Ventilator-Associated Event (VAE)

For use in adult locations only

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Introduction

Mechanical ventilation is an essential, life-saving therapy for patients with critical illness and respiratory failure. Studies have estimated that more than 300,000 patients receive mechanical ventilation in the United States each year [1-3]. These patients are at high risk for complications and poor outcomes, including death [1-5]. Ventilator-associated pneumonia (VAP), sepsis, Acute Respiratory Distress Syndrome (ARDS), pulmonary embolism, barotrauma, and pulmonary edema are among the complications that can occur in patients receiving mechanical ventilation. Such complications can lead to longer duration of mechanical ventilation, longer stays in the ICU and hospital, increased healthcare costs, and increased risk of disability and death. Mortality in patients with acute lung injury on mechanical ventilation has been estimated to range from 24% in persons 15-19 years of age to 60% for patients 85 years and older [4].

Surveillance for ventilator-associated events in the National Healthcare Safety Network (NHSN) prior to 2013 was limited to VAP. For the year 2012, VAP incidence for various types of hospital units ranged from 0.0-4.4 per 1,000 ventilator days [6]. However, there is currently no valid, reliable definition for VAP, and even the most widely used VAP criteria and definitions are neither sensitive nor specific [7-10].

A particular difficulty with many commonly used VAP definitions, including the NHSN PNEU definitions (revised in 2002), is that they require radiographic findings of pneumonia. Evidence suggests that chest radiograph findings do not accurately identify VAP. The subjectivity and variability inherent in chest

radiograph technique, interpretation, and reporting make chest imaging ill-suited for inclusion in a definition algorithm to be used for the potential purposes of public reporting, inter-facility comparisons, and pay-for-reporting and pay-for-performance programs. Another major limitation of the available VAP definitions is their reliance on specific clinical signs or symptoms, which are subjective and may be poorly or inconsistently documented in the medical record. The NHSN PNEU protocol includes multiple definition pathways and special criteria for selected patient populations (for example, children, immunocompromised patients), increasing its complexity.

The limitations of VAP surveillance definitions have implications for prevention. Valid and reliable surveillance data are necessary for assessing the effectiveness of prevention strategies. It is notable that some of the most effective measures for improving outcomes of patients on mechanical ventilation do not specifically target pneumonia prevention [11-14].

In 2011, CDC convened a Working Group composed of members of several stakeholder organizations to address the limitations of the NHSN PNEU definitions and propose a new approach to surveillance for Ventilator-Associated Events (VAE) for NHSN [15]. The organizations represented in the Working Group include: the Critical Care Societies Collaborative (the American Association of Critical-Care Nurses, the American College of Chest Physicians, the American Thoracic Society, and the Society for Critical Care Medicine), the American Association for Respiratory Care, the Association of Professionals in Infection Control and Epidemiology, the Council of State and Territorial Epidemiologists, the Healthcare Infection Control Practices Advisory Committee's Surveillance Working Group, the Infectious Diseases Society of America, and the Society for Healthcare Epidemiology of America.

The VAE surveillance definition algorithm developed by the Working Group and implemented in the 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 [16]. Several modifications to the VAE definitions have been made since January 2013. These modifications address issues raised by NHSN users and discussed with the Working Group. There are three definition tiers within the VAE algorithm: 1) Ventilator-Associated Condition (VAC); 2) Infection-related Ventilator-Associated Complication (IVAC); and 3) Possible VAP (PVAP). Data indicate that streamlined, objective algorithms to detect ventilator-associated complications (similar to the VAC tier of the VAE algorithm) are easily implemented, can make use of electronic health record systems to automate event detection, and identify events that are clinically important and associated with outcomes such as ICU and hospital length of stay and mortality [16,17]. Research suggests that most VACs are due to pneumonia, ARDS, atelectasis, and pulmonary edema [16]. These are significant clinical conditions that may be preventable. VAE rates and event characteristics in adult inpatient locations reporting data to NHSN in 2014 have been published [18].

NOTE: The VAE definition algorithm is for use in surveillance; it is not a clinical definition algorithm and is not intended for use in the clinical management of patients. Examples provided throughout this protocol and in the VAE "Frequently-Asked Questions" are for illustration purposes only and are not intended to represent actual clinical scenarios.

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 and patient days) can be collected for patients. Such locations may include critical/intensive care units (ICU), specialty care areas (SCA), step-down units, and wards. A complete listing of adult inpatient locations can be found in Chapter 15 CDC Locations and Descriptions.

NOTE: Non-acute care mapped locations in acute care facilities (chronic care units in acute care facilities) are not eligible to participate in VAE surveillance.

NOTE: It is not required to monitor for VAEs after discharge if a patient is transferred to another facility while still on mechanical ventilation. However, VAEs discovered within 2 calendar days of discharge (where the day of discharge is day 1) should be reported to NHSN. No additional ventilator days are reported.

Definitions

VAE: VAEs are identified by using a combination of objective criteria: deterioration in respiratory status after a period of stability or improvement on the ventilator, evidence of infection or inflammation, and laboratory evidence of respiratory infection. The following pages outline the criteria that must be used for meeting the VAE surveillance definitions (Figure 1). To report VAEs, use the *Ventilator-Associated Event (VAE)* form (CDC 57.112) and *Instructions for Completion of Ventilator-Associated Event Form*.

> NOTE: Patients must be mechanically ventilated for at least 4 calendar days to fulfill VAE criteria (where the day of intubation and initiation of mechanical ventilation is day 1). The earliest date of event for VAE (the date of onset of worsening oxygenation) is day 3 of mechanical ventilation. Line lists of VAE data elements demonstrating scenarios that meet and do not meet the VAE definitions are presented in "Frequently-Asked Questions (FAQs)" number (no.) 2 at the end of this protocol.
>
> NOTE: The baseline period of stability or improvement on the ventilator is defined as the 2 calendar days immediately preceding the first day of increased daily minimum PEEP or FiO_2, and must be characterized by ≥ 2 calendar days of stable or decreasing daily minimum FiO_2 or PEEP values (specifically the daily minimum PEEP or FiO_2 on the second day of the baseline period of stability or improvement must be equal to or less than the daily minimum PEEP or FiO_2 on the first day of the baseline period of stability or improvement). The definitions of "daily minimum PEEP" and "daily minimum FiO_2" are included below. Note that the minimum daily PEEP or FiO_2 used for VAE surveillance is the lowest setting during a calendar day that was maintained for > 1 hour (see daily minimum PEEP and FiO_2 definitions for exception to 1 hour requirement).
>
> For the purposes of VAE surveillance, PEEP values between 0 cmH_2O and 5 cmH_2O will be considered equivalent. This means that patients with daily minimum PEEP values from 0 to 5

cmH_2O must then have an increase in the daily minimum PEEP to at least 8 cmH_2O, sustained for at least 2 calendar days, to meet the VAC definition.

EXAMPLE: In the example below, the baseline period is defined by mechanical ventilation (MV) days 1 through 4 (shaded in light gray), and the period of worsening oxygenation by MV days 5 and 6 (shaded in darker gray), where the daily minimum PEEP is ≥ 3 cmH_2O greater than the daily minimum PEEP of the first day in the baseline period. Note that there is no VAC on MV day 3, because PEEP values 0-5 cmH_2O are considered equivalent for the purposes of this surveillance.

MV Day	Daily minimum PEEP (cmH_2O)	Daily minimum FiO_2 (oxygen concentration, %)	VAE
1	0 (5)	1.00 (100%)	-
2	0 (5)	0.50 (50%)	-
3	**5**	0.50 (50%)	-
4	**5**	0.50 (50%)	-
5	**8**	0.50 (50%)	**VAC**
6	**8**	0.50 (50%)	-

EXAMPLE: In the example below, the baseline period is defined by mechanical ventilation (MV) days 1 through 4 (shaded in light gray), and the period of worsening oxygenation by MV days 5 and 6 (shaded in darker gray), where the daily minimum PEEP is ≥ 3 cmH_2O greater than the daily minimum PEEP of the first day in the baseline period. In this example, note that MV days 1-4 are considered a baseline period even though the daily minimum PEEP increases from 0 to 3 to 5 cmH_2O during this time period—because PEEP values from 0-5 cmH_2O are considered equivalent for the purposes of this surveillance.

MV Day	Daily minimum PEEP (cmH_2O)	Daily minimum FiO_2 (oxygen concentration, %)	VAE
1	0 (5)	1.00 (100%)	-
2	0 (5)	0.50 (50%)	-
3	**3 (5)**	0.50 (50%)	-
4	**5**	0.50 (50%)	-
5	**8**	0.50 (50%)	**VAC**
6	**8**	0.50 (50%)	-

EXAMPLE: In the example below, the baseline period is defined by mechanical ventilation (MV) days 3 and 4 (shaded in light gray), and the period of worsening oxygenation by MV days 5 and 6 (shaded in darker gray), where the daily minimum FiO_2 is ≥ 0.20 (20 points) over the daily minimum FiO_2 of the first day in the baseline period.

MV Day	Daily minimum PEEP (cmH_2O)	Daily minimum FiO_2 (oxygen concentration, %)	VAE
1	8	1.00 (100%)	
2	6	0.50 (50%)	
3	5	**0.40 (40%)**	
4	5	**0.40 (40%)**	
5	6	**0.70 (70%)**	**VAC**
6	6	**0.70 (70%)**	

EXAMPLE: In the example below, there is no VAC, because the FiO_2 on MV day 4 is higher than the FiO_2 on MV day 3 (and therefore not stable or decreasing) – even though the FiO_2 on MV days 3 and 4 meets the 20-point threshold when compared with the daily minimum FiO_2 on MV days 5 and 6.

MV Day	Daily minimum PEEP (cmH_2O)	Daily minimum FiO_2 (oxygen concentration, %)	VAE
1	8	1.0 (100%)	
2	6	0.50 (50%)	
3	5	0.35 (35%)	
4	5	0.40 (40%)	
5	6	0.70 (70%)	No event
6	6	0.70 (70%)	

NOTE: Patients on high frequency ventilation, extracorporeal life support, or paracorporeal membrane oxygenation are EXCLUDED from VAE surveillance during periods of time when the support is in place the entire calendar day (see FAQ no. 22 at the end of this protocol).

NOTE: Patients who are receiving a conventional mode of mechanical ventilation while in the prone position and patients who are receiving a conventional mode of mechanical ventilation while receiving nitric oxide therapy, helium-oxygen mixtures (heliox), or epoprostenol therapy are INCLUDED in VAE surveillance.

NOTE: Patients on Airway Pressure Release Ventilation (APRV) or related modes (see FAQ nos. 22 and 23 at the end of this protocol), are INCLUDED, but when this mode is in use the VAE period of stability or improvement on the ventilator and the period of worsening oxygenation should be determined by changes in FiO_2 only, since changes in PEEP as indicated in this surveillance algorithm may not be applicable to APRV. In addition, patients with VAE who are on APRV or related modes of mechanical ventilation can optionally be indicated as such on the VAE form (CDC 57.112).

Date of Event: The date of onset of worsening oxygenation. This is defined as the first calendar day in which the daily minimum PEEP or FiO_2 increases above the thresholds outlined in the VAE definition algorithm (specifically day 1 of the required ≥ 2-day period of worsening oxygenation following a ≥ 2-day period of stability or improvement on the ventilator).

EXAMPLE: A patient is intubated in the Emergency Room for severe community-acquired pneumonia and admitted to the MICU (day 1). The patient stabilizes and improves on days 2-5, with a daily minimum FiO_2 of 0.35 (35%) on days 4 and 5. On day 6, the patient experiences respiratory deterioration, and requires a minimum FiO_2 of 0.60 (60%) on days 6 and 7, meeting the criteria for a VAC. The date of the VAC event is day 6.

NOTE: The "date of event" is NOT the date on which all VAE criteria have been met. It is the first day (of a ≥ 2-day period) on which either of the worsening oxygenation thresholds (for PEEP or FiO_2) is met.

