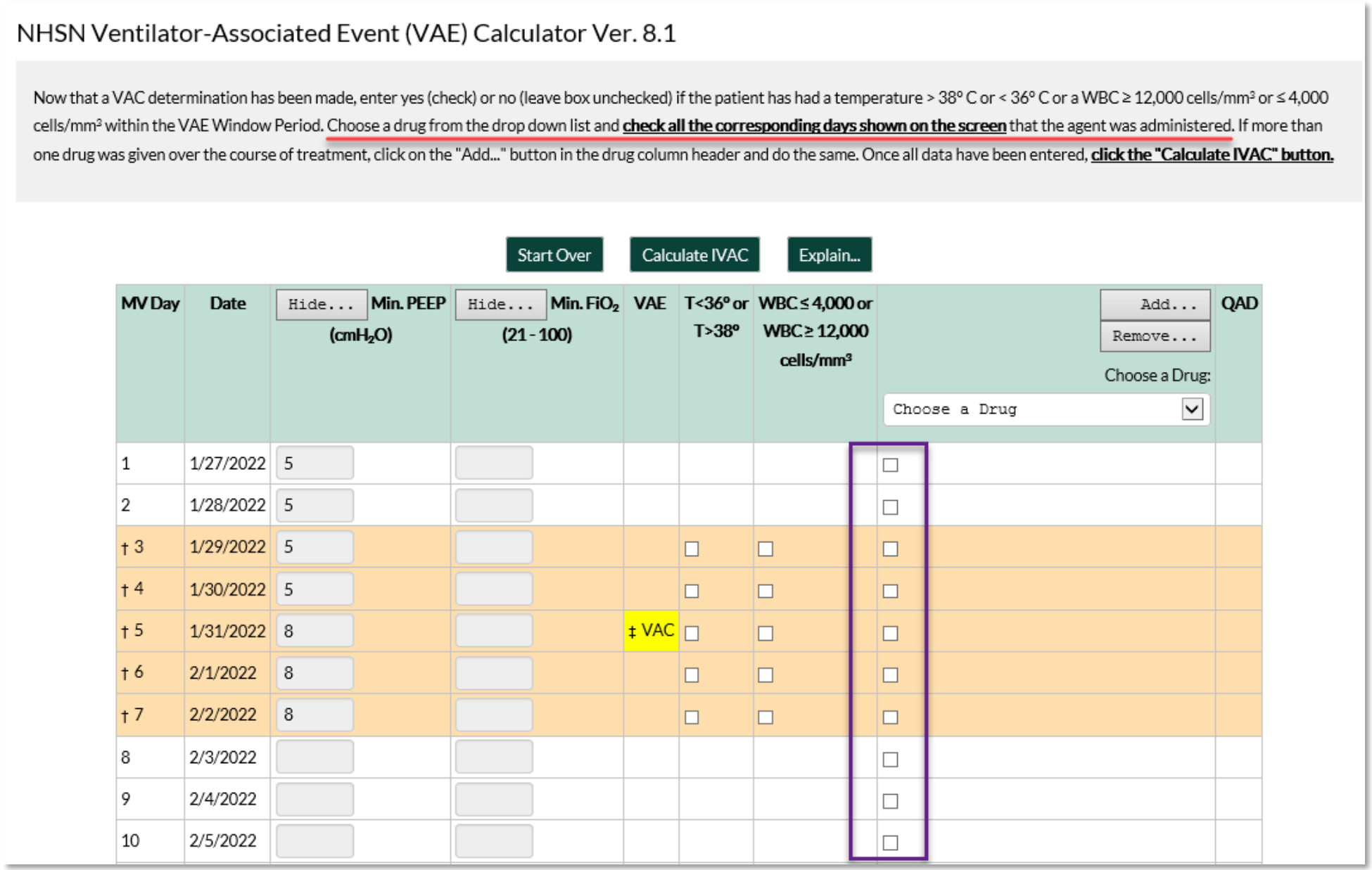
QADs: Different Agents

- In contrast, days between administration of **DIFFERENT** antimicrobial agents do NOT count as QADs

