
In September 2011, the Centers for Disease Control and Prevention (CDC) convened a Ventilator-Associated Pneumonia (VAP) Surveillance Definition Working Group to organize a formal process for leaders and experts of key stakeholder organizations to discuss the challenges of VAP surveillance definitions and to propose new approaches to VAP surveillance in adult patients (see Table). The charges to the Working Group were as follows:

1. To critically review a draft of a streamlined VAP surveillance definition developed for use in adult patients,

2. To suggest modifications to enhance the reliability and credibility of the surveillance definition within the critical care and infection prevention communities, and

3. To propose a final adult surveillance definition algorithm, to be implemented in the CDC’s National Healthcare Safety Network (NHSN), taking into consideration the potential future use of the definition algorithm in public reporting, interfacility comparisons, and pay-for-reporting and pay-for-performance programs.

The Working Group’s surveillance definition algorithm, which is referred to as the ventilator-associated events or VAE surveillance definition algorithm, represents a purposeful departure from VAP toward...
more general, objective measures of conditions and complications occurring in patients receiving mechanical ventilation (see Figure; VAE surveillance protocol available at: http://www.cdc.gov/nhsn/acute-care-hospital/vae/index.html). The VAE surveillance definition algorithm uses a tiered approach, moving from measures of ventilator-associated conditions (VAC), to infection-related ventilator-associated complications (IVAC), to possible and probable VAP.

About the Authors
Shelley S. Magill, Scott Fridkin, Alice Guh, and Teresa Horan are from the Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia. Michael Klompas is from the Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute and the Infection Control Department, Brigham and Women's Hospital, Boston, Massachusetts and represents the Society for Healthcare Epidemiology of America, Arlington, Virginia. Robert Balk is from the Division of Pulmonary and Critical Care Medicine, Rush University Medical Center, Chicago, Illinois and represents the Critical Care Societies Collaborative (CCSC, American Association of Critical-Care Nurses, American College of Chest Physicians, American Thoracic Society, and Society of Critical Care Medicine). Suzanne M. Burns is from the School of Nursing, Critical and Acute Care, University of Pennsylvania, Philadelphia and represents the CCSC. Cliff Deutschman, Marin Kollef, and Pamela Lipsett are from the Department of Anesthesiology and Critical Care, Perelman School of Medicine at the University of Pennsylvania, Philadelphia and represents the CCSC. Daniel Diekema is from the Division of Infectious Diseases, University of Iowa Carver College of Medicine, Iowa City and represents the CCSC. Edward Septimus is from the Department of Anesthesiology and Critical Care Medicine, University of Arizona and represents the CCSC. Linda Greene is from the Department of Anesthesiology and Critical Care Medicine, University of Arizona and represents the CCSC. Michael Klompas is from the Department of Population Medicine, Harvard Medical School and Harvard Pilgrim Health Care Institute and the Infection Control Department, Brigham and Women's Hospital, Boston, Massachusetts and represents the Society for Healthcare Epidemiology of America, Arlington, Virginia. Scott Fridkin is from the Division of Pulmonary and Critical Care Medicine, Tufts Medical Center, Boston and represents the CCSC. Nicholas Hill is from the Division of Pulmonary and Critical Care Medicine, Tufts Medical Center, Boston and represents the CCSC. Don Wright is from the Office of Disease Prevention and Health Promotion, US Department of Health and Human Services, Washington, DC. David Henderson is from the Department of Cardiology, Zablocki VA Medical Center, Milwaukee, Wisconsin and represents the CCSC. Beth Hammer is from the Department of Cardiology, Zablocki VA Medical Center, Milwaukee, Wisconsin and represents the CCSC. David Henderson is from the Hospital Epidemiology and Quality Improvement, the Clinical Center, National Institutes of Health, Bethesda, Maryland. Dean R. Hess is from the Department of Respiratory Care, Massachusetts General Hospital, Boston, the Department of Anesthesia, Harvard Medical School, Boston, and represents the American Association for Respiratory Care, Irving, Texas. Nicholas S. Hill is from the Division of Pulmonary and Critical Care Medicine, Tufts Medical Center, Boston and represents the CCSC. Marin Kollef is from the Division of Pulmonary and Critical Care Medicine, Washington University, St. Louis, Missouri and represents the CCSC. Mitchell Levy is from the Division of Pulmonary, Critical Care, and Sleep, Warren Alpert Medical School at Brown University, Rhode Island Hospital, Providence and represents the CCSC. Edward Septimus is from the Department of Internal Medicine, Texas A&M Health Science Center, College Station, Texas and represents the Infectious Diseases Society of America, Arlington, Virginia. Carole VanAntwerpen is from the New York State Department of Health, Bureau of Healthcare-Associated Infections, Albany, and represents the Council of State and Territorial Epidemiologists, Atlanta. Don Wright is from the Office of Disease Prevention and Health Promotion, US Department of Health and Human Services, Washington, DC. Pamela Lipsett is from the Department of Surgery, Anesthesiology and Critical Care Medicine, Johns Hopkins University School of Medicine, Baltimore, Maryland and represents the CCSC.