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 (specifically the first day of worsening oxygenation, the day of VAE onset). There is an exception, however, in which the VAE Window Period is only 3 or 4 days, as follows:

In cases where the VAE date of event corresponds to MV day 3 or day 4, the window period described above may only be a 3-day or a 4-day window, because it can NOT include any days before the 3rd day of MV. For example, if the VAE date of event 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).

14-day Event Period: VAEs are defined by a 14-day period, starting on the day of onset of worsening oxygenation (the date of event, day 1). A new VAE cannot be identified or reported until this 14-day period has elapsed. See FAQ no. 4 at the end of this protocol.

Positive End-Expiratory Pressure (PEEP): "A technique used in respiratory therapy in which airway pressure greater than atmospheric pressure is achieved at the end of exhalation by the introduction of a mechanical impedance to exhalation" [19]. In patients on mechanical ventilation, PEEP is one of the key parameters that can be adjusted depending on the patient's oxygenation needs and is typically in the range of 0 to 15 cmH_2O. A sustained increase (defined later in this protocol) in the daily minimum PEEP of ≥ 3 cmH_2O following a period of stability or improvement on the ventilator is one of two criteria that can be used in meeting the VAC definition. For the purposes of this surveillance, PEEP values from 0 to 5 cmH_2O are considered equivalent.

Fraction of Inspired Oxygen (FiO_2): The fraction of oxygen in inspired gas. For example, the FiO_2 of ambient air is 0.21; the oxygen concentration of ambient air is 21%. In patients on mechanical ventilation, the FiO_2 is one of the key parameters that can be adjusted depending on the patient's oxygenation needs and is typically in the range of 0.30 (oxygen concentration of 30%) to 1.0 (oxygen concentration of 100%). A sustained increase (defined later in this protocol) in the daily minimum FiO_2 of ≥ 0.20 (20%) following a period of stability or improvement on the ventilator is the second of the two criteria that can be used in meeting the VAC definition.

Daily Minimum PEEP: The lowest value of PEEP during a calendar day that is set on the ventilator and *maintained for > 1 hour*. This requirement that the daily minimum PEEP be the lowest setting maintained for > 1 hour will ensure that units monitoring and recording PEEP settings hourly or more frequently than once per hour are able to apply the VAE surveillance PEEP criterion in a standardized way. In the event that ventilator settings are monitored and recorded less frequently than once per hour, the daily minimum PEEP is simply the lowest value of PEEP set on the ventilator during the calendar day. In circumstances where there is no value that is documented to have been maintained for > 1 hour (for example, the lowest value of PEEP is set late in the calendar day, mechanical ventilation is discontinued early in the calendar day, PEEP settings are changed very frequently throughout the calendar day) the daily minimum PEEP should default to the lowest PEEP setting during the calendar day (regardless of how long that setting was maintained). For example, a patient who is intubated and started on mechanical ventilation at 11:30 pm on June 1, with a PEEP setting of 10 cmH_2O from 11:30 pm to midnight, would have a daily minimum PEEP of 10 cmH_2O on June 1 for the purposes of VAE surveillance.

NOTE: In units tracking PEEP settings every hour or more frequently than every hour, there must be sufficient consecutive recordings of a specific PEEP setting to meet the minimum required duration of > 1 hour. For example, in units tracking PEEP every 15 minutes, 5 consecutive recordings of PEEP at a certain level would be needed to meet the required > 1 hour minimum duration (for example, at 09:00, 09:15, 09:30, 09:45, and 10:00). In units tracking PEEP every 30 minutes, 3 consecutive recordings of PEEP at a certain level would be needed to meet the required > 1 hour minimum duration (for example, at 09:00, 09:30, and 10:00). In units tracking PEEP every hour, 2 consecutive recordings of PEEP at a certain level would be needed to meet the required > 1 hour minimum duration (for example, at 09:00 and 10:00).

EXAMPLE: The patient is intubated at 6 pm. PEEP is set at the following values through the remainder of the calendar day:

Time	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**
PEEP (cmH_2O)	10	8	5	5	8	8

In this example, the daily minimum PEEP for the purposes of VAE surveillance is 5 cmH_2O. PEEP settings are being monitored and recorded every hour. There are two consecutive hours where the PEEP setting is noted to be 5 cmH_2O (8 pm and 9 pm), and therefore required minimum duration of > 1 hour is met.

EXAMPLE: The patient is intubated at 6 pm. PEEP is set at the following values through the remainder of the calendar day:

Time	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**
PEEP (cmH_2O)	8	8	5	8	5	8

In this example, the daily minimum PEEP for the purposes of VAE surveillance is 8 cmH_2O. PEEP settings are being monitored and recorded every hour. Although the lowest PEEP is 5 cmH_2O, it is recorded at two non-consecutive time points only (8 pm, then 10 pm), and so the required > 1 hour minimum duration is not met. There are two consecutive hours where the PEEP setting is noted to be 8 cmH_2O (6 pm and 7 pm), and therefore the required minimum duration of > 1 hour is met to allow use of this setting as the daily minimum value for VAE surveillance.

EXAMPLE: PEEP is set at the following values through the course of a calendar day:

Time	**12 am**	**4 am**	**8 am**	**12 pm**	**4 pm**	**8 pm**
PEEP (cmH_2O)	5	8	5	8	8	10

In this example, the daily minimum PEEP is 5 cmH_2O. PEEP settings are being monitored and recorded every 4 hours; therefore, the lowest recorded PEEP setting for the calendar day is the value used in VAE surveillance.

EXAMPLE: You are reviewing a patient's ventilator settings on Wednesday morning to determine the daily minimum PEEP values for Monday and Tuesday. The MICU monitors and records PEEP settings for mechanically-ventilated patients every 30 minutes. You see that the lowest PEEP setting on Monday (5 cmH_2O) was recorded at 11:30 pm when the episode of mechanical ventilation was initiated for this patient. The patient remained at this PEEP setting for an additional 30 minutes on Tuesday morning, and was then maintained on PEEP 10 cmH_2O for the rest of the day on Tuesday. What do you record as the daily minimum PEEP for Monday and for Tuesday? In this example, the only PEEP setting recorded on Monday was 5 cmH_2O. Because there is no value on Monday that has been maintained for > 1 hour, the lowest (and only) setting of 5 cmH_20 is recorded as the daily minimum PEEP for that calendar day. On Tuesday, the daily minimum PEEP should be recorded as 10 cmH_2O, which is the lowest PEEP setting maintained for > 1 hour on Tuesday.

Day	**Time**	**PEEP (cmH_2O)**
Monday	23:30	5
Tuesday	00:00	5
Tuesday	00:30	5
Tuesday	01:00	10
Tuesday	01:30	10
Tuesday	02:00 through 23:30	10

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*. This requirement that the daily minimum FiO_2 be the lowest setting maintained for > 1 hour will ensure that units monitoring and recording FiO_2 settings hourly or more frequently than once per hour are able to apply the VAE surveillance FiO_2 criterion in a standardized way. In the event that ventilator settings are monitored and recorded less frequently than once per hour, the daily

minimum FiO_2 is simply the lowest value of FiO_2 set on the ventilator during the calendar day. In circumstances where there is no value that is documented to have been maintained for > 1 hour (for example, the lowest value of FiO_2 is set late in the calendar day, mechanical ventilation is discontinued early in the calendar day, FiO_2 settings are changed very frequently throughout the calendar day) the daily minimum FiO_2 should default to the lowest FiO_2 setting during the calendar day (regardless of how long that setting was maintained). For example, a patient who is intubated and started on mechanical ventilation at 11:30 pm on June 1, with a FiO_2 setting of 0.30 from 11:30 pm to midnight, would have a daily minimum FiO_2 of 0.30 on June 1 for the purposes of VAE surveillance.

NOTE: In units tracking FiO_2 settings every hour or more frequently than every hour, there must be sufficient consecutive recordings of a specific FiO_2 setting to meet the minimum required duration of > 1 hour. For example, in units tracking FiO_2 every 15 minutes, 5 consecutive recordings of FiO_2 at a certain level would be needed to meet the required > 1 hour minimum duration (for example, 09:00, 09:15, 09:30, 09:45, and 10:00). In units tracking FiO_2 every 30 minutes, 3 consecutive recordings of FiO_2 at a certain level would be needed to meet the required > 1 hour minimum duration (for example, 09:00, 09:30, and 10:00). In units tracking FiO_2 every hour, 2 consecutive recordings of FiO_2 at a certain level would be needed to meet the required > 1 hour minimum duration (for example, 09:00 and 10:00).

EXAMPLE: The patient is intubated at 6 pm. FiO_2 is set at the following values through the remainder of the calendar day:

Time	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**
FiO_2	1.0	0.8	0.5	0.5	0.8	0.8

In this example, the daily minimum FiO_2 for the purposes of VAE surveillance is 0.5. FiO_2 settings are being monitored and recorded every hour. There are two consecutive hours where the FiO_2 setting is noted to be 0.5 (8 pm and 9 pm), and therefore required minimum duration of > 1 hour is met.

EXAMPLE: The patient is intubated at 6 pm. FiO_2 is set at the following values through the remainder of the calendar day:

Time	**6 pm**	**7 pm**	**8 pm**	**9 pm**	**10 pm**	**11 pm**
FiO_2	0.8	0.8	0.5	0.8	0.5	0.8

In this example, the daily minimum FiO_2 for the purposes of VAE surveillance is 0.8. FiO_2 settings are being monitored and recorded every hour. Although the lowest FiO_2 is 0.5, it is recorded at two non-consecutive time points only (8 pm, and then 10 pm), and so the required 1 hour minimum duration is not met. There are two consecutive hours where the FiO_2 setting is noted to be 0.8 (6 pm and 7 pm), and therefore the required minimum duration of > 1 hour is met to allow use of this setting as the daily minimum value for VAE surveillance.

EXAMPLE: FiO_2 is set at the following values through the course of a calendar day:

Time	2 pm	4 pm	6 pm	8 pm	10 pm	12 am
FiO_2	1.0	0.60	0.40	0.50	0.55	0.60

In this example, the patient was intubated at 2 pm. The daily minimum FiO_2 is 0.40. FiO_2 settings are being monitored and recorded every 2 hours; therefore, the lowest recorded FiO_2 setting for the calendar day is the value used in VAE surveillance.

EXAMPLE: You are reviewing a patient's ventilator settings on Friday morning to determine the daily minimum FiO_2 value for Thursday. The patient was intubated and initiated on mechanical ventilation at 21:45 hours on Thursday. The ICU monitored and recorded FiO_2 settings for the patient every 15 minutes during the remainder of the day on Thursday. Based on the information recorded in the table below, what should you record as the daily minimum FiO_2 for Thursday? In this example, since there is no setting that is maintained for > 1 hour during the calendar day, the daily minimum FiO_2 for Thursday is 0.70 (70%). This is the lowest value of FiO_2 set on the ventilator during the calendar day.

Day	Time	FiO_2
Thursday	21:45	Intubated; 1.0
	22:00	1.0
	22:15	0.90
	22:30	0.90
	22:45	0.70
	23:00	0.80
	23:15	0.85
	23:30	0.85
	23:45	0.85

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).

Episode of Mechanical Ventilation: Defined as a period of days during which the patient was mechanically ventilated for some portion of each consecutive day.

NOTE: A break in mechanical ventilation of at least one full calendar day, followed by reintubation and/or reinitiation of mechanical ventilation during the same hospitalization, defines a new episode of mechanical ventilation.

EXAMPLE: A patient is intubated and mechanical ventilation is initiated at 11 pm on hospital day 1. The patient remains intubated and mechanically ventilated from hospital days 2-10. The patient is extubated at 9 am on hospital day 11 and remains extubated on hospital day 12. The patient is reintubated and mechanical ventilation is reinitiated on hospital day 13. The patient remains intubated and mechanically ventilated from hospital day 14-18. This patient has had two episodes of mechanical ventilation (days 1-11 and days 13-18), separated by at least one full calendar day off of mechanical ventilation.