MV Day	Date	Hide... Min. PEEP (cmH_2O)	Hide... Min. FiO_2 (21 - 100)	VAE	T<36° or T>38°	WBC≤ 4,000 or WBC≥ 12,000 cells/mm^3	Add... Remove... Choose a Drug: CEFTAZIDIME	Add... Remove... Choose a Drug: MEROPENEM	QAD
2	3/2/2019	5 (2)*	40				☐	☐	
3	3/3/2019	5 (2)*	40				☐	☐	
† 4	3/4/2019	5	40		☑	☐	☑	☐	¶ yes
† 5	3/5/2019	5	40		☐	☐	☑	☐	¶ yes
† 6	3/6/2019	10	40	‡ VAC	☑	☐	☐	☐	
† 7	3/7/2019	10	40		☐	☐	☐	☑	¶ yes
† 8	3/8/2019				☐	☐	☐	☑	¶ yes
9	3/9/2019						☐	☑	¶ yes

- Ceftazidime is administered MV days 4 and 5, and there is a gap on MV day 6 between different agents. Meropenem is administered MV days 7-9.
- MV day 4 does not count as a QAD. Therefore, the 4 QAD criterion is NOT met.

Date of Initiation of Antimicrobial Agent is Important



NHSN Ventilator-Associated Event (VAE) Calculator Ver. 8.1

Now that a VAC determination has been made, enter yes (check) or no (leave box unchecked) if the patient has had a temperature > 38° C or < 36° C or a WBC ≥ 12,000 cells/mm³ or ≤ 4,000 cells/mm³ within the VAE Window Period. Choose a drug from the drop down list and **check all the corresponding days shown on the screen** that the agent was administered. If more than one drug was given over the course of treatment, click on the "Add..." button in the drug column header and do the same. Once all data have been entered, **click the "Calculate IVAC" button.**

Start Over | Calculate IVAC | Explain...

MV Day	Date	Hide... Min. PEEP (cmH_2O)	Hide... Min. FiO_2 (21 - 100)	VAE	T<36° or T>38°	WBC ≤ 4,000 or WBC ≥ 12,000 cells/mm³	Add... Remove... Choose a Drug: Choose a Drug	QAD
1	1/27/2022	5					☐	
2	1/28/2022	5					☐	
† 3	1/29/2022	5			☐	☐	☐	
† 4	1/30/2022	5			☐	☐	☐	
† 5	1/31/2022	8		‡ VAC	☐	☐	☐	
† 6	2/1/2022	8			☐	☐	☐	
† 7	2/2/2022	8			☐	☐	☐	
8	2/3/2022						☐	
9	2/4/2022						☐	
10	2/5/2022						☐	

No QADs – VAC Determination

NEW: Initiated on or after the third calendar day of mechanical ventilation and in the VAE Window Period

No IVACs were found for this patient. You should report the event as a VAC. Click on the "Explain..." button for an explanation of

Start Over | Calculate IVAC | Explain...

MV Day	Date	Hide... Min. PEEP (cmH_2O)	Hide... Min. FiO_2 (21 - 100)	VAE	T<36° or T>38°	WBC ≤ 4,000 or WBC ≥ 12,000 cells/mm^3	Add... / Remove... Choose a Drug: AMIKACIN	QAD
1	1/27/2022	5					☐	
2	1/28/2022	5					☑	
† 3	1/29/2022	5			☑	☐	☑	
† 4	1/30/2022	5			☑	☐	☑	
† 5	1/31/2022	8		‡ VAC	☐	☐	☑	
† 6	2/1/2022	8			☐	☐	☑	
† 7	2/2/2022	8			☐	☐	☐	
8	2/3/2022						☐	

Started before MV day 3 and outside the VAE Window Period – not a "new" antimicrobial agent

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?

