Ventilator-Associated Pneumonia (VAP) Event

Introduction: In 2002, an estimated 250,000 healthcare-associated pneumonias developed in U.S. hospitals and 36,000 of these were associated with deaths.[1] Patients with mechanically-assisted ventilation have a high risk of developing healthcare-associated pneumonia. For the year 2010, NHSN facilities reported more than 3,525 VAPs and the incidence for various types of hospital units ranged from 0.0-5.8 per 1,000 ventilator days.[2]

Prevention and control of healthcare-associated pneumonia is discussed in the CDC/HICPAC document, *Guidelines for Prevention of Healthcare-Associated Pneumonia, 200.3*[3]. The Guideline strongly recommends that surveillance be conducted for bacterial pneumonia in ICU patients who are mechanically ventilated to facilitate identification of trends and for inter-hospital comparisons.

Settings: Surveillance will occur in any inpatient location where denominator data can be collected, which may include critical/intensive care units (ICU), specialty care areas (SCA), neonatal units, including neonatal intensive care units (NICUs), step-down units, wards, and long term care units. A complete listing of inpatient locations can be found in Chapter 15.

NOTE: It is not required to monitor for VAPs after the patient is discharged from the facility, however, if discovered, any VAPs occurring within 48 hours of discharge should be reported to NHSN. No additional ventilator days are reported.

Requirements: Surveillance for VAP in at least one inpatient location in the healthcare institution for at least one calendar month as indicated in the *Patient Safety Monthly Reporting Plan* (CDC 57.106).

Definitions: As for all infections reported to NHSN, infections associated with complications or extensions of infections already present on admission, unless a change in pathogen or symptoms strongly suggests the acquisition of a new infection area not considered healthcare associated. Therefore, infections that become apparent within the first few days of admission must be carefully reviewed to determine whether they should be considered healthcare associated.

Pneumonia (PNEU) is identified by using a combination of radiologic, clinical and laboratory criteria. The following pages outline the various assessment criteria that may be used for meeting the surveillance definition of healthcare-associated pneumonia (Tables 2-5 and Figures 1 and 2). Report PNEUs that are ventilator-associated (i.e., patient was intubated and ventilated at the time of, or within 48 hours before, the onset of the event).

NOTE: There is no minimum period of time that the ventilator must be in place in order for the PNEU to be considered ventilator associated.

Location of attribution: The inpatient location where the patient was assigned on the date of the PNEU event, which is further defined as the date when the first clinical evidence appeared or the date the specimen used to meet the PNEU criterion was collected, whichever came first.

EXAMPLE: Patient is intubated and ventilated in the Operating Room and then is admitted to the MICU. Within 24 hours of admission to the MICU, patient meets criteria for PNEU. This is reported to NHSN as a VAP for the MICU, because the Operating Room is not an inpatient location and no denominator data are collected there.

EXCEPTION:

Transfer Rule: If a VAP develops within 48 hours of transfer from one inpatient location to another in the same facility or a new facility, the infection is attributed to the transferring location. This is called the Transfer Rule and examples are shown below:

- Patient on a ventilator in the SICU is transferred to the surgical ward. Thirty six (36) hours later, the patient meets the criteria for PNEU. This is reported to NHSN as a VAP for the SICU.
- Patient is transferred to the medical ward from the MSICU after having ventilator removed. Within 24 hours, the patient meets criteria for a PNEU. This is reported to NHSN as a VAP for the MSICU.
- Patient on a ventilator is transferred from the medical ward to the coronary care ICU (CCU). After 4 days in the CCU, the patient meets the criteria for a PNEU. This is reported to NHSN as a VAP for the CCU.
- Patient on the Respiratory ICU (RICU) of Hospital A had the endotracheal tube and ventilator removed and is discharged home a few hours later. The ICP from Hospital B calls the next day to report that this patient has been admitted to Hospital B with a PNEU. This VAP should be reported to NHSN for, and by, Hospital A and attributed to the RICU. No additional ventilator days are reported.

Ventilator: A device to assist or control respiration continuously, inclusive of the weaning period, through a tracheostomy or by endotracheal intubation.