New Antimicrobial Agent: Defined as any agent listed in the Appendix that is initiated on or after the third calendar day of mechanical ventilation AND in the VAE Window Period (specifically, the period typically defined by the 2 calendar days before, the day of, and the 2 calendar days after the onset date of the VAE). The agent is considered new for the purposes of this definition if it was NOT given to the patient on either of the 2 days preceding the current start date.

EXAMPLE: A patient is intubated and mechanically ventilated on hospital day 1 in the MSICU. Ceftriaxone and azithromycin are started on day 1 and administered daily. After 3 days of improving respiratory status, the patient's oxygenation deteriorates on days 4 and 5, with a daily minimum PEEP that is 4 cmH_2O higher than it was on days 2 and 3. Criteria for the VAC definition are met; the date of the event is hospital day 4. Ceftriaxone is discontinued and meropenem is begun on day 5. Azithromycin is continued. In this case, meropenem is a new antimicrobial agent: 1) it was begun on day 5 of mechanical ventilation, and 2) within the VAE Window Period (on the day after VAE onset), and 3) it was not given to the patient on either of the 2 days preceding the current start date. By contrast, ceftriaxone and azithromycin would not be considered new antimicrobial agents, since they were begun on day 1 of mechanical ventilation and continued daily into the VAE Window Period.

The antimicrobial agent(s) must have been given by one of the routes of administration outlined in Table 1, and therapy with one or more new antimicrobial agents must be continued for at least 4 calendar days (referred to as 4 "qualifying antimicrobial days" or "QADs"). For further guidance on identification of new antimicrobial agents and on how to determine whether the requirement for 4 QADs is met, refer to FAQs nos. 6-10 at the end of this protocol.

Table 1: Definitions of routes of administration

Route of Administration[a]	Definition[b]
Intravenous	An intravascular route that begins with a vein.
Intramuscular	A route that begins within a muscle.
Digestive Tract	A route that begins anywhere in the digestive tract extending from the mouth through rectum.
Respiratory Tract	A route that begins within the respiratory tract, including the oropharynx and nasopharynx.

[a]Other routes of administration are excluded (for example, antibiotic locks, intraperitoneal, intraventricular, irrigation, topical).
[b]Definitions per SNOMED Reference Terminology

Qualifying Antimicrobial Day (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—starting within the VAE Window Period. Days on which a new antimicrobial agent is administered count as QADs. 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. For example, if levofloxacin is given on VAE Day 1, has not been given in the 2 preceding calendar days, and is given again on VAE Days 3, 5, and 7, there are 7 QADs—because the days between levofloxacin doses also count as QADs. By contrast, days between administrations of different antimicrobial agents do NOT count as QADs; for example, if levofloxacin is given to the patient on VAE Days -2 and -1 only, no antimicrobials are given on VAE Day 1, and meropenem is given only on VAE Day 2 (remember there is no VAE Day 0), then there are not 4 consecutive QADs. VAE Days -2 and -1 count as 2 consecutive QADs, but VAE Day 1 cannot be counted as a QAD because it is a day between different antimicrobial agents. For further guidance on identification of new antimicrobial agents and on how to determine whether the requirement for 4 QADs is met, refer to FAQ nos. 6-10 at the end of this protocol.

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].

> NOTE: Some clinical laboratories may use different results reporting formats for direct examinations of respiratory secretions. Additional instructions for using the purulent respiratory secretions criterion are provided in Table 2, below (see also FAQ no. 19 at the end of this 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.

Location of Attribution: The inpatient location where the patient was assigned on the date of the VAE, which is further defined as the date of onset of worsening oxygenation.

EXAMPLE: Patient is intubated and ventilated in the Operating Room on hospital day 1, and then is admitted post-operatively to the SICU on hospital day 1, still on the ventilator. On hospital day 3, the patient experiences the onset of worsening oxygenation, manifested by an increase in the daily minimum FiO_2 of ≥ 0.20 (20%). On day 4 (also the 4th day of mechanical ventilation) the patient meets criteria for a VAC. This is reported to NHSN as a VAC for the SICU.

EXCEPTION:
Transfer Rule: If a VAE develops 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 (where the day of transfer is day 1), the event is attributed to the transferring location. This is called the Transfer Rule, and examples are shown below.

EXAMPLE: Patient on a ventilator in the SICU who has had improving oxygenation for 3 days is transferred to the MICU, still on the ventilator. On the day of transfer, after the patient has arrived in the MICU, the patient experiences an acute decompensation, requiring an increase of 0.30 (30 points) in FiO_2 that persists during the following calendar day. VAC criteria are met on calendar day 2 in the MICU. Because the onset of worsening oxygenation occurred on the day of transfer to the MICU, the VAC event is attributed to the SICU.

EXAMPLE: Patient is extubated in the MICU and transferred to the medical stepdown unit on hospital day 6. The next day, while in the stepdown unit (day 7), the patient experiences worsening oxygenation and is reintubated and transferred back to the MICU. Criteria for VAC are met the next day (day 8). In this case, the day prior to extubation and the day of extubation (hospital days 5 and 6) count as the required 2-day period of stability or improvement. The day of reintubation (day 7) and the following day (day 8) count as the required 2-day period of worsening oxygenation. Because the onset of worsening oxygenation occurred on the day following transfer out of the MICU, the event is reported to NHSN as a VAC for the MICU.

EXAMPLE: Patient intubated and mechanically ventilated for 8 days in the MSICU of Hospital A is transferred for further care on day 8 to the MSICU of Hospital B. The patient was stable on the ventilator in Hospital A from days 3-8. On the day of transfer to Hospital B (day 1 in Hospital B), the patient's respiratory status deteriorates. The patient's respiratory status continues to worsen on the day after transfer (day 2 in Hospital B), the patient meets criteria for VAC on hospital day 3. The date of the event is day 2 in Hospital B, the first day of the period of worsening oxygenation meeting VAE PEEP or FiO_2 thresholds. The infection preventionist (IP) from Hospital B calls the Hospital A IP to report that this patient was admitted to Hospital B with a VAC. This VAC should be reported to NHSN for and by Hospital A and attributed to the Hospital A MSICU. Date of event was day following transfer. No additional ventilator days are reported by Hospital A.

Reporting Instructions

(additional guidance may be found in the FAQs at the end of this protocol)

- Conducting in-plan VAE surveillance means assessing patients for the presence of ALL events included in the algorithm—from VAC to IVAC to PVAP. At this time, a unit conducting in-plan VAE surveillance cannot decide, for example, that only surveillance for VAC (and not for IVAC or PVAP) will be performed.
- There is a hierarchy of definitions within VAE:
  - If a patient meets criteria for VAC and IVAC, report as IVAC.
  - If a patient meets criteria for VAC, IVAC, and PVAP, report PVAP.
- Do not upgrade an event using findings that occur outside the VAE Window Period.
- If the date of event (date of onset of worsening oxygenation) is on or after the date of documentation of evidence of consent AND the patient is being supported for organ donation purposes, the event should not be reported as a VAE.
- Pathogens are not reported for VAC or IVAC events.
- Secondary BSIs are not reported for VAC or IVAC events (see FAQ no. 11 at the end of this protocol).
- Pathogens may be reported for PVAP events, provided they are isolated or identified from appropriate specimen types according to the requirements of the algorithm and are NOT on the list of excluded organisms and culture or non-culture based microbiologic testing method results:
  - Excluded organisms and culture or non-culture based microbiologic testing method results that cannot be used to meet the PVAP definition are as follows:
    - "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
    - Any *Candida* species or yeast not otherwise specified; any coagulase-negative *Staphylococcus* species; and any *Enterococcus* species, when identified from sputum, endotracheal aspirates, bronchoalveolar lavage, or protected specimen brushings specimens. These organisms can be reported as PVAP pathogens if identified from lung tissue or 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).
  - Additionally, because organisms belonging to the following genera are typically causes of community-associated respiratory infections and are rarely or are not known to be causes of healthcare-associated infections, they are also excluded, and cannot be used to meet the PVAP definition when isolated from any eligible specimen type (to include lung tissue and pleural fluid): *Blastomyces, Histoplasma, Coccidioides, Paracoccidioides, Cryptococcus,* and *Pneumocystis.*
- There are three criteria that can be used to meet the PVAP definition (Figure 1):
  - Criterion 1: Positive culture meeting specific quantitative or semi-quantitative threshold (Table 3);
  - Criterion 2: Purulent respiratory secretions AND identification of organisms NOT meeting the quantitative or semi-quantitative thresholds specified in Table 3;
  - Criterion 3: (one of the following)

- Organisms identified from pleural fluid specimen (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)
- Positive lung histopathology
- Lower respiratory specimen cytology findings suggestive of infection
- Positive diagnostic test for *Legionella* species or selected respiratory viruses.

- See Table 3 for the required quantitative culture thresholds meeting the PVAP definition (Criterion 1). Note that if your laboratory reports semi-quantitative culture results, you should check with your laboratory to confirm that semi-quantitative results match the quantitative thresholds noted in Table 3 (see also FAQ no. 24 at the end of this protocol).

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)

- Secondary BSIs may be reported for PVAP events, provided that at least one organism identified from the blood matches an organism isolated from an appropriate respiratory tract specimen (including respiratory secretions, pleural fluid, and lung tissue). The respiratory tract specimen must have been collected on or after the 3rd day of mechanical ventilation and within 2 calendar days before or after the day of onset of worsening oxygenation to be considered as a criterion for meeting the PVAP definition. In addition, the organisms identified from blood must have been collected during the 14-day event period, where day 1 is the day of onset of worsening oxygenation (See FAQ no.13 at the end of this protocol).
  - 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, and there is also a positive blood specimen a secondary BSI is not reported.
  - 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, a secondary BSI is not reported.
  - A matching organism is defined as one of the following:

    1. If genus and species are identified in both specimens, they must be the same.

a. Example: A blood specimen resulted with *Enterobacter cloacae* and a BAL specimen resulted with *Enterobacter cloacae* are matching organisms.
b. Example: A blood specimen resulted with *Enterobacter cloacae* and a BAL specimen resulted with *Enterobacter agglomerans* are NOT matching organisms as the species are different.

2. If the organism is less definitively identified in one specimen than the other, the lesser identified organism must be identified to at least the genus level and at that level the organisms must be the same.

   a. Example: A BAL resulted with *Pseudomonas spp*. and a blood specimen resulted with *Pseudomonas aeruginosa* are considered a match at the genus level and therefore the BSI can be reported as secondary BSI to VAE.

      Exception: In cases where an organism is identified only as "yeast" or "yeast not otherwise specified", the organism can be considered a match to other yeasts, when collected during the required timeframe, whether more fully identified or not.

      Example: A blood specimen reported as *Candida albicans* and a lung tissue resulted with yeast not otherwise specified are considered to have matching organisms. In this example the two organisms are considered matching organisms because the organisms are complementary (specifically *Candida* is a type of yeast). NOTE: This exception is limited to yeast. It does not apply to identification of organisms as Gram positive cocci, Gram negative rods, etc.

      NOTE: Any *Candida* species or yeast not otherwise specified, any coagulase-negative *Staphylococcus* species, and any *Enterococcus* species identified from blood cannot be deemed secondary to a PVAP, unless the organism was also identified from pleural fluid or lung tissue.

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)

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/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)

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)

Numerator and Denominator Data

Numerator Data: The *Ventilator-Associated Event (VAE)* form (CDC 57.112) is used to collect and report each VAE that is identified during the month selected for surveillance. The *Instructions for Completion of Ventilator-Associated Event Form* includes brief instructions for collection and entry of each data element on the form. The VAE form includes patient demographic information and information on the start date and location of initiation of mechanical ventilation. Additional data include the specific criteria met for identifying VAE, whether the patient developed a secondary bloodstream infection, whether the patient died, and, where applicable, the organisms detected and their antimicrobial susceptibilities.