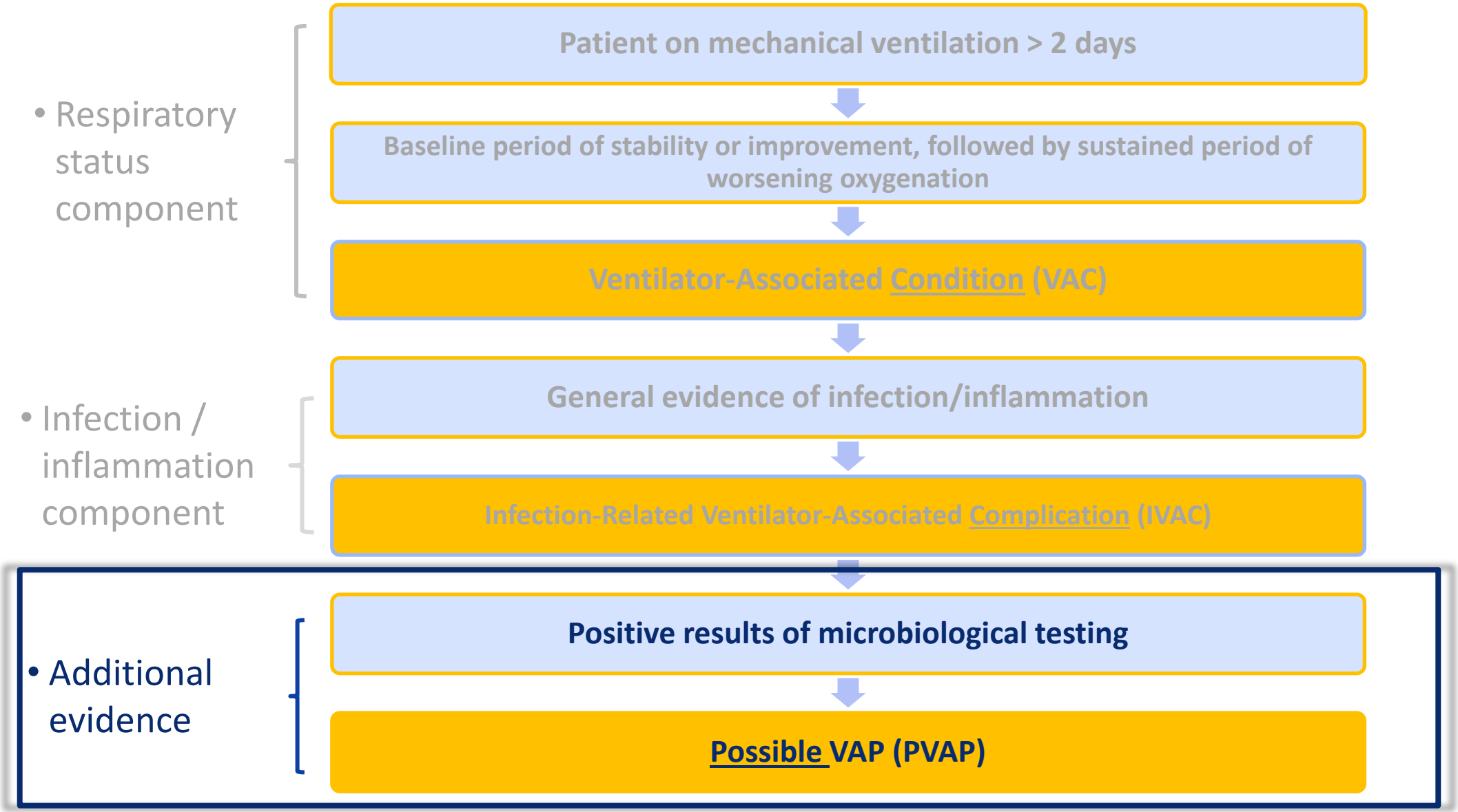
Yes

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 Infection-related Ventilator-Associated Complication (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.
- Still, it is possible that an existing agent may have dual purposes and not necessarily be treating 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

Additional Evidence Component of VAE Algorithm



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)

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, ≥ 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

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 laboratory 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

*Reference: Garcia, LS (Ed.). (2010). Clinical Microbiology Procedures Handbook. Herndon, VA: ASM Press, page 3.2.1.16.