Corresponding author: Shelley S. Magill, MD, PhD. Division of Healthcare Quality Promotion, Centers for Disease Control and Prevention, 1600 Clifton Road, MS A-24, Atlanta, GA 30329 (e-mail: smagill@cdc.gov).

Table
VAP Surveillance Definition Working Group organizations, representatives, and federal participants

<table>
<thead>
<tr>
<th>Organization</th>
<th>Representative(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Association of Critical-Care Nurses</td>
<td>Suzanne Burns and Beth Hammer</td>
</tr>
<tr>
<td>American Association for Respiratory Care</td>
<td>Dean Hess</td>
</tr>
<tr>
<td>American College of Chest Physicians</td>
<td>Robert Balk and David Gutterman</td>
</tr>
<tr>
<td>American Thoracic Society</td>
<td>Nicholas Hill and Mitchell Levy</td>
</tr>
<tr>
<td>Association of Professionals in Infection Control and Epidemiology</td>
<td>Linda Greene</td>
</tr>
<tr>
<td>Council of State and Territorial Epidemiologists</td>
<td>Carole VanAntwerpen</td>
</tr>
<tr>
<td>Healthcare Infection Control Practices Advisory Committee Surveillance Working Group</td>
<td>Daniel Diekema</td>
</tr>
<tr>
<td>Infectious Diseases Society of America</td>
<td>Edward Septimus</td>
</tr>
<tr>
<td>Society for Healthcare Epidemiology of America</td>
<td>Michael Klompas</td>
</tr>
<tr>
<td>Society of Critical Care Medicine</td>
<td>Clifford Deutschman, Marin Kollef, and Pamela Lipsett</td>
</tr>
<tr>
<td>US Department of Health and Human Services, Office of Disease Prevention and Health Promotion</td>
<td>Don Wright</td>
</tr>
<tr>
<td>National Institutes of Health, Division of Healthcare Quality Promotion</td>
<td>David Henderson</td>
</tr>
<tr>
<td>Centers for Disease Control and Prevention, Division of Healthcare Quality Promotion</td>
<td>Scott Fridkin, Alice Guh, Shelley Magill, Teresa Horan, others</td>
</tr>
</tbody>
</table>
Patient has a baseline period of stability or improvement on the ventilator, defined by ≥2 calendar days of stable or decreasing daily minimum FiO₂ or PEEP values. The baseline period is defined as the 2 calendar days immediately preceding the first day of increased daily minimum PEEP or FiO₂.