NOTE: Lung expansion devices such as intermittent positive-pressure breathing (IPPB); nasal positive end-expiratory pressure (PEEP); and continuous nasal positive airway pressure (CPAP, hypoCPAP) are not considered ventilators unless delivered via tracheostomy or endotracheal intubation (e.g., ET-CPAP).

General Comments Applicable to All Pneumonia Specific Site Criteria:

1. Physician's diagnosis of pneumonia alone is not an acceptable criterion for healthcare-associated pneumonia.
2. Although specific criteria are included for infants and children, pediatric patients may meet any of the other pneumonia specific site criteria.
3. Ventilator-associated pneumonia (i.e., pneumonia in persons who had a device to assist or control respiration continuously through a tracheostomy or by endotracheal intubation within the 48-hour period before the onset of infection, inclusive of the weaning period) should be so designated when reporting data.
4. When assessing a patient for presence of pneumonia, it is important to distinguish between changes in clinical status due to other conditions such as myocardial infarction, pulmonary embolism, respiratory distress syndrome, atelectasis, malignancy, chronic obstructive pulmonary disease, hyaline membrane disease, bronchopulmonary dysplasia, etc. Also, care must be taken when assessing intubated patients to distinguish between tracheal colonization, upper respiratory tract infections (e.g., tracheobronchitis), and early onset pneumonia.

Finally, it should be recognized that it may be difficult to determine healthcare-associated pneumonia in the elderly, infants, and immunocompromised patients since such conditions may mask typical signs or symptoms associated with pneumonia. Alternate specific criteria for the elderly, infants and immunocompromised patients have been included in this definition of healthcare-associated pneumonia.

5. Healthcare-associated pneumonia can be characterized by its onset: early or late. Early onset pneumonia occurs during the first four days of hospitalization and is often caused by *Moraxella catarrhalis*, *H. influenzae*, and *S. pneumoniae*. Causative agents of late onset pneumonia are frequently gram negative bacilli or *S. aureus*, including methicillin-resistant *S. aureus*. Viruses (e.g., Influenza A and B or Respiratory Syncytial Virus) can cause early and late onset healthcare-associated pneumonia, whereas yeasts, fungi, legionellae, and *Pneumocystis carinii* are usually pathogens of late onset pneumonia.
6. Pneumonia due to gross aspiration (for example, in the setting of intubation in the field, emergency room, or operating room) is considered healthcare-associated if it meets any specific criteria and was not clearly present or incubating at the time of admission to the hospital.
7. Multiple episodes of healthcare-associated pneumonia may occur in critically ill patients with lengthy hospital stays. When determining whether to report multiple episodes of healthcare-associated pneumonia in a single patient, look for evidence of resolution of the initial infection. The addition of or change in pathogen alone is not indicative of a new episode of pneumonia. The combination of new signs and symptoms and radiographic evidence or other diagnostic testing is required.
8. Positive Gram stain for bacteria and positive KOH (potassium hydroxide) mount for elastin fibers and/or fungal hyphae from appropriately collected sputum specimens are important clues that point toward the etiology of the infection. However, sputum samples are frequently contaminated with airway colonizers and therefore must be interpreted cautiously. In particular, *Candida* is commonly seen on stain, but infrequently causes healthcare-associated pneumonia.

Table 1: Abbreviations used in PNEU laboratory criteria

BAL – bronchoalveolar lavage	LRT – lower respiratory tract
EIA – enzyme immunoassay	PCR – polymerase chain reaction
FAMA – fluorescent-antibody staining of membrane antigen	PMN – polymorphonuclear leukocyte
IFA – immunofluorescent antibody	RIA − radioimmunoassay

REPORTING INSTRUCTIONS:

- There is a hierarchy of specific categories within the major site pneumonia. Even if a patient meets criteria for more than one specific site, report only one:
    - If a patient meets criteria for both PNU1 and PNU2, report PNU2
    - If a patient meets criteria for both PNU2 and PNU3, report PNU3
    - If a patient meets criteria for both PNU1 and PNU3, report PNU3
- Report concurrent lower respiratory tract infection (e.g., abscess or empyema) and pneumonia with the same organism(s) as pneumonia
- Lung abscess or empyema without pneumonia are classified as LUNG

- Bronchitis, tracheitis, tracheobronchitis, or bronchiolitis without pneumonia are classified as BRON.