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])

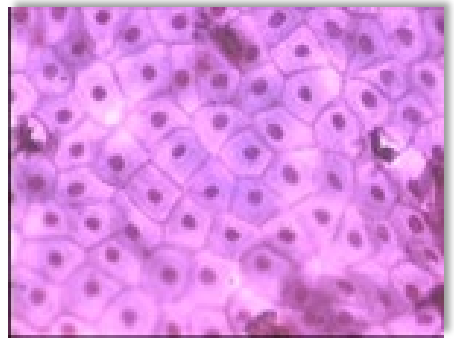
AND

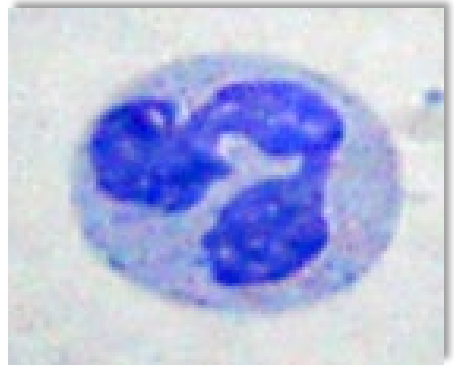
A positive culture of one of the following specimens (qualitative culture, or quantitative/semi-quantitative culture without sufficient growth to meet Criterion #1):

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

What if my laboratory reports Gram stain / direct exam results in a manner that does not quantitate neutrophils and squamous epithelial cells as the definition is written?

- Check with the laboratory for direction in interpreting your facility's reporting method
- If your laboratory cannot provide guidance on how to correlate your facility's reporting method to the purulent respiratory secretions quantitative definition, refer to **Table 2** or **FAQ no. 19** in the VAE protocol





*Reference: Garcia, LS (Ed.). (2010). Clinical Microbiology Procedures Handbook. Herndon, VA: ASM Press, page 3.2.1.16.

Table 2

Some clinical laboratories use different result reporting formats for respiratory secretion direct examination results

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:

- 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, pseudo hyphae 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

PVAP – Criterion 3 (continued)

One of the following positive tests:

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

Pathogen Reporting

- Pathogens may only be reported for PVAP events
  - Exception: excluded pathogens (see next slide)
- Pathogens are not reported for VAC or for IVAC

Pathogen Exclusions

- ***Candida* species or yeast not otherwise specified**, **coagulase-negative *Staphylococcus* species,** and ***Enterococcus* species** are excluded for use unless isolated from lung tissue or pleural fluid

- A BSI with these exclude pathogens cannot be attributed as secondary to VAE unless the excluded pathogen is isolated from lung tissue or pleural fluid

What if I have a BAL culture report similar to this:

"Normal Flora with many *Pseudomonas aeruginosa* and moderate *Candida* species"

Can I use this report to meet Criterion 1 of the PVAP definition?

Yes

- An eligible pathogen accompanied by an ineligible pathogen may be used to satisfy the PVAP criteria.
- Note the report is not a quantitative report, however, the "Many" quantity is acceptable as a semi-quantitative equivalent

What if a pathogen is identified outside the VAE Window Period and then during the VAE Window Period the same pathogen is identified again. Can I use that pathogen identification to meet a PVAP criterion?

Yes

- It does not matter if the patient had previous positive cultures for certain organisms—if an eligible pathogen is recovered from an eligible specimen with a collection date during the VAE window period, it should be used in determining if PVAP is met.