Reporting Instruction: If no VAEs are identified during the month of surveillance, the "*Report No Events*" box must be checked on the appropriate denominator summary screen, for example, Denominators for Intensive Care Unit (ICU)/Other Locations (Not NICU or SCA), etc.

Denominator Data: Device days and patient days are used for denominators (see Chapter 16 General Key Terms). Ventilator days, which are the numbers of patients managed with ventilatory devices, are collected daily, at the same time each day, according to the chosen location using the appropriate form (CDC 57.117 [Specialty Care Areas] or 57.118 [ICU/Other Locations]). These daily counts are summed and only the total for the month is entered into NHSN. Ventilator and patient days are collected for each of the locations monitored. When denominator data are available from electronic sources, these sources may be used as long as the counts are within +/- 5% of manually-collected counts, validated for a minimum of 3 consecutive months. Validation of electronic counts should be performed separately for each location conducting VAE surveillance.

When converting from one electronic counting system to another electronic counting system, the new electronic system should be validated against manual counts as above. If electronic counts for the new electronic system are not within 5% of manual counts, resume manual counting and continue working with IT staff to improve design of electronic denominator data extraction (while reporting manual counts) until concurrent counts are within 5% for 3 consecutive months.

> NOTE: This guideline is important because validating a new electronic counting system against an existing electronic system can magnify errors and result in inaccurate denominator counts.
>
> NOTE: All ventilator days are counted, including ventilator days for patients on mechanical ventilation for < 3 days, and patients on high frequency ventilation and other therapies excluded from VAE surveillance. Patients with tracheostomies who are undergoing weaning from mechanical ventilation using tracheostomy collar trials are included in ventilator day counts as long as they spend some portion of the day on mechanical ventilation at a time that overlaps with the daily time during which ventilator day counts are performed.
>
> NOTE: In addition to the total number of patients on ventilators on each day of surveillance, the number of patients on ventilators who are on the APRV mode of mechanical ventilation or related

modes (which is a subset of all patients on ventilators) can optionally be indicated on the appropriate form (CDC 57.117 and 57.118). See FAQ nos. 22 and 23 at the end of this protocol.

Collection of an additional denominator, episodes of mechanical ventilation (EMV), is optionally available for VAE surveillance. The EMV denominator represents the sum of the number of episodes of mechanical ventilation that occurred in that location during the month. A single episode of mechanical ventilation for each patient is to be counted only once per month. Do note, it is possible for a patient to have more than one episode of ventilation occur during a month (for example, discontinuation of mechanical ventilation for greater than 1 calendar day followed by re-initiation of mechanical ventilation). The EMV denominator is determined by counting all patients in the location who are on mechanical ventilation on the first day of the month regardless of eligibility for inclusion in VAE surveillance. Then, on each subsequent day of the month, count each additional patient that is started on mechanical ventilation. This would include those that are admitted to the location already on mechanical ventilation, those that are newly ventilated, and any previously ventilated patients who have new episodes of mechanical ventilation occurring during the same month. The sum of the count for the first day and each subsequent day of the month is entered in NHSN.

EXAMPLE: On January 1, there are 5 patients on mechanical ventilation in the MICU (2 patients were started on mechanical ventilation on December 24, 2 patients on December 31, and 1 patient on January 1). During the rest of the month, the following are noted: 1 patient is started on mechanical ventilation on January 8; 2 patients are transferred to the MICU on mechanical ventilation on January 15, and 1 patient who was previously ventilated (from January 1 through January 12) goes back on mechanical ventilation on January 20. No other patients are on mechanical ventilation during the month of January. The number of EMV for January is nine. This is calculated as follows: 5 patients (on mechanical ventilation on the first day of the month) + 4 patients who were either started on mechanical ventilation, transferred into the MICU on mechanical ventilation, or re-initiated on mechanical ventilation after being off of the vent for at least 1 calendar day = 9 EMV.

Data Analyses

All data that is entered into NHSN can be analyzed at event or summary level. The data in NHSN can be visualized and analyzed in various ways, specifically, descriptive analysis reports for both the denominator and numerator data.

Types of VAE Analysis Reports

The Standardized Infection Ratio

The Standardized Infection Ratio (SIR) is a summary measure used to track HAIs at a national, state, or local level over time. The SIR adjusts for various facility and/or patient-level factors that contribute to HAI risk within each facility. In HAI data analysis, the SIR compares the actual number of HAIs reported to the number that would be predicted, given the standard population (specifically, the NHSN baseline), adjusting for several risk factors that have been found to be significantly associated with differences in infection incidence. The number of predicted infections in NHSN is calculated based on the 2015 national aggregate data and is adjusted for each facility using variables found to be significant predictors of HAI incidence (called as NHSN baseline). NHSN uses negative binomial regression model to perform the VAE SIR calculations.

$$\text{SIR} = \frac{Observed\ (O) HAIs}{Predicted\ (P) HAIs}$$

An SIR will be created for each VAE Category, IVAC Plus, and Total VAE.

$$\text{Total VAE SIR} = \frac{VAC+IVAC+PVAP}{Num\ Predicted\ VAEs}$$

$$\text{IVAC Plus SIR} = \frac{IVAC+PVAP}{Num\ Predicted\ VAEs}$$

A SIR greater than 1.0 indicates that more HAIs were observed than predicted; conversely, a SIR less than 1.0 indicates that fewer HAIs were observed than predicted.

More information regarding the VAE SIR model and the parameter estimates can be found in The NHSN Guide to the SIR.

> NOTE: The SIR will be calculated only if the number of predicted VAEs (numPred) is ≥ 1 to help enforce a minimum precision criterion. This rule was instituted to avoid the calculation and interpretation of statistically imprecise SIRs, which typically have extreme values.

While the VAE SIR can be calculated for single locations, the measure also allows you to summarize your data by multiple locations, adjusting for differences in the incidence of VAEs among the location types. For example, you can calculate one VAE SIR adjusting for all locations reported. Similarly, you can calculate one VAE SIR for all specialty care areas in your facility.

The Standardized Utilization Ratio

The Standardized Utilization Ratio (SUR) is a summary measure used to track device use at a national, state, or local, or facility level over time. The SUR adjusts for various facility and/or location-level factors that contribute to device use. The method of calculating a SUR is similar to the method used to calculate the Standardized Infection Ratio (SIR), a summary statistic used in NHSN to track healthcare-associated infections (HAIs). In device-associated HAI data analysis, the SUR compares the actual number of device days reported to what would be predicted, given the standard population (specifically, the NHSN baseline), adjusting for several factors that have been found to be significantly associated with differences in device utilization.

$$\text{SUR} = \frac{Observed\ (O)\ Ventilator\ Days}{Predicted\ (P)\ Ventilator\ Days}$$

In other words, a SUR greater than 1.0 indicates that more device days were observed than predicted; conversely, a SUR less than 1.0 indicates that fewer device days were observed than predicted. SURs are currently calculated in NHSN for the following device types: central lines, urinary catheters, and ventilators.

More information regarding the VAE SUR model and the parameter estimates can be found at
The NHSN Guide to the SUR
How to Run and Interpret SUR Reports in NHSN

VAE Rate

The VAE rate per 1000 ventilator days is calculated by dividing the number of VAEs by the number of ventilator days and multiplying the result by 1000 (ventilator days).

$$\text{VAE Rate per 1000 ventilator days} = \frac{No.\ of\ VAEs}{No.of\ Ventilator\ Days} * 1000$$

The VAE rate per 100 episodes of mechanical ventilation (EMV) is calculated by dividing the number of VAEs by the number of episodes of mechanical ventilation and multiplying the result by 100 (episodes of mechanical ventilation).

$$\text{VAE Rate per 100 EMV} = \frac{No.\ of\ VAEs}{No.of\ EMV} * 100$$

Rates and SIRs that may be appropriate for use in public reporting, inter-facility comparisons, and pay-for-reporting/pay-for-performance programs are the overall VAE rate (where the numerator consists of all events meeting at least the VAC definition). Rates and SIRs that may be appropriate for internal use within an individual unit or facility include the "IVAC-plus" rate (where the numerator consists of all events meeting at least the IVAC definition), and rates of specific event types (for example, events meeting only the VAC definition, events meeting only the IVAC definition, events meeting only the PVAP definition). The Ventilator Utilization Ratio is calculated by dividing the number of ventilator days by the number of patient days. These calculations will be performed separately for the different types of ICUs, SCAs, and other locations in the institution.

Device Utilization Ratio

The Ventilator or Device Utilization Ratio (DUR) is calculated by dividing the number of ventilator days by the number of patient days. These calculations will be performed separately for the different types of ICUs, SCAs, and other locations in the institution.

$$\text{DUR} = \frac{No.\ of\ Ventilator\ Days}{No.\ of\ Patient\ Days}$$

Descriptive Analysis Output Options

Descriptive analysis output options of numerator and denominator data, such as line listings, frequency tables, and bar and pie charts are available in the NHSN application. SIRs, SURs and VAE rates and run charts are also available.

Line List: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/linelists.pdf
Frequency Tables: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/frequencytables.pdf
Bar Chart: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/BarCharts.pdf
Pie Chart: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/PieChart.pdf

Additional Analysis Resources

Analysis Reference Guides: www.cdc.gov/nhsn/PS-Analysis-resources/reference-guides.html.
VAE Analysis Training: https://www.cdc.gov/nhsn/training/patient-safety-component/vae.html
Updated SIR Guide: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/nhsn-sir-guide.pdf
Updated SUR Guide: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/nhsn-sur-guide-508.pdf
Data Quality Website: https://www.cdc.gov/nhsn/ps-analysis-resources/data-quality/index.html

Table 4. VAE Measures Available in NHSN

Measure	Calculation	Application
VAE SIR	The number of Observed VAEs / The number of Predicted VAEs	Both location specific and summarized measure
VAE Rates	The number of VAEs for a location / The number of Ventilator Days for a location x 1000	Location specific measure only
Ventilator SUR	The number of Observed Ventilator Days / The number of Predicted Ventilator Days	Both location specific and summarized measure
DUR	The Ventilator Days for a location / The Patient Days for that location	Location specific measure only

NHSN Group Analysis

NHSN Group Users can perform the same analysis as facility level users in NHSN. A few helpful tools in NHSN for groups are listed in the resources below. These tools are guides on how to start and join a Group; how to create a template to request data from facilities; how to determine the level of access granted by the facility following the previous steps; and how to analyze the facilities data.

Group Analysis Resources

NHSN Group Users Page:

https://www.cdc.gov/nhsn/group-users/index.html

Group User's Guide to the Membership Rights Report:

https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/GroupAnalysisWebinar.pdf

Group User's Guide to the Line Listing- Participation Alerts:

https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/group-alerts.pdf

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Appendix. List of Antimicrobial Agents Eligible for IVAC, PVAP

Antimicrobial Agent
AMIKACIN
AMPHOTERICIN B
AMPHOTERICIN B LIPOSOMAL
AMPICILLIN
AMPICILLIN/SULBACTAM
ANIDULAFUNGIN
AZITHROMYCIN
AZTREONAM
BALOXAVIR MARBOXIL
CASPOFUNGIN
CEFAZOLIN
CEFEPIME
CEFIDEROCOL
CEFOTAXIME
CEFOTETAN
CEFOXITIN
CEFTAROLINE
CEFTAZIDIME
CEFTAZIDIME/AVIBACTAM
CEFTOLOZANE/TAZOBACTAM
CEFTRIAXONE
CEFUROXIME
CIPROFLOXACIN
CLARITHROMYCIN
CLINDAMYCIN
COLISTIMETHATE
DALBAVANCIN
DELAFLOXACIN
DOXYCYCLINE
ERAVACYCLINE
ERTAPENEM
FLUCONAZOLE
FOSFOMYCIN
GEMIFLOXACIN
GENTAMICIN
IMIPENEM/CILASTATIN

IMIPENEM/CILASTATIN/RELEBACTAM
ISAVUCONAZONIUM
ITRACONAZOLE
LEFAMULIN
LEVOFLOXACIN
LINEZOLID
MEROPENEM
MEROPENEM/VABORBACTAM
METRONIDAZOLE
MICAFUNGIN
MINOCYCLINE
MOXIFLOXACIN
NAFCILLIN
OMADACYCLINE
ORITAVANCIN
OSELTAMIVIR
OXACILLIN
PENICILLIN G
PERAMIVIR
PIPERACILLIN/TAZOBACTAM
PLAZOMICIN
POLYMYXIN B
POSACONAZOLE
QUINUPRISTIN/DALFOPRISTIN
REMDESIVIR
RIFAMPIN
SULFAMETHOXAZOLE/TRIMETHOPRIM
TEDIZOLID
TELAVANCIN
TETRACYCLINE
TIGECYCLINE
TOBRAMYCIN
VANCOMYCIN, intravenous only
VORICONAZOLE
ZANAMIVIR

VAE Frequently Asked Questions (FAQs)

1) When should I use VAE? Are there circumstances in which I should still use PNEU?