Table 2: Specific Site Algorithms for Clinically Defined Pneumonia (PNU1)

Radiology	**Signs/Symptoms/Laboratory**
Two or more serial chest radiographs with at least **one** of the following[1,2]: New or progressive and persistent infiltrate Consolidation Cavitation Pneumatoceles, in infants ≤ 1 year old	FOR ANY PATIENT, at least **one** of the following: -Fever (>38°C or >100.4°F) with no other recognized cause -Leukopenia (<4000 WBC/mm^3) or leukocytosis (≥12,000 WBC/mm^3) -For adults ≥70 years old, altered mental status with no other recognized cause **and** at least **two** of the following: -New onset of purulent sputum[3], or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements -New onset or worsening cough, or dyspnea, or tachypnea[5] -Rales[6] or bronchial breath sounds -Worsening gas exchange (e.g. O_2 desaturations (e.g., $PaO_2/FiO_2 \leq 240$)[7], increased oxygen requirements, or increased ventilator demand)
NOTE: In patients **without** underlying pulmonary or cardiac disease (e.g. respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), one definitive chest radiograph is acceptable.[1]	ALTERNATE CRITERIA, for infants ≤1 year old: Worsening gas exchange (e.g., O_2 desaturations [e.g. pulse oximetry < 94%], increased oxygen requirements, or increased ventilator demand) **and** at least **three** of the following: -Temperature instability with no other recognized cause -Leukopenia (<4000 WBC/mm^3) or leukocytosis (≥15,000 WBC/mm^3) and left shift (≥10% band forms) -New onset of purulent sputum[3] or change in character of sputum[4], or increased respiratory secretions or increased suctioning requirements -Apnea, tachypnea[5], nasal flaring with retraction of chest wall or grunting -Wheezing, rales[6], or rhonchi -Cough -Bradycardia (<100 beats/min) or tachycardia (>170 beats/min)
	ALTERNATE CRITERIA, for child >1 year old or ≤ 12 years old, at least **three** of the following: -Fever (>38.4°C or >101.1°F) or hypothermia (<36.5°C or <97.7°F) with no other recognized cause -Leukopenia (<4000 WBC/mm^3) or leukocytosis (≥15,000 WBC/mm^3) -New onset of purulent sputum[3], or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements -New onset or worsening cough, or dyspnea, apnea, or tachypnea[5.] -Rales[6] or bronchial breath sounds -Worsening gas exchange (e.g. O_2 desaturations [e.g. pulse oximetry < 94%], increased oxygen requirements, or increased ventilator demand)

Table 3: Specific Site Algorithms for Pneumonia with Common Bacterial or Filamentous Fungal Pathogens and Specific Laboratory Findings (PNU2)

Radiology	Signs/Symptoms	Laboratory
Two or more serial chest radiographs with at least one of the following[1,2]: New or progressive and persistent infiltrate Consolidation Cavitation Pneumatoceles, in infants ≤ 1 year old NOTE: In patients **without** underlying pulmonary or cardiac disease (e.g. respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), one definitive chest radiograph is acceptable.[1]	At least **one** of the following: Fever (>38°C or >100.4°F) with no other recognized cause Leukopenia (<4000 WBC/mm^3) or leukocytosis (≥12,000 WBC/mm^3) For adults ≥70 years old, altered mental status with no other recognized cause **and** at least **one** of the following: New onset of purulent sputum[3], or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements New onset or worsening cough, or dyspnea or tachypnea[5] Rales[6] or bronchial breath sounds Worsening gas exchange (e.g. O_2 desaturations [e.g., $PaO_2/FiO_2 \leq 240$][7], increased oxygen requirements, or increased ventilator demand)	At least **one** of the following: Positive growth in blood culture[8] not related to another source of infection Positive growth in culture of pleural fluid Positive quantitative culture[9] from minimally contaminated LRT specimen (e.g., BAL or protected specimen brushing) ≥5% BAL-obtained cells contain intracellular bacteria on direct microscopic exam (e.g., Gram stain) Histopathologic exam shows at least **one** of the following evidences of pneumonia: Abscess formation or foci of consolidation with intense PMN accumulation in bronchioles and alveoli Positive quantitative culture[9] of lung parenchyma Evidence of lung parenchyma invasion by fungal hyphae or pseudohyphae