Positive quantitative or semi-quantitative* ETA culture *(meeting specified threshold)*

Vent Day	PEEPmin	FiO_2 min	Temp min	Temp max	WBC min	WBC max	QAD	Spec	Polys /Epis	Org
1	10	60								
2	5	40					None			
3	5	40	36.9	37.6	12.1	12.1	None	ETA		10^5 CFU/ml *S. aureus*
4	8	60	38.1	39.2	14.5	16.8	Yes	--	--	--
5	8	50	38.4	38.9	12.6	15.9	Yes	--		
6	7	40	36.5	37.8	11.1	13.6	Yes	--		
7	5	40					Yes			

= PVAP Criterion #1

*semi-quantitative result of “moderate” “many” “numerous” or “heavy” growth, or 2+, 3+ or 4+ growth (in a culture of lung tissue, BAL, PSB, or ETA) meets the PVAP surveillance definition.

Vent Day	PEEPmin	FiO_2 min	Temp min	Temp max	WBC min	WBC max	QAD	Spec	Polys/ Epis	Org
1	10	60								
2	5	40								
3	5	40	36.9	37.6	12.1	12.1	None	ETA	>25/ <10	*S. aureus*
4	8	60	38.1	39.2	14.5	16.8	Yes	--	--	--
5	8	50	38.4	38.9	12.6	15.9	Yes			
6	7	40	36.5	37.8	11.1	13.6	Yes	--	--	---
7	5	40					Yes			
8	5	40								

Purulent respiratory secretions and ETA culture positive for *S. aureus (not meeting the specified threshold)*

= PVAP (Criterion #2)

Positive pleural fluid, lung histopathology, *Legionella* or viral test result

Vent Day	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	QAD	Spe	Polys/ Epis	Org
1	10	60								
2	5	40								
3	5	40	36.9	37.6	12.1	12.1	None	Pleural Fluid		*Candida albicans*
4	8	60	38.1	39.2	14.5	16.8	Yes	--	--	--
5	8	50	38.4	38.9	12.6	15.9	Yes	--	--	--
6	7	40	36.5	37.8	11.1	13.6	Yes	--	--	---
7	5	40					Yes			
8	5	40								

= PVAP Criterion #3

What about positive blood cultures that occur around the same time as a VAE?

- Secondary BSIs are not reported for VAC or IVAC
- Secondary BSI may only be reported for PVAP
  - When at least one eligible organism from the blood culture specimen matches an eligible organism from an appropriate respiratory tract specimen collected during the VAE Window Period
  - When the blood culture was collected within the 14-day event period (VAE Date of Event is Day 1 of the 14-day event period)
- Secondary BSI may not be reported for PVAP:
  - In cases where PVAP is met with only the histopathology criterion and no culture or non-culture based testing is performed on an eligible respiratory specimen
  - In cases where a culture or non-culture based testing of respiratory secretions, pleural fluid, or lung tissue is performed and does not identify an organism that matches an organism identified from blood

Location of Attribution

The inpatient location where the patient was assigned on the date of the VAE (date of onset of worsening oxygenation).

Transfer Rule

If a VAE date of event is **on the day of transfer** or **the day following transfer** from one inpatient location to another in the same facility or to a new facility, the event is attributed to the transferring location.

Transfer from MICU to SICU on MV Day 2, Date of Event is MV Day 4 - therefore VAE is attributed to SICU (more than one day since transfer)

Vent Day	Location	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Poly/Epis	Org
1	MICU	10	60								
2	MICU to SICU	5	40					None			
3	**SICU**	5	40	36.9	37.6	12.1	12.1	None	**Pleural Fluid**		***Candida albicans***
4	**SICU**	8	60	38.1	39.2	14.5	16.8	Yes	--	--	--
5	SICU	8	50	38.4	38.9	12.6	15.9	Yes	--	--	--
6	SICU	7	40	36.5	37.8	11.1	13.6	Yes	--	--	---
7	SICU	5	40					Yes			
8	SICU	5	40								

Transfer from MICU to SICU on MV Day 3, Date of Event is MV Day 4 - therefore VAE is attributed to MICU (within 2 days of transfer)