- VAE surveillance is location based and restricted to adult inpatient units only.
- Pediatric and neonatal units are excluded from VAE surveillance (even in circumstances where a pediatric unit may occasionally care for patients who are 18 years of age and older).
- Locations mapped to mixed age CDC location codes are excluded from VAE surveillance.
- Ventilated patients who are 18 years of age and older and who are cared for in pediatric units should be included in any in-plan PedVAP and/or PedVAE surveillance for that location.

  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. Facilities may want to evaluate their location mapping to be sure that locations are mapped appropriately to the correct CDC location codes. In circumstances where the populations of adults and children cared for in the same physical location is more mixed (for example, 50% adult patients and 50% pediatric patients), it is recommended that facilities weigh the possibility of establishing a virtual pediatric location for the purposes of surveillance. More information on virtual locations and location mapping can be found here: www.cdc.gov/nhsn/PDFs/pscManual/15LocationsDescriptions_current.pdf

- While on high frequency ventilation, extracorporeal life support, or paracorporeal membrane oxygenation, patients are EXCLUDED from VAE surveillance.

  NOTE: Patients who are receiving a conventional mode of mechanical ventilation while in the prone position and patients who are receiving a conventional mode of mechanical ventilation while receiving nitric oxide therapy, helium-oxygen mixtures (heliox), or epoprostenol therapy are INCLUDED.

  NOTE: Patients on Airway Pressure Release Ventilation (APRV) and related modes of mechanical ventilation (see FAQ nos. 22 and 23 at the end of this protocol) are INCLUDED; however, during periods of time while the patient is on APRV, the VAE period of stability or improvement on the ventilator and the period of worsening oxygenation should be determined by changes in FiO_2 only, since changes in PEEP as indicated in this surveillance algorithm may not be applicable to APRV. In addition, patients with VAE who are on APRV or a related mode of mechanical ventilation at the time of VAE onset can be optionally indicated as such on the VAE Form (CDC 57.112).

- In-plan surveillance for ventilator-associated PNEU may still be conducted for pediatric patients ONLY ("PedVAP" surveillance).
- The PNEU definitions are still available for those units seeking to conduct off-plan PNEU/VAP surveillance for patients of any age and for assignment of a secondary BSI.

2) I am having difficulty visualizing how to arrange the VAE data elements to facilitate easy identification of events. Can you provide some additional guidance?

- For units in which VAE surveillance will be conducted manually, we recommend that you organize the necessary data elements in a table or spreadsheet to assist in identifying VAEs. There are a number of different ways in which to organize the data – you may consider limiting your spreadsheet to just include the daily minimum PEEP and FiO_2 values, and then, if a VAC event is identified, utilize other data sources to gather information on the data elements included in the IVAC and PVAP definitions. Alternatively, you may choose to include columns for all data elements (from VAC through PVAP) in a single spreadsheet.

  NOTE: For most patients under surveillance for VAE, the only data elements you will need to record are the ventilator days, minimum daily PEEP, and minimum daily FiO_2. The maximum and minimum daily temperatures and white blood cell counts only need to be recorded for those patients who are identified as having met criteria for VAC. The antimicrobial criterion only needs to be assessed for those patients with VAC and with an abnormal temperature or white blood cell count that meets the criteria within the IVAC definition. Microbiology and related data elements included as criteria in the PVAP definition only need to be assessed for those patients who have met the IVAC definition.

  NOTE: Keep in mind that the baseline period of stability or improvement on the ventilator is defined as the 2 calendar days immediately preceding the first day of increased daily minimum PEEP or FiO_2, and must be characterized by ≥ 2 calendar days of stable or decreasing daily minimum FiO_2 or PEEP values (specifically the daily minimum PEEP or FiO_2 on the second day of the baseline period of stability or improvement must be equal to or less than the daily minimum PEEP or FiO_2 on the first day of the baseline period of stability or improvement). Keep in mind, too, that PEEP values of 0 to 5 cmH_2O are considered equivalent for the purposes of VAE surveillance. This means that any daily minimum value of 0 to 5 cmH_2O will be evaluated as if it were 5 cmH_2O when determining whether a VAC has occurred or not. Also, the daily minimum PEEP or FiO_2 is defined as the lowest setting during a calendar day that is maintained for > 1 hour.

  EXAMPLE: In the table below, the data elements used to meet VAC, IVAC, and PVAP definition are organized in a fashion that facilitates identification of an event, highlighted in the shaded region. In this example, MV days 3 and 4 constitute the baseline period, with stable minimum PEEP of 5 cmH_2O on each day. On MV days 5 and 6, the daily minimum PEEP is 8 cmH_2O, which meets the VAC criterion for worsening oxygenation. If we scan across the table, we can see that the IVAC temperature/white blood cell count criterion is not met (there are no temperatures < 36°C or > 38°C, and no white blood cell counts ≤ 4,000 cells/mm^3 or ≥ 12,000 cells/mm^3) – so even though the patient was started on a new antimicrobial agent and continued on that agent for 4 calendar days, IVAC is not met. Therefore, this event would be reported as a VAC, with the date of event being MV day 5.

Patient	MV Day	$PEEP_{min}$	FiO_{2min}	$Temp_{min}$	$Temp_{max}$	WBC_{min}	WBC_{max}	Abx	Specimen	Polys / Epis	Organism	VAE
1	1	10	1.0	37.1	37.6	4.3	4.3	None	--	--	--	--
1	2	5	0.60	36.8	37.2	4.6	4.6	None	--	--	--	--
1	3	5	0.40	37.0	37.9	5.4	5.4	None	--	--	--	--
1	4	5	0.40	36.5	37.3	9.2	9.2	Yes	--	--	--	--
1	5	8	0.50	36.3	36.9	8.4	8.4	Yes	ETA	≥ 25 / ≤ 10	*S. aureus*	**VAC**
1	6	8	0.40	37.2	37.5	8.5	8.8	Yes	--	--	--	
1	7	5	0.40	37.8	37.9	7.6	7.6	Yes	--	--	--	

MV = mechanical ventilation. $PEEP_{min}$ = Daily minimum PEEP. FiO_{2min} = Daily minimum FiO_2. $Temp_{min}$ = Daily minimum temperature. $Temp_{max}$ = Daily maximum temperature. WBC_{min} = Daily minimum white blood cell count. WBC_{max} = Daily maximum white blood cell count. Abx = antimicrobial agents. Polys / epis = Polymorphonuclear leukocytes and squamous epithelial cells from respiratory specimen.

EXAMPLE: In the table below, by scanning across the data elements, you can see that there are no periods in which there is a stable, 2-day baseline period followed by a 2-day period where the PEEP or FiO_2 are increased 3 cmH_2O or 20 points over the first day in the baseline period. On MV days 2 and 3, the PEEP values are 7 cmH_2O and 6 cmH_2O respectively, and then increase to 9 cmH_2O on MV days 4 and 5 – but the difference between day 4 or day 5 and day 2 is only 2 cmH_2O, rather than the required 3 cmH_2O. Also, the gradual increase in FiO_2 from the time of initiation of mechanical ventilation means that there are not two days on which the FiO_2 is at least 20 points higher than on the 2 previous days. Therefore, although the temperature and white blood cell counts exceed the required thresholds for IVAC on several occasions, and the patient appears to have received a new antimicrobial agent for several days in the setting of a positive blood culture, the VAC definition is not met, and so no VAE is reported.

Patient	MV Day	$PEEP_{min}$	FiO_{2min}	$Temp_{min}$	$Temp_{max}$	WBC_{min}	WBC_{max}	Abx	Specimen	Polys / Epis	Organism	VAE
2	1	5	0.30	37.1	37.6	4.3	4.3	None	--	--	--	--
2	2	7	0.30	36.8	37.2	4.6	4.6	None	--	--	--	--
2	3	6	0.45	37.0	37.9	5.4	5.4	None	--	--	--	--
2	4	9	0.45	36.5	37.3	9.2	9.2	None	--	--	--	--
2	5	9	0.60	36.3	36.9	8.4	8.4	None	ETA	≥ 25 / ≤ 10	*S. aureus*	--
2	6	8	0.60	37.2	37.5	8.5	8.8	None	--	--	--	--
2	7	6	0.75	37.8	37.9	7.6	7.6	None	--	--	--	--
2	8	6	0.75	38.2	38.4	10.5	11.9	Yes	Blood	--	*S. aureus*	--
2	9	5	0.80	38.5	38.9	12.7	12.7	Yes	--	--	--	--
2	10	5	0.75	37.4	38.1	12.9	12.9	Yes	--	--	--	--
2	11	5	0.70	37.2	37.9	9.4	9.4	Yes	--	--	--	--
2	12	5	0.60	37.3	37.5	9.5	9.5	Yes	--	--	--	--
2	13	7	0.60	37.2	37.8	8.2	8.2	Yes	--	--	--	--
2	14	8	0.60	37.0	37.7	8.6	8.6	Yes	--	--	--	--

3) <u>Is there a hierarchy of reporting for VAE? How do I know whether to report a VAC, an IVAC, or a PVAP?</u>
   - Conducting in-plan VAE surveillance means assessing patients for the presence of ALL events included in the algorithm—from VAC to IVAC to PVAP. At this time, a unit participating in in-plan

VAE surveillance cannot decide, for example, that only surveillance for VAC (and not for IVAC or PVAP) will be performed.

- There is a hierarchy of definitions within VAE:
  - If a patient meets criteria for VAC and IVAC, report as IVAC.
  - If a patient meets criteria for VAC, IVAC, and PVAP, report PVAP.

4) How do I determine the duration of a VAE? Can a patient have more than one VAE during a hospitalization?

- Patients may have multiple VAEs during a single hospitalization. The event period is defined by the 14-day period that starts on the date of onset of worsening oxygenation. VAE criteria met during that 14-day period are attributed to the current VAE.

  EXAMPLE: Patient is intubated and mechanical ventilation is initiated in the MICU (day 1). The patient is stable during the following 4 calendar days (days 2 through 5). On days 6 and 7 the patient's minimum daily FiO_2 is increased more than 0.20 (20 points) over the first day in the baseline period, therefore meeting the VAC FiO_2 threshold. The VAC episode is defined by the period encompassing days 6 through 19 (14 days, starting on day 1 of worsening oxygenation, which in this case is day 6). If the patient were to experience a period of stability or improvement on the ventilator on days 18 and 19, followed by another 2-day period of worsening on days 20 and 21, a new VAE would be reported, since the second period of worsening oxygenation has occurred more than 14 days after the start of the initial period of worsening oxygenation.

5) Sometimes patients are intubated, extubated, and reintubated several times during a single hospitalization. How do I define an episode of mechanical ventilation, and can a VAE occur in a patient who has recently been extubated?

- An episode of mechanical ventilation is defined as a period of days during which the patient was mechanically ventilated for some portion of each consecutive day during the period.