After a period of stability or improvement on the ventilator, the patient has at least 1 of the following indicators of worsening oxygenation:

1. Minimum daily FiO₂ values increase ≥0.20 (20 points) over the daily minimum FiO₂ in the preceding 2 calendar days (the baseline period), for ≥2 calendar days.
2. Minimum daily PEEP values increase ≥3 cm H₂O over the daily minimum PEEP in the preceding 2 calendar days (the baseline period), for ≥2 calendar days.

**Ventilator-associated condition (VAC)**

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

1. Temperature >38°C or <36°C, OR white blood cell count ≥12 000 cells/mm³ or ≤4000 cells/mm³ AND
2. A new antimicrobial agent(s)* is started, and continued for ≥4 calendar days


**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, 1 of the following criteria is met:

1. Purulent respiratory secretions (from ≥1 specimen collection)
   - Defined as secretions from the lungs, bronchi, or trachea that contain ≥25 neutrophils and ≤10 squamous epithelial cells per low-power field (x100)(or corresponding semiquantitative results).

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

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

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, 1 of the following criteria is met:

1. Purulent respiratory secretions (from ≥1 specimen collection—and defined as for possible VAP)
   AND 1 of the following:
   - Positive culture of endotracheal aspirate*, ≥10⁵ CFU/mL or equivalent semiquantitative result
   - Positive culture of bronchoalveolar lavage*, ≥10⁴ CFU/mL or equivalent semiquantitative result
   - Positive culture of lung tissue, ≥10⁴ CFU/g or equivalent semiquantitative result
   - Positive culture of protected specimen brush*, ≥10³ CFU/mL or equivalent semiquantitative result

*Same organism exclusions as noted for possible VAP.

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

**Possible ventilator-associated pneumonia**

**Probable ventilator-associated pneumonia**

---

**Figure** Ventilator-associated events surveillance definition algorithm.*

*Abbreviations: CFU, colony-forming units; FiO₂, fraction of inspired oxygen; PEEP, positive end-expiratory pressure; VAP, ventilator-associated pneumonia. Available at: http://www.cdc.gov/nhsn/acute-care-hospital/vae/index.html.
The first tier of VAE surveillance, VAC, seeks to identify episodes of sustained respiratory deterioration and will capture both infectious and noninfectious conditions and complications occurring in patients receiving mechanical ventilation. VAC is defined by a sustained period of worsening oxygenation that immediately follows a baseline period of stability or improvement with mechanical ventilation. To meet the VAC definition, a patient receiving mechanical ventilation must have at least 2 calendar days of stable or decreasing daily minimum positive end-expiratory pressure (PEEP) or fraction of inspired oxygen (FIO2), followed by at least 2 days of increased daily minimum PEEP or FIO2, where the increase in the daily minimum PEEP is at least 3 cm H2O greater than the daily minimum PEEP during the baseline period, or where the increase in the daily minimum FIO2 is ≥0.20 (or 20 percentage points in oxygen concentration) greater than the daily minimum FIO2 during the baseline period. For example, if a patient’s daily minimum FIO2 requirement on days 4 and 5 of mechanical ventilation is 0.40, then the patient’s daily minimum FIO2 requirement would need to be at least 0.60 on days 6 and 7 of mechanical ventilation for the VAC definition to be met.

The Working Group’s decisions to set specific thresholds of 3 cm H2O and 0.20 (20 points) for the increases in PEEP and FIO2, respectively, and to define a “sustained” increase as an increase persisting for at least 2 calendar days, were based on expert opinion of what criteria would most likely indicate clinically important events, while minimizing inadvertent inclusion of other types of events resulting in transient changes in oxygenation—such as surgery or performance of other procedures.