Vent Day	Location	PEEP min	FiO_2 min	Temp min	Temp max	WBC min	WBC max	Abx	Spec	Poly/Epis	Org
1	MICU	10	60								
2	MICU	5	40					None			
3	**MICU to SICU**	5	40	36.9	37.6	12.1	12.1	None	**Pleural Fluid**		***Candida albicans***
4	**SICU**	8	60	38.1	39.2	14.5	16.8	Yes	--	--	--
5	SICU	8	50	38.4	38.9	12.6	15.9	Yes	--	--	--
6	SICU	7	40	36.5	37.8	11.1	13.6	Yes	--	--	---
7	SICU	5	40					Yes			
8	SICU	5	40								

Tips for VAE Surveillance and Reporting

VAE Resources

- Familiarize yourself with the VAE web page: https://www.cdc.gov/nhsn/psc/vae/index.html
  - Review the Supporting Materials section
- Read the protocol: https://www.cdc.gov/nhsn/pdfs/pscmanual/10-vae_final.pdf
- Review the FAQs
  - Protocol FAQs – starting on page 10-28
  - FAQs found on the VAE web page: https://www.cdc.gov/nhsn/faqs/faq-vae.html
- VAE training resources: https://www.cdc.gov/nhsn/training/patient-safety-component/vae.html
- Use the VAE Calculator: https://www.cdc.gov/nhsn/vae-calculator/index.html

Use the VAE Calculator

- Available as a tool to assist with making VAE determinations
  - Operates based on the VAE algorithm
- The “Explain” button in the calculator will pop up an explanation as to how the “calculation” for the case determination was made
- The calculator runs locally on your computer and none of the data you enter is reported, uploaded, or stored
  - Experiment with it – put in test scenarios to see what happens
- Remember - the correct determination by the calculator is dependent upon the correct data being entered
  - It is not a substitute for you knowing and understanding the rules for entering the values into the designated data fields

Tips for VAE Surveillance

- Establish relationships with **Respiratory Therapy and Critical Care colleagues**:
  - Share the protocol and FAQs
  - Discuss options for collection of minimum daily PEEP and FiO_2 for each MV day (IP, RT, electronically generated)
  - Inquire about the frequency of use of excluded therapies (HFV, ECLS) and APRV, and how to identify these patients
- Determine your **laboratory's** approach to Gram stain and culture result reporting
  - Share the protocol and FAQs
  - How does your hospital laboratory report Gram stain results?
  - Does your hospital laboratory report culture results quantitatively?
  - What quantitative ranges correspond to the semi-quantitative reports?
  - Where will you find histopathology/cytology reports?

VAE Reporting – Event Data

- When conducting in-plan reporting (selected in your monthly reporting plan) you must report all events detected and at the highest level of the algorithm that is met.
- Assess patients for ALL events: VAC, IVAC, and PVAP
- Hierarchy of definitions:
    - If a patient meets VAC only, report as VAC
    - If a patient meets criteria for VAC and IVAC, report as IVAC only
    - If a patient meets criteria for VAC, IVAC and PVAP, report PVAP only
- Review the VAE Event Form and Table of Instructions on the VAE wepage

VAE Reporting – Denominator Data

- Collect device (ventilator) days and patient days at the same time each day
- Patient days
  - Number of patients in the chosen location at the time of the count
- Ventilator days
  - Number of patients in the chosen location who are on a mechanical ventilator at the time of the count
  - All patients (not just those eligible for VAE surveillance) are counted to include those on a ventilator < 3 days, those receiving excluded therapies, etc.
- Review the Denominator Forms and Tables of Instructions on the VAE webpage

Questions?
Please contact the NHSN Helpdesk
nhsn@cdc.gov

For more information please contact Centers for Disease Control and Prevention
1600 Clifton Road NE, Atlanta, GA 30333
Telephone, 1-800-CDC-INFO (232-4636)/TTY: 1-888-232-6348
E-mail: cdcinfo@cdc.gov Web: www.cdc.gov