  EXAMPLE: A patient is intubated and mechanically ventilated on hospital day 1. The patient remains on mechanical ventilation from hospital day 2 through 12 noon on hospital day 6. At noon on hospital day 6, the patient is extubated. The patient remains extubated on hospital day 7 and is then reintubated on hospital day 8. In this case, the first episode of mechanical ventilation is defined by days 1 through 6. Since the patient was extubated on day 6 and remained extubated for a full calendar day on day 7, the reintubation of the patient on day 8 defines the start of a second episode of mechanical ventilation. See figure, below.

Hosp Day No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
MV Episode	1	1	1	1	1	1	--	2	2	2
MV Day No.	1	2	3	4	5	6—extubated at noon	--	1--reintubated	2	3

1 full calendar day off mechanical ventilation, followed by reintubation, defines a new episode of mechanical ventilation.

EXAMPLE: A patient is intubated and mechanically ventilated on hospital day 1. The patient remains on mechanical ventilation from hospital day 2 through hospital day 6 at 12 noon. At noon on hospital day 6, the patient is extubated. The patient is reintubated at 9 pm on hospital day 7 and remains intubated and mechanically ventilated till 2 pm on day 10. The patient is extubated at 2 pm on day 10 and remains extubated until hospital discharge on day 15. In this case, there is only a single episode of mechanical ventilation, defined by days 1 through 10, because the patient was extubated on day 6 but reintubated the next calendar day (day 7). See figure, below.

Hosp Day No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
MV Episode	1	1	1	1	1	1	1	1	1	1
MV Day No.	1	2	3	4	5	6—extubated at noon	7—reintubated at 9 pm	8	9	10—extubated at 2 pm

Patient was reintubated on the calendar day following extubation (days 6-7). Because there is not 1 calendar day off mechanical ventilation, there is only 1 episode of mechanical ventilation.

- A VAE can occur in a patient who has been extubated and is then reintubated, subject to the amount of time the patient was off the ventilator, as noted in the examples below.

  EXAMPLE: A patient is intubated and mechanically ventilated on hospital day 1. The patient remains on mechanical ventilation from hospital day 2 through 12 noon on hospital day 6. At noon on hospital day 6, the patient is extubated. The patient remains extubated on hospital day 7 and is then reintubated on hospital day 8. In this case, because the patient has been extubated for 1 full calendar day (day 7), the "VAE clock" starts over with reintubation on hospital day 8. To meet VAE during this second episode of mechanical ventilation, the patient would have to have at least 2 days of stability or improvement and at least 2 days of worsening oxygenation on the ventilator; therefore, the earliest date on which the patient could meet VAE criteria would be hospital day 11 (stable or improving settings on days 8 and 9, increased ventilator settings on days 10 and 11). The VAE date of event would be reported as day 10—the first day of worsening oxygenation meeting VAE criteria. See figure, below.

Hosp Day No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
MV Episode	1	1	1	1	1	1	--	2	2	2	2
MV Day No.	1	2	3	4	5	6—extubated at noon	--	1--reintubated	2	3	4
VAE Criterion	--	--	--	--	--	--	--	Day 1 of stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation

EXAMPLE: A patient is intubated and mechanically ventilated on hospital day 1. The patient remains on mechanical ventilation from hospital day 2 through 12 noon on hospital day 6, when the patient is extubated. The patient is reintubated at 9 pm on hospital day 7. In this case, there is no "new" episode of mechanical ventilation, since there was not a full, ventilator-free calendar day. Therefore, the period of worsening oxygenation may be determined to have started on day

7, the day of reintubation, as long as PEEP or FiO_2 criteria are met. PEEP and FiO_2 data from hospital days 5 and 6 (through the time of extubation) may be used to determine whether a period of stability and improvement occurred, and these data may be compared to PEEP and FiO_2 data obtained from the time of reintubation on day 7 and beyond to determine whether at least 2 days of worsening oxygenation occurred. The earliest that the patient could meet VAE criteria would be day 8 (assuming stable or improving ventilator settings on days 5 and 6, and two days of worsening oxygenation meeting criteria on days 7 and 8). The VAE date of event would be reported as day 7—the first day of worsening oxygenation meeting VAE criteria. See figure, below.

Hosp Day No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
MV Episode	1	1	1	1	1	1	1	1	1	1
MV Day No.	1	2	3	4	5	6—extubated at noon	7—reintubated at 9 pm	8	9	10
VAE Criterion					Day 1 of stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation		

- A patient may also meet criteria for VAC while intubated, and then meet criteria for IVAC (or PVAP) following extubation.

  EXAMPLE: A patient is intubated and mechanically ventilated on hospital day 1. The patient remains on mechanical ventilation till 11 am on hospital day 10, when the patient is extubated. Criteria for VAC are met during the episode of mechanical ventilation, based on 2 days of stability or improvement (MV days 5 and 6) followed by 2 days of worsening oxygenation (MV days 7 and 8). The date of the event is MV day 7, the day of onset of worsening oxygenation. Within the 2 days before and 2 days after the day of onset of worsening oxygenation, the patient has a temperature of 38.4°C, and a new antimicrobial agent is started (meropenem, on MV day 9—see FAQ no. 6-10 at the end of this protocol). The new antimicrobial agent is continued for at least 4 days (hospital days 8 through 11). Therefore, even though the patient was extubated on hospital day 10 and remained extubated on hospital day 11 (the day on which all IVAC criteria were fulfilled), the event should be reported as an IVAC. See figure, below.

Hosp Day No.	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
MV Day No.	**4**	**5**	**6**	**7**	**8**	**9**	**Extubated at 11 am**	**--**
VAE Criterion	--	Day 1 of stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation	Temp 38.4°C	--	--
Antimicrobial agent	Ceftriaxone	Ceftriaxone	Ceftriaxone	Ceftriaxone	**Meropenem**	**Meropenem**	**Meropenem**	**Meropenem**

Patient has fulfilled all IVAC criteria, and IVAC should be reported. Date of the IVAC event is hospital day/MV day 7.

6) What antimicrobial agents are included in the IVAC definition?
   - See the Appendix for a list of the antimicrobial agents eligible for consideration in the IVAC definition (as well as the PVAP definition).
   - See Table 1 for eligible routes of administration.

7) How do I figure out if an antimicrobial agent is "new" for the IVAC definition?
   - A new antimicrobial agent is defined as any agent listed in the Appendix that is initiated on or after 3 days of mechanical ventilation AND in the VAE Window Period (defined by the two days before, the day of, and the two days after the onset date of the VAE—as long as all of these days are on or after the 3rd day of mechanical ventilation). The agent is considered new for the purposes of this definition if it was NOT given to the patient on either of the 2 days preceding the current start date. The agent must be administered via one of the routes listed in Table 1. See the example in the figure below:

MV Day No.	4	5	6	7	8	9	10	11
VAE Criterion		-	-	Onset (day 1) of worsening oxygenation meeting VAE PEEP or FiO_2 thresholds	Day 2 of worsening oxygenation meeting VAE PEEP or FiO_2 thresholds	-		

Example of the 5-day period during which the first dose of a new antimicrobial agent must be given to meet requirements of IVAC definition

EXAMPLE: A single dose of intravenous vancomycin is given to a patient on the VAE onset date (which is the day of onset of worsening oxygenation meeting VAE criteria, in this case MV day 7), and was not given to the patient during the 2 previous days (MV days 5 and 6). Vancomycin is therefore considered a new antimicrobial agent. See figure below.

MV Day No.	4	5	6	7	8	9	10
VAE Criterion	--	Day 1 of stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation	-	
Antimicrobial agent	None	None	None	**Single dose of vancomycin ordered and administered**	**None**	**None**	**Single dose of vancomycin ordered and administered**

A single dose of vancomycin is ordered and administered to the patient within the period defined by the two days before, the day of, and the two days after the VAE onset date. Note that no vancomycin was given in the 2 preceding days, and so vancomycin is a "new" antimicrobial agent for the purposes of the VAE definition.

EXAMPLE: If meropenem is given to a patient on the VAE onset date (which is the day of onset of worsening oxygenation meeting VAE criteria, in this case MV day 7), and was not given to the patient during the 2 previous days (MV days 5 and 6), then meropenem is considered a new antimicrobial agent (see figure below). Note that the patient is also receiving ceftriaxone, and receives doses during the 5-day period around the onset of worsening oxygenation (first dose during the 5-day period was on MV day 5). However, because ceftriaxone was given to the patient

the day before the 5-day period (on MV day 4), ceftriaxone does not count as a new antimicrobial agent for the purposes of the IVAC definition.

MV Day No.	4	5	6	7	8	9	10
VAE Criterion	--	Day 1 of stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation		
Antimicrobial agent	Ceftriaxone	Ceftriaxone	Ceftriaxone	**Meropenem**	**Meropenem**	**Meropenem**	**Meropenem**

First dose of meropenem during the 5-day period around the onset of worsening oxygenation. Note that no meropenem was given in the 2 preceding days, and so meropenem is a "new" antimicrobial agent for the purposes of the VAE definition.

8) I have figured out that a new antimicrobial agent was given to the patient. How do I determine whether it was continued for 4 days?

- Make sure you are using the Medication Administration Record. You need to know which antimicrobial agents were actually administered to the patient. Antimicrobial orders or dispensing information is not sufficient.
- You do not need to know the dose or frequency of administration.
- Four consecutive Qualifying Antimicrobial Days (QADs)—starting within the VAE Window Period—are needed to meet the IVAC criterion. A QAD is a day on which the patient was administered an antimicrobial agent that was determined to be "new" within the VAE Window Period. 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 of the same antimicrobial agent. For example, if levofloxacin is given on VAE Day 1, has not been given in the 2 preceding calendar days, and is given again on VAE Days 3, 5, and 7, there are 7 QADs—because the days between levofloxacin doses also count as QADs.
- The requirement for 4 consecutive QADs can be met with 4 days of therapy with the same antimicrobial (with a gap of no more than 1 calendar day between administrations of that antimicrobial)—or it can be met with 4 days of therapy with multiple antimicrobial agents, as long as each antimicrobial was started within the VAE Window Period.

EXAMPLE: In the figure below, meropenem would meet the antimicrobial criterion of the IVAC definition because at least one dose was given on 4 consecutive days.

MV Day No.	1	2	3	4	5	6	7
VAE Criterion	--	Day 1 of Stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation		
Antimicrobial agent	Ceftriaxone	Ceftriaxone	Ceftriaxone	**Meropenem**	**Meropenem**	**Meropenem**	**Meropenem**
QAD	No	No	No	**Yes**	**Yes**	**Yes**	**Yes**

EXAMPLE: In the figure below, the 3 drugs shown in bold lettering all qualify as new antimicrobial agents, and therefore the antimicrobial criterion of IVAC is met, since the patient is given 4 consecutive days of new antimicrobial agents.

MV Day No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
VAE Criterion	--	Day 1 of Stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation		
Antimicrobial agent	Ceftriaxone	Ceftriaxone	Ceftriaxone	**Meropenem**	**Imipenem/ Cilastatin**	**Piperacillin/ Tazobactam**	**Piperacillin/ Tazobactam**
QAD	No	No	No	**Yes**	**Yes**	**Yes**	**Yes**

EXAMPLE: In the figure below, levofloxacin is a new antimicrobial agent (it was started during the VAE Window Period, on MV day 3, and was not given in the 2 days preceding the first day of administration). There are gaps of no more than 1 calendar days between days on which levofloxacin is given, and so the intervening days also count as QADs. In this example, there are 5 QADs (MV days 3-7); therefore, the antimicrobial criterion of IVAC is met.

MV Day No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
VAE Criterion	--	Day 1 of Stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation		
Antimicrobial agent			**Levofloxacin**		**Levofloxacin**		**Levofloxacin**
QAD	No	No	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

9) <u>There are many patients in my ICU with renal insufficiency and/or who are receiving hemodialysis. These patients may receive certain antimicrobial agents on an infrequent dosing schedule (for example, every 48 hours). How do I determine whether they have received 4 consecutive days of new antimicrobial therapy?</u>
   - See above. You do not need to know the patient's renal function, the dose of the antimicrobial agent, or the frequency of administration. The antimicrobial criterion rules remain the same, regardless of whether patients have renal dysfunction or not.