Table 4: Specific Site Algorithms for Viral, Legionella, and other Bacterial Pneumonias with Definitive Laboratory Findings (PNU2)

Radiology	Signs/Symptoms	Laboratory
Two or more serial chest radiographs with at least one of the following[1,2]: New or progressive and persistent infiltrate Consolidation Cavitation Pneumatoceles, in infants ≤ 1 year old NOTE: In patients **without** underlying pulmonary or cardiac disease (e.g. respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), one definitive chest radiograph is acceptable.[1]	At least **one** of the following: Fever (>38°C or >100.4°F) with no other recognized cause Leukopenia (<4000 WBC/mm^3) or leukocytosis (≥12,000 WBC/mm^3) For adults ≥70 years old, altered mental status with no other recognized cause **and** at least one of the following: New onset of purulent sputum[3], or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements New onset or worsening cough or dyspnea, or tachypnea[5] Rales[6] or bronchial breath sounds Worsening gas exchange (e.g. O_2 desaturations [e.g., $PaO_2/FiO_2 \leq 240$][7], increased oxygen requirements, or increased ventilator demand)	At least **one** of the following[10-12]: Positive culture of virus or *Chlamydia* from respiratory secretions Positive detection of viral antigen or antibody from respiratory secretions (e.g., EIA, FAMA, shell vial assay, PCR) Fourfold rise in paired sera (IgG) for pathogen (e.g., influenza viruses, *Chlamydia*) Positive PCR for *Chlamydia* or *Mycoplasma* Positive micro-IF test for *Chlamydia* Positive culture or visualization by micro-IF of *Legionella* spp, from respiratory secretions or tissue. Detection of *Legionella pneumophila* serogroup 1 antigens in urine by RIA or EIA Fourfold rise in *L. pneumo*phila serogroup 1 antibody titer to ≥1:128 in paired acute and convalescent sera by indirect IFA.

Table 5: Specific Site Algorithm for Pneumonia in Immunocompromised Patients (PNU3)

Radiology	Signs/Symptoms	Laboratory
Two or more serial chest radiographs with at least one of the following[1,2]: New or progressive and persistent infiltrate Consolidation Cavitation Pneumatoceles, in infants ≤ 1 year old NOTE: In patients **without** underlying pulmonary or cardiac disease (e.g. respiratory distress syndrome, bronchopulmonary dysplasia, pulmonary edema, or chronic obstructive pulmonary disease), one definitive chest radiograph is acceptable.[1]	Patient who is immunocompromised[13] has at least **one** of the following: Fever (>38°C or >100.4°F) with no other recognized cause For adults ≥70 years old, altered mental status with no other recognized cause New onset of purulent sputum[3], or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements New onset or worsening cough, or dyspnea, or tachypnea[5] Rales[6] or bronchial breath sounds Worsening gas exchange (e.g. O_2 desaturations [e.g., $PaO_2/FiO_2 \leq 240$][7], increased oxygen requirements, or increased ventilator demand) Hemoptysis Pleuritic chest pain	At least **one** of the following: Matching positive blood and sputum cultures with *Candida* spp. [14, 15] Evidence of fungi or *Pneumocystis carinii* from minimally contaminated LRT specimen (e.g., BAL or protected specimen brushing) from one of the following: - Direct microscopic exam - Positive culture of fungi Any of the following from **LABORATORY CRITERIA DEFINED UNDER PNU2**

Footnotes to Algorithms:

1. Occasionally, in nonventilated patients, the diagnosis of healthcare-associated pneumonia may be quite clear on the basis of symptoms, signs, and a single definitive chest radiograph. However, in patients with pulmonary or cardiac disease (for example, interstitial lung disease or congestive heart failure), the diagnosis of pneumonia may be particularly difficult. Other non-infectious conditions (for example, pulmonary edema from decompensated congestive heart failure) may simulate the presentation of pneumonia. In these more difficult cases, serial chest radiographs must be examined to help separate infectious from non-infectious pulmonary processes. To help confirm difficult cases, it may be useful to review radiographs on the day of diagnosis, 3 days prior to the diagnosis and on days 2 and 7 after the diagnosis. Pneumonia may have rapid onset and progression, but does not resolve quickly. Radiographic changes of pneumonia persist for several weeks. As a result, rapid radiographic resolution suggests that the patient does not have pneumonia, but rather a non-infectious process such as atelectasis or congestive heart failure.

2. Note that there are many ways of describing the radiographic appearance of pneumonia. Examples include, but are not limited to, “air-space disease”, “focal opacification”, “patchy areas of increased density”. Although perhaps not specifically delineated as pneumonia by the radiologist, in the appropriate clinical setting these alternative descriptive wordings should be seriously considered as potentially positive findings.

3. Purulent sputum is defined as secretions from the lungs, bronchi, or trachea that contain ≥25 neutrophils and ≤10 squamous epithelial cells per low power field (x100). If your laboratory reports these data qualitatively (e.g., "many WBCs" or "few squames"), be sure their descriptors match this definition of purulent sputum. This laboratory confirmation is required since written clinical descriptions of purulence are highly variable.

4. A single notation of either purulent sputum or change in character of the sputum is not meaningful; repeated notations over a 24 hour period would be more indicative of the onset of an infectious process. Change in character of sputum refers to the color, consistency, odor and quantity.

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

6. Rales may be described as "crackles".

7. This measure of arterial oxygenation is defined as the ratio of the arterial tension (PaO_2) to the inspiratory fraction of oxygen (FiO_2).

8. Care must be taken to determine the etiology of pneumonia in a patient with positive blood cultures and radiographic evidence of pneumonia, especially if the patient has invasive devices in place such as intravascular lines or an indwelling urinary catheter. In general, in an immunocompetent patient, blood cultures positive for coagulase negative staphylococci, common skin contaminants, and yeasts will not be the etiologic agent of the pneumonia.

9. Refer to Threshold values for cultured specimens (Table 6). An endotracheal aspirate is not a minimally contaminated specimen. Therefore, an endotracheal aspirate does not meet the laboratory criteria.

10. Once laboratory-confirmed cases of pneumonia due to respiratory syncytial virus (RSV), adenovirus, or influenza virus have been identified in a hospital, clinician's presumptive diagnosis of these pathogens in subsequent cases with similar clinical signs and symptoms is an acceptable criterion for presence of healthcare-associated infection.

11. Scant or watery sputum is commonly seen in adults with pneumonia due to viruses and *Mycoplasma* although sometimes the sputum may be mucopurulent. In infants, pneumonia due to RSV or influenza yields copious sputum. Patients, except premature infants, with viral or mycoplasmal pneumonia may exhibit few signs or symptoms, even when significant infiltrates are present on radiographic exam.

12. Few bacteria may be seen on stains of respiratory secretions from patients with pneumonia due to *Legionella* spp, mycoplasma, or viruses.

13. Immunocompromised patients include those with neutropenia (absolute neutrophil count $<500/mm^3$), leukemia, lymphoma, HIV with CD4 count <200, or splenectomy; those who are early post-transplant, are on cytotoxic chemotherapy, or are on high dose steroids (e.g., >40mg of prednisone or its equivalent (>160mg hydrocortisone, >32mg methylprednisolone, >6mg dexamethasone, >200mg cortisone) daily for >2weeks).