Thresholds were also selected on the basis of published data indicating that increases of ≥2.5 cm H2O in PEEP or ≥0.15 (15 points) in FIO2 sustained for at least 2 days were associated with longer duration of mechanical ventilation, longer intensive care unit (ICU) and hospital stays, and increased mortality.1 Subsequently, additional data have been published that support the Working Group’s approach to VAC.2

The second tier, IVAC, attempts to identify the subset of VACs that are potentially related to infection, as evidenced by an abnormal white blood cell count or temperature and initiation of a new antimicrobial agent. IVAC will most likely capture patients with pulmonary infections and extrapulmonary infections of sufficient severity to trigger respiratory deterioration. The Working Group recognized the low predictive value of an abnormal body temperature or white blood cell count in ICU patients, and Klompas and colleagues3 have shown that the addition of fever or abnormal white blood cell count to VAC definition does not substantially enhance the definition’s predictive value for death. Nevertheless, these are objective and readily available signs that are frequently used at the bedside to assess for the presence of infection. The additional required criterion of starting a new antimicrobial agent, where the new agent is continued for at least 4 days, may add specificity and clinical credibility to the IVAC definition, although data are needed.

The third tier, possible and probable VAP, attempts to zero in on the subset of IVAC patients with respiratory infections as manifested by objective evidence of purulent respiratory secretions (where purulence is defined by using quantitative or semiquantitative criteria for the number of neutrophils on Gram stain) and/or positive results of microbiological tests performed on respiratory tract specimens. The possible VAP definition is met with the presence of purulent secretions or a positive lower respiratory tract culture (showing any growth); the probable VAP definition requires purulent secretions in addition to a positive lower respiratory tract culture meeting certain quantitative or semiquantitative thresholds of pathogen growth. Organisms that are uncommonly regarded as true VAP pathogens are excluded from possible and probable VAP culture criteria (with the exception of lung tissue cultures): Candida spp, coagulase-negative staphylococci, and Enterococcus spp. The probable VAP definition can also be met on the basis of the presence of a positive pleural fluid culture, lung tissue with histopathologic evidence of infection, or positive diagnostic tests for Legionella or selected respiratory tract viruses, without the concomitant requirement for purulent secretions. Although data have shown that requiring purulent secretions or positive cultures in patients who have met a VAC definition actually diminishes the association between mortality and VAC;2 the Working Group felt that it was important to provide definitions within the VAE algorithm that more closely resemble VAP diagnostic criteria used at the bedside.

This tiered approach is believed to be the most appropriate approach in the current environment. It acknowledges limitations in the ability to accurately identify VAP for surveillance purposes—simply labeling an event “VAP” does not make it so—and focuses instead on a more general measure of complications...
of mechanical ventilation. This approach may also reduce the likelihood of definition gaming or manipulation that could artificially lower event rates.

Two features of the VAE surveillance definition algorithm are of particular note. First, radiographic evidence of pneumonia is not included as a criterion in any tier of the algorithm because of lack of specificity and the subjectivity inherent in facilities’ and individual providers’ practices in ordering, performing, interpreting, and reporting results of chest radiographs. Second, only VAC and IVAC (and therefore the overall VAE rate—the rate of all events meeting at least the VAC definition—and the rate of all events meeting at least the IVAC definition) are intended to be possible candidates for future use in public reporting, interfacility comparisons, and pay-for-performance programs.

The VAC and IVAC definitions use criteria based on data anticipated to be available from most patients receiving mechanical ventilation and less subject to manipulation or gaming. By contrast, the third definition tier, possible and probable VAP, was developed to be used only in internal quality improvement. These VAP definitions include criteria based on documentation of purulent secretions and/or microbiological findings and are more in keeping with traditional clinical constructs of VAP. Because of the substantial variability in the ordering and collection of lower respiratory tract specimens, and in laboratory processing of specimens and reporting of results, the Working Group determined that it was not appropriate to include these data elements in the VAC and IVAC definitions.

An iterative process for refining the definitions must be ensured as experience using the definition algorithm accumulates in the coming years. Although there was clearly a need to establish a new surveillance approach in the NHSN, there is also an urgent need to advance the science of surveillance for VAP and other VAEs. The VAE surveillance definition algorithm should be studied, validated, and improved in an ongoing manner. The definitions should be evaluated and refined in collaboration with members of the Working Group and other members of stakeholder communities and organizations. The Working Group is already discussing potential modifications that are based on user feedback received during the first 3 months of VAE surveillance.