10) <u>What if the patient is being given one-time doses of intravenous vancomycin? How do I take that into account when using the IVAC surveillance definition?</u>
   - The rules for determining whether the antimicrobial criterion is met do not require that you know the dose or frequency of administration.
   - Make sure that vancomycin qualifies as a new antimicrobial agent—that it was not given in the 2 days preceding the day on which vancomycin was given during the VAE Window Period.
   - Check to see whether there are 4 consecutive QADs with vancomycin; if there are gaps of no more than 1 calendar day between days on which vancomycin is given, the intervening days may be counted as QADs. If there are gaps of longer than 1 calendar day between days of vancomycin therapy, the requirement for 4 consecutive QADs cannot be met using vancomycin alone—but make sure to check whether the 4 consecutive QAD requirement is met by considering any other antimicrobials being administered to the patient. See the example in the figure below:

EXAMPLE: A patient is given a single dose of vancomycin 1 gram IV on MV day 5. Since vancomycin was started on or after day 3 of mechanical ventilation, and no vancomycin was administered on MV days 2, 3, or 4, vancomycin qualifies as a new antimicrobial agent. A second, single dose of vancomycin 1 gram IV is administered on MV day 8. Because there is a gap of more than 1 calendar day between days of vancomycin administration (there is a gap of 2 days in this example), the requirement for 4 consecutive QADs is not met, and therefore the IVAC antimicrobial criterion is not met.

MV Day No.	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
VAE Criterion	--	--	Day 1 of Stability or improvement	Day 2 of stability or improvement	Day 1 of worsening oxygenation	Day 2 of worsening oxygenation		
Antimicrobial agent	None	None	None	**Vancomycin 1 gram IV x 1 dose**	None	None	**Vancomycin 1 gram IV x 1 dose**	None
QAD	No	No	No	**Yes**	No	No	**Yes**	No

11) Can I report pathogens or secondary BSIs for VAC and IVAC?

- Pathogens are NOT reported for VAC or IVAC events.
- Secondary BSIs are NOT reported for VAC or IVAC events.

EXAMPLE: A patient hospitalized and mechanically ventilated in the MICU for 14 days develops worsening oxygenation following a 7-day period of stability on the ventilator. VAC criteria are met on hospital day 15 (stable ventilator settings on days 12 and 13, increased ventilator settings on days 14 and 15). The onset date is day 14. The white blood cell count is noted to be 15,500 cells/mm^3 on day 14. Meropenem and intravenous vancomycin are begun on day 15, administered through the patient's right-sided central line, which was inserted on ICU admission. The antibiotics continue to be administered on day 18, meeting IVAC criteria. Endotracheal aspirate cultures done on days 15 and 16 grow scant upper respiratory flora. A blood culture collected on day 15 is positive for *Klebsiella oxytoca*. There are no other signs or symptoms of infection. This patient should be reported as having an IVAC and a central line-associated BSI if the BSI cannot be attributed as secondary to another primary site of infection. The BSI cannot be reported as secondary to the IVAC event.

12) Can I report pathogens for PVAP?

- Pathogens may be reported for PVAP events, provided they are isolated or identified from appropriate specimen types according to the requirements of the algorithm and are NOT on the list of excluded organisms and culture results:
    - Excluded organisms and culture results that cannot be used to meet the PVAP definition are as follows: "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; any *Candida* species or yeast not otherwise specified; any coagulase-negative *Staphylococcus* species; and any *Enterococcus* species, when identified from sputum, endotracheal aspirates, bronchoalveolar lavage, or protected specimen brushings. Only eligible pathogens

identified from eligible specimens with a collection date occurring in the VAE Window Period can be reported.

NOTE: When any *Candida* species or yeast not otherwise specified, any coagulase-negative *Staphylococcus* species, or any *Enterococcus* species are identified from lung tissue or pleural fluid, these organisms may be reported as PVAP pathogens.

Additionally, because organisms belonging to the following genera are usually causes of community-associated respiratory infections and rarely or are not known to be causes of healthcare-associated infections, they are also excluded, and cannot be used to meet the PVAP definition when isolated from any eligible specimen type (to include lung tissue and pleural fluid): *Blastomyces, Histoplasma, Coccidioides, Paracoccidioides, Cryptococcus,* and *Pneumocystis.*

- See Table 3 for the required quantitative culture thresholds associated with various specimen types in the PVAP definition. Note that if your laboratory reports semi-quantitative culture results, you should check with your laboratory to confirm that semi-quantitative results match the quantitative thresholds noted in Table 3.

13) Can I report secondary BSIs for PVAP?

- Secondary BSIs may be reported for PVAP events, provided that the organism identified from blood specimen matches an organism identified from an appropriate respiratory tract specimen (including respiratory secretions, pleural fluid, and lung tissue). The respiratory tract specimen must have been collected within 2 calendar days before or after the day of onset of worsening oxygenation to be considered as a criterion for meeting the PVAP definition. In addition, the positive blood specimen must have been collected during the 14-day event period, where day 1 is the day of onset of worsening oxygenation.
    - In cases where PVAP is met with only the histopathology criterion and no culture or non-culture based test is performed on an eligible respiratory specimen, and there is also a positive blood specimen, a secondary BSI for VAE is not reported.
    - In cases where a culture or non-culture based test of respiratory secretions, pleural fluid, or lung tissue is performed and does not identify an organism that matches an organism identified from blood, a secondary BSI for VAE is not reported.

NOTE: Any *Candida* species or yeast not otherwise specified, any coagulase-negative *Staphylococcus* species, and any *Enterococcus* species identified from blood cannot be deemed secondary to a PVAP, unless the organism was also identified from pleural fluid or lung tissue.

EXAMPLE: Patient hospitalized and mechanically ventilated in the MICU for 14 days develops worsening oxygenation following a 7-day period of stability on the ventilator. VAC criteria are met on hospital day 15 (stable ventilator settings on days 12 and 13, increased ventilator settings on days 14 and 15). The onset date is day 14. The white blood cell count is noted to be 15,500 cells/mm^3 on day 14. Meropenem and vancomycin are begun on day 15, administered through the patient's right-sided central line (inserted on ICU admission). The

antibiotics continue to be administered on day 18, meeting IVAC criteria. Endotracheal aspirate specimens collected on days 15 and 16 grow ≥ 10^5 CFU/ml *Klebsiella oxytoca*. A blood culture collected on day 15 is positive for *K. oxytoca*. This patient should be reported as having a PVAP with a secondary BSI due to *K. oxytoca*.

EXAMPLE: Patient hospitalized and mechanically ventilated in the MICU for 14 days develops worsening oxygenation following a 7-day period of stability on the ventilator. VAC criteria are met on hospital day 15 (stable ventilator settings on days 12 and 13, increased ventilator settings on days 14 and 15). The onset date is day 14. The white blood cell count is noted to be 15,500 cells/mm^3 on day 14. Meropenem and vancomycin are begun on day 15, administered through the patient's right-sided central line (inserted on ICU admission). The antibiotics continue to be administered on day 18, meeting IVAC criteria. A thoracentesis is performed on day 15 at the patient's bedside using aseptic technique. Pleural fluid is sent for culture and grows *Candida albicans*. A blood culture collected on day 16 is positive for *C. albicans*. This patient should be reported as having a PVAP with a secondary BSI due to *C. albicans.*

EXAMPLE: Patient hospitalized and mechanically ventilated in the MICU for 14 days develops worsening oxygenation following a 7-day period of stability on the ventilator. VAC criteria are met on hospital day 15 (stable ventilator settings on days 12 and 13, increased ventilator settings on days 14 and 15). The onset date is day 14. The white blood cell count is noted to be 15,500 cells/mm^3 on day 14. Meropenem and vancomycin are begun on day 15, administered through the patient's right-sided central line (inserted on ICU admission). The antibiotics continue to be administered on day 18, meeting IVAC criteria. An endotracheal aspirate collected on day 15 is a good quality specimen, with ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per low power field, and grows *Staphylococcus aureus* (qualitative result). A blood culture collected on day 24 is positive for *S. aureus* and for coagulase-negative staphylococci (CoNS). This patient should be reported as having a PVAP, with *S. aureus* reported as the pathogen. A secondary BSI should also be reported for the PVAP, since the positive blood culture was collected within the 14-day period of the VAE, and an organism isolated from blood (*S. aureus*) matched an organism isolated from culture of the endotracheal aspirate. The CoNS also isolated from the blood culture on day 24 is <u>not</u> reported as a pathogen for the PVAP because it is an excluded organism.

14) <u>Can I only report pathogens if they are isolated in cultures of appropriate specimens? What about pathogens identified by non-culture-based diagnostic testing?</u>

- PVAP incorporates results of non-culture-based microbiological diagnostic testing. For PVAP, pathogens that are grown in culture OR selected pathogens that are identified as a result of other laboratory testing (for example, antigen testing, PCR, immunohistochemistry, etc.) should be reported. Do not limit reporting to just those organisms isolated in culture. For example, influenza A identified by polymerase chain reaction (PCR) in a patient meeting PVAP criteria should be reported as a pathogen for that event.

15) The "PVAP" Criterion 3 includes "positive diagnostic tests" for *Legionella* species, and selected viruses. What kinds of diagnostic tests can be used to meet the definition?
    - Diagnostic testing practices may vary from facility to facility and change over time as better tests are developed. Listed here are some examples of diagnostic tests for specific pathogens included in the PVAP definition. Positive results of these tests may be used in meeting the PVAP definition. Your facility may use other testing methods; positive results obtained using these methods may also be appropriate for use in meeting the PVAP definition. If you have a question regarding a diagnostic test method, check with your laboratory.
    - For *Legionella* species, positive results of any of the following, performed on the appropriate specimen: urinary antigen, *Legionella*-specific respiratory culture, paired serology (4-fold rise in titer between acute and convalescent specimens), direct fluorescent antibody stain, immunohistochemistry stain, or nucleic acid detection assays (such as PCR) performed on a respiratory specimen.
    - For respiratory viruses (influenza, respiratory syncytial virus [RSV], parainfluenza viruses, human metapneumovirus, coronaviruses, rhinoviruses and adenovirus), positive results for any of the following:
        - Performed on an appropriate respiratory specimen – PCR or other viral nucleic acid detection methods, antigen detection methods, including rapid tests, viral cell culture, or
        - Performed on appropriate pathologic specimens – immunohistochemical assays, cytology, microscopy, or
        - Performed on appropriately timed paired sera (acute and convalescent) – serological assays demonstrating seroconversion or a significant rise in antibody titer.

16) What about pneumonitis that occurs in a mechanically-ventilated patient and is determined to be due to herpes simplex virus (HSV) or cytomegalovirus (CMV)? Can these infections be reported as VAEs?
    - In most cases pneumonitis due to HSV and CMV represents reactivation of a latent infection, and therefore would not be considered healthcare-associated, according to the NHSN definition of a healthcare-associated infection. As it relates to VAE surveillance, laboratory confirmation of HSV or CMV would not be used to meet PVAP.

17) Are there any culture results or microorganisms that CANNOT be used to meet the PVAP definition?
    - The following pathogens and culture results may NOT be used to meet the definition and may NOT be reported as causes of PVAP when they are identified from sputum, endotracheal aspirates, bronchoalveolar lavages, or protected specimen brushings:
        - Culture results reported as "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
        - Any *Candida* species or yeast not otherwise specified
        - Any coagulase-negative *Staphylococcus* species
        - Any *Enterococcus* species

      NOTE: These organisms are excluded because they are common upper respiratory tract commensals, colonizers, or contaminants, and are unusual causes of VAP. Their exclusion from the surveillance definitions should NOT be used in clinical decision-making regarding patient treatment. Providers must independently determine the clinical significance of these organisms identified from respiratory specimens and the need for treatment.

NOTE: When any *Candida* species or yeast not otherwise specified, any coagulase-negative *Staphylococcus* species or any *Enterococcus* species are identified from lung tissue or pleural fluid, these organisms may be reported as PVAP pathogens.

Additionally, because organisms belonging to the following genera are typically causes of community-associated respiratory infections and are rarely or are not known to be causes of healthcare-associated infections, they are also excluded, and cannot be used to meet the PVAP definition when isolated from any eligible specimen type (to include lung tissue and pleural fluid): *Blastomyces, Histoplasma, Coccidioides, Paracoccidioides, Cryptococcus,* and *Pneumocystis.*

- When sputum, endotracheal aspirate, bronchoalveolar lavage, or protected specimen brushing culture or non-culture based testing results are mixed and contain one or more of the excluded pathogens in addition to one or more non-excluded pathogens, the culture may be used to meet the PVAP definition (depending on whether a qualitative, semi-quantitative, or quantitative culture was performed, and whether the semi-quantitative or quantitative CFU/ml thresholds were met) BUT only the non-excluded pathogen(s) should be reported.

  EXAMPLE: Patient intubated and mechanically ventilated in the MSICU meets IVAC criteria on day 8 of mechanical ventilation. On the day after the onset of worsening oxygenation, an endotracheal aspirate is collected. The Gram stain shows ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per low power field, and the culture grows "heavy *Staphylococcus aureus*" and "heavy *Candida albicans*." This patient should be reported as having a PVAP (Criterion 1) due to *Staphylococcus aureus* – as long as the semi-quantitative result "heavy" is equivalent to the quantitative threshold of ≥ 10^5 CFU/ml for endotracheal aspirates. If the semi-quantitative result is not equivalent to the quantitative threshold of ≥ 10^5 CFU/ml for endotracheal aspirates, the patient should still be reported as PVAP (Criterion 2). *Candida albicans* from the endotracheal aspirate culture is not reported, because it is an excluded result.

18) What about organisms identified from pleural fluid and lung tissue specimens? Can I report any pathogen identified from a lung tissue, or from a pleural fluid specimen, assuming the specimen was obtained during thoracentesis or within 24 hours of chest tube insertion?
    - Any pathogen identified from lung tissue, when that lung tissue was obtained during an open lung biopsy, video-assisted thoracoscopic surgery, or via other transthoracic or transbronchial biopsy approach, may be reported with the exception of the excluded pathogens belonging to the following genera: *Blastomyces, Histoplasma, Coccidioides, Paracoccidioides, Cryptococcus,* and *Pneumocystis*.
    - Any pathogen identified from pleural fluid, when that fluid was obtained during thoracentesis or within 24 hours of chest tube insertion (where there was no repositioning of the chest tube prior to specimen collection), may be reported with the exception of the excluded pathogens belonging to the following genera: *Blastomyces, Histoplasma, Coccidioides, Paracoccidioides, Cryptococcus,* and *Pneumocystis*.

19) How are "purulent respiratory secretions" defined?
    - Purulent respiratory secretions used to meet Criterion 2 of the PVAP definition are defined as:

- Secretions from the lungs, bronchi, or trachea with ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per low power field [lpf, x100].
- If the laboratory reports semi-quantitative results, you should check with your laboratory to be certain that the semi-quantitative results match the quantitative thresholds noted above.

- If your laboratory is not able to provide additional information on how a semi-quantitative reporting system corresponds to quantitative reporting ranges for neutrophils and squamous epithelial cells, here is some guidance from the *Clinical Microbiology Procedures Handbook* (3rd ed., 2010)*:

  1+ = occasional or rare = < 1 cell per low power field [lpf, x100]
  2+ = few = 1-9 cells per low power field [lpf, x100]
  3+ = moderate = 10-25 cells per low power field [lpf, x100]
  4+ = heavy = > 25 cells per low power field [lpf, x100]

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

  - With this range in mind, and in the absence of additional information from your laboratory, "purulent respiratory secretions" are defined as secretions that contain 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 low power field [lpf, x100].
- If your laboratory uses a different reporting format for results of direct examination of respiratory secretions, you may still be able to use the purulent respiratory secretions in meeting the PVAP definition. See the instructions available in the VAE Protocol, Table 2.

20) What is the definition of "positive lung histopathology" that can be used to meet the PVAP definition?
- If the lung tissue specimen was obtained via open lung biopsy, video-assisted thoracoscopic surgery, or via other transthoracic or transbronchial biopsy approach, it is eligible for consideration in meeting the PVAP definition (Criterion 3).
- Histopathological findings that can be used to meet the PVAP definition include:
  - Abscess formation or foci of consolidation with intense neutrophil accumulation in bronchioles and alveoli;
  - Evidence of lung parenchyma invasion by fungi (hyphae, pseudohyphae, or yeast forms);
  - Evidence of infection with the viral pathogens listed in FAQ no. 14 (at the end of this protocol) based on results of immunohistochemical assays, cytology, or microscopy performed on lung tissue.
- Additionally, lower respiratory specimen cytology findings suggestive of infection are eligible for consideration in meeting the PVAP definition (Criterion 3).

21) I am still having trouble understanding the time frame that defines a VAE. Can you explain what is meant by this statement that appears in the algorithm: *"On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation"*?
- The intent of these criteria is to determine whether a VAC is due to an infectious process (IVAC) and/or pneumonia (PVAP) by looking for corroborating inflammatory and infectious signs at the time of VAC onset. The criterion, "on or after calendar day 3" is intended to exclude inflammatory

and infectious signs present on the first two days of mechanical ventilation because they are more likely to be due to pre-existing conditions than ventilator-acquired complications. The criterion, "within 2 calendar days before or after the onset of worsening oxygenation," is intended to identify infectious and inflammatory signs that arise at the same time as VAC and may therefore point to the cause of the VAC.

- The figures below illustrate the time frame that defines a VAE. The date of event is the first day of worsening oxygenation, defined by the PEEP and FiO_2 thresholds outlined in the algorithm. The date of event defines the time frame within which all other criteria must be met. In the examples below, the shaded area defines the VAE Window Period in which IVAC criteria (temperature or white count abnormalities, plus a new antimicrobial agent started and continued for at least 4 days) must be met, and in which a PVAP criterion must be met.

  NOTE: Keep in mind that VAE criteria must be met based on specimens collected or antimicrobial agents started after day 2 of mechanical ventilation.

  EXAMPLE 1: When the onset date of the VAE occurs early in the course of mechanical ventilation (for example, day 3 or 4 of mechanical ventilation), the period in which certain inflammatory and infectious criteria are sought for IVAC and PVAP is shorter, because the first 2 days of mechanical ventilation are excluded from the normal 5 day window surrounding the day of increased ventilator support.

MV Day No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
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 abnormality or white blood cell count abnormality			←An abnormal temperature or white blood cell count, according to the algorithm parameters, must be documented within this shaded period→				
Antimicrobial agent			←New agent must be started on any day within this shaded period, and then continued for at least 4 days→				
Purulent respiratory secretions, positive culture, positive histopathology			←Specimen must be collected on any day within this shaded period→				

  EXAMPLE 2: When the onset date of the VAE occurs later in the course of mechanical ventilation, the period in which certain criteria must be met is a day longer, because the patient has already been on mechanical ventilation for more than 3 days and therefore inflammatory and infectious signs arising anywhere in the full 5-day window surrounding the day of increased ventilator settings can count towards IVAC and PVAP.

MV Day No.	10	11	12	13	14	15	16
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 abnormality or white blood cell count abnormality		←An abnormal temperature or white blood cell count, according to the algorithm parameters, must be documented within this shaded period→					
Antimicrobial agent		←New agent must be started on any day within this shaded period, and then continued for at least 4 days→					
Purulent respiratory secretions, positive culture, positive histopathology		←Specimen must be collected on any day within this shaded period→					

22) Providers in my ICU use different types of mechanical ventilation for different patients. Can you explain the circumstances in which mechanically-ventilated patients are to be excluded from VAE surveillance, and the circumstances in which mechanically-ventilated patients should be included in VAE surveillance?

- VAE surveillance is restricted to adult inpatient locations. Patients on mechanical ventilation who are in adult inpatient locations in acute care and long-term acute care hospitals and inpatient rehabilitation facilities are eligible for inclusion in VAE surveillance.
- Patients are excluded from VAE surveillance during periods of time when they are receiving high frequency ventilation, or if they are receiving extracorporeal life support or paracorporeal membrane oxygenation (for example extracorporeal membrane oxygenation - ECMO). Patients may be on these types of support for a portion of a calendar day, but not for the entire calendar day. In these instances, the patient is eligible for inclusion in VAE surveillance during the portion of the calendar day when the patient was being mechanically ventilated using a conventional type of mechanical ventilation. Ventilator settings documented while on a conventional mode of ventilation are to be used to select daily minimum PEEP and FiO_2 values for the calendar day.
- Patients are included in surveillance if they are on a ventilator (as defined in the VAE surveillance protocol), and are being mechanically ventilated through an endotracheal or tracheostomy tube using a conventional mode of mechanical ventilation (such as volume controlled, pressure controlled, or pressure support mechanical ventilation).
    - Patients on conventional mechanical ventilation who are receiving nitric oxide, helium-oxygen mixtures (heliox), or epoprostenol therapy are included in surveillance.
    - Patients on conventional mechanical ventilation who are being ventilated in the prone position are included in surveillance.
- Patients are also included in surveillance if they are on a ventilator (as defined in the VAE surveillance protocol) and are being mechanically ventilated through an endotracheal or tracheostomy tube using Airway Pressure Release Ventilation (APRV) or related modes. Some terms that are used to indicate APRV or a related mode of mechanical ventilation include (but may not be limited to): BiLevel, Bi Vent, BiPhasic, PCV+, and DuoPAP.
    - For patients on APRV or related modes the entire calendar day, the period of worsening oxygenation following a period of stability or improvement on the ventilator that is required for identification of a VAE will be defined by the FiO_2 criterion within the VAE surveillance definition algorithm. The PEEP criterion may not be applicable in patients on APRV or related modes of mechanical ventilation.
    - For patients on APRV or related modes for a portion of the calendar day identification of a VAE can be determined in either the PEEP or FiO_2 parameter. However, only ventilator

settings documented during the calendar day while on a conventional mode of ventilation are to be used to select the daily minimum PEEP.

- If you have questions about mechanical ventilation, you should check with the Respiratory Care or Respiratory Therapy and/or Critical Care departments in your facility.

23) Do I need to indicate if a patient was on APRV at the time of VAE onset, and do I need to indicate the number of patients on APRV in my ICU for each day of VAE surveillance?

- If the VAE occurred in a patient on Airway Pressure Release Ventilation (APRV) or a related mode of mechanical ventilation (for example, BiLevel, Bi Vent, BiPhasic, PCV+, DuoPAP) at the time of VAE onset, responding "Yes" in the "APRV" field is optional on the VAE Form (CDC 57.112). Otherwise, indicate "No."
- On the appropriate denominator form (CDC 57.117 or 57.118), in the column for "Number of patients on a ventilator," you will see that there are two sub-columns. In the sub-column, "Total patients," enter the total number of patients on a ventilator on that day. It is optional to provide the "Number on APRV," in the sub-column. If provided, enter the number for the subset of patients on a ventilator on that day who are on the APRV mode of mechanical ventilation or related modes (for example, BiLevel, Bi Vent, BiPhasic, PCV+, DuoPAP) at the time the count is performed. If there are no patients on APRV or a related mode of mechanical ventilation, enter "0" (zero).

24) My laboratory only performs semi-quantitative cultures of lower respiratory tract specimens and cannot provide me with additional guidance to help me know what semi-quantitative culture result corresponds to the quantitative thresholds specified in Criterion 1 of the PVAP definition. Can you provide more information?

For the purposes of this surveillance, and in the absence of additional information available from your laboratory, a semi-quantitative result of "moderate" "many" "numerous" or "heavy" growth, or 2+, 3+ or 4+ growth, meets the PVAP definition (Criterion 1).