The VAP Surveillance Definition Working Group’s new approach to surveillance in adults receiving mechanical ventilation acknowledges the current limitations in VAP diagnosis and the potential benefit in focusing surveillance on an objective, reliable, but more general measure of significant conditions and complications that occur in patients receiving mechanical ventilation. VAE surveillance was implemented by the CDC’s NHSN in January 2013. Although much work remains, we believe that this innovative approach to surveillance has significant potential to increase the validity of comparisons among health care facilities and, more importantly, to improve measurement and patient safety in the intensive care unit.

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention, the American Association for Respiratory Care, the Association of Professionals in Infection Control and Epidemiology, the Council of State and Territorial Epidemiologists, or the Infectious Diseases Society of America.

FINANCIAL DISCLOSURES
This work was supported by the Centers for Disease Control and Prevention (CDC), Atlanta, Georgia. Dr Klompas received grant support from the CDC, US Food and Drug Administration, and the Office of the National Coordinator for Health Information Technology. Dr Balk received grant support from the CDC and bioMérieux for participation in the EPIC CAP study (CDC) and the Procalcitonin in ICU antibiotic stewardship study (CDC and bioMérieux). Dr Deutschman received grant support from the National Institute of General Medical Sciences. Dr Diekema received grant support from Merck, Cerexa, bioMérieux, PurThread Technologies, and Pfizer. Ms Greene consults for INC. Dr. Hess consulted for Philips Respironics, ResMed, Pari, and Breathe and received honoraria from Covidien and Maquet. Ms Greene lectured for Premier, Advanced Sterilization Products, and APIC. Dr Burns lectured for AACN. Ms Greene presented speeches for Covidien and Maquet. Dr Septimus received an honorarium for a lecture. Dr. Klompas received support from the Society of Healthcare Epidemiologists of America for the development of educational presentations. Dr Deutschman received royalties from Elsevier for the textbook, Evidence-based Practice of Critical Care Medicine. Dr Burns receives royalties from McGraw-Hill for books endorsed by AACN. Ms Greene receives royalties from Up-To-Date, Jones and Bartlett, and McGraw-Hill. The remaining authors have disclosed that they do not have any potential conflicts of interest.

REFERENCES

To purchase electronic or print reprints, contact American Association of Critical-Care Nurses, 101 Columbia, Aliso Viejo, CA 92656. Phone, (800) 899-1712 or (949) 362-2050 (ext 532); fax, (949) 362-2049; e-mail, reprints@aacn.org.
Developing a New, National Approach to Surveillance for Ventilator-Associated Events
Shelley S. Magill, Michael Klompas, Robert Balk, Suzanne M. Burns, Clifford S. Deutschman, Daniel Diekema, Scott Fridkin, Linda Greene, Alice Guh, David Gutterman, Beth Hammer, David Henderson, Dean R. Hess, Nicholas S. Hill, Teresa Horan, Marin Kollef, Mitchell Levy, Edward Septimus, Carole VanAntwerpen, Don Wright and Pamela Lipsett

Am J Crit Care 2013;22 469-473 10.4037/ajcc2013893
©2013 American Association of Critical-Care Nurses
Published online http://ajcc.aacnjournals.org/

Personal use only. For copyright permission information:
http://ajcc.aacnjournals.org/cgi/external_ref?link_type=PERMISSIONDIRECT

Subscription Information
http://ajcc.aacnjournals.org/subscriptions/

Information for authors
http://ajcc.aacnjournals.org/misc/ifora.xhtml

Submit a manuscript
http://www.editorialmanager.com/ajcc

Email alerts
http://ajcc.aacnjournals.org/subscriptions/etoc.xhtml