14. Blood and sputum specimens must be collected within 48 hours of each other.

15. Semiquantitative or nonquantitative cultures of sputum obtained by deep cough, induction, aspiration, or lavage are acceptable. If quantitative culture results are available, refer to algorithms that include such specific laboratory findings

Figure 1: Pneumonia Flow Diagram

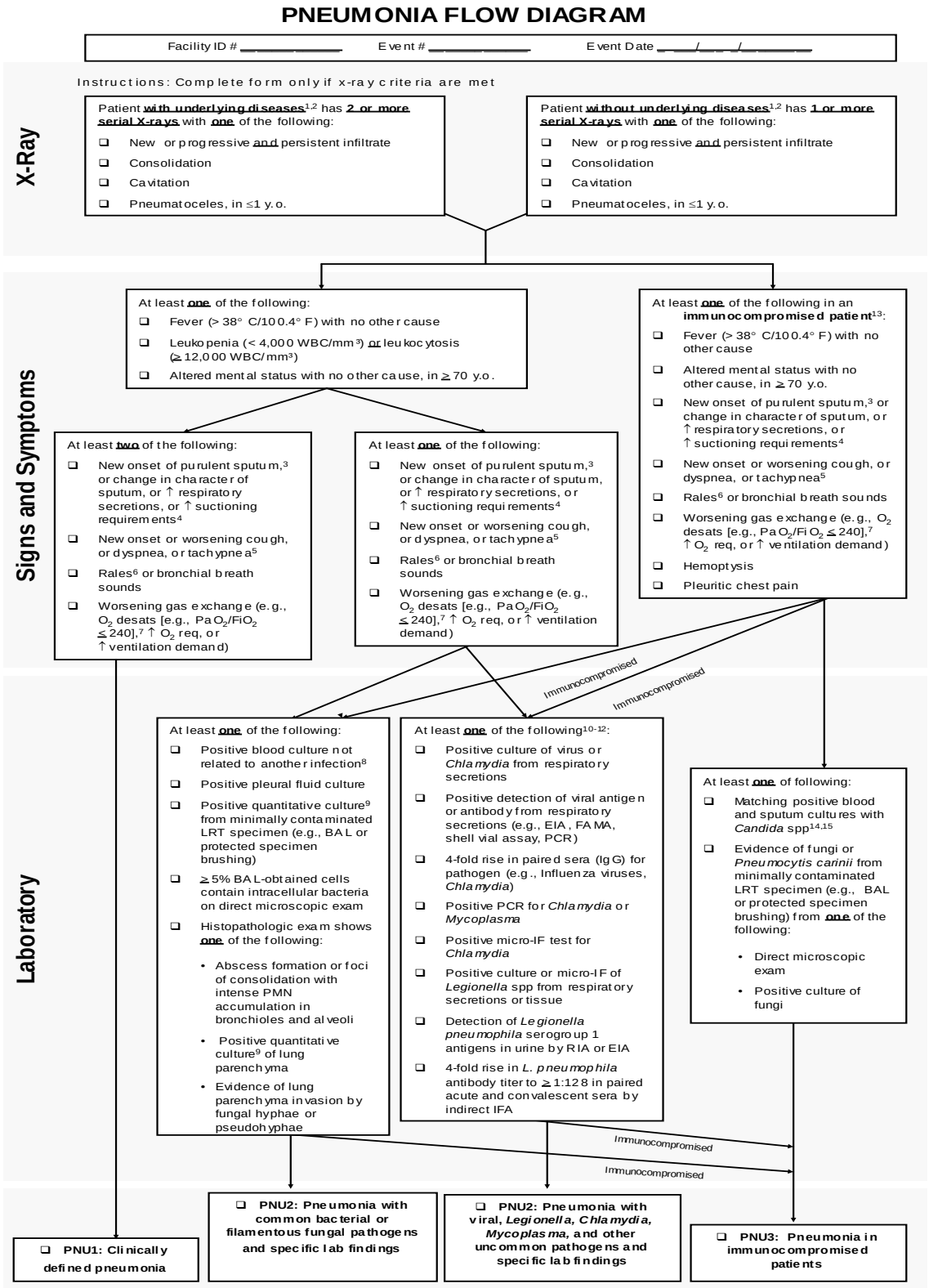

Figure 2: Pneumonia Flow Diagram, Alternative Criteria for Infants and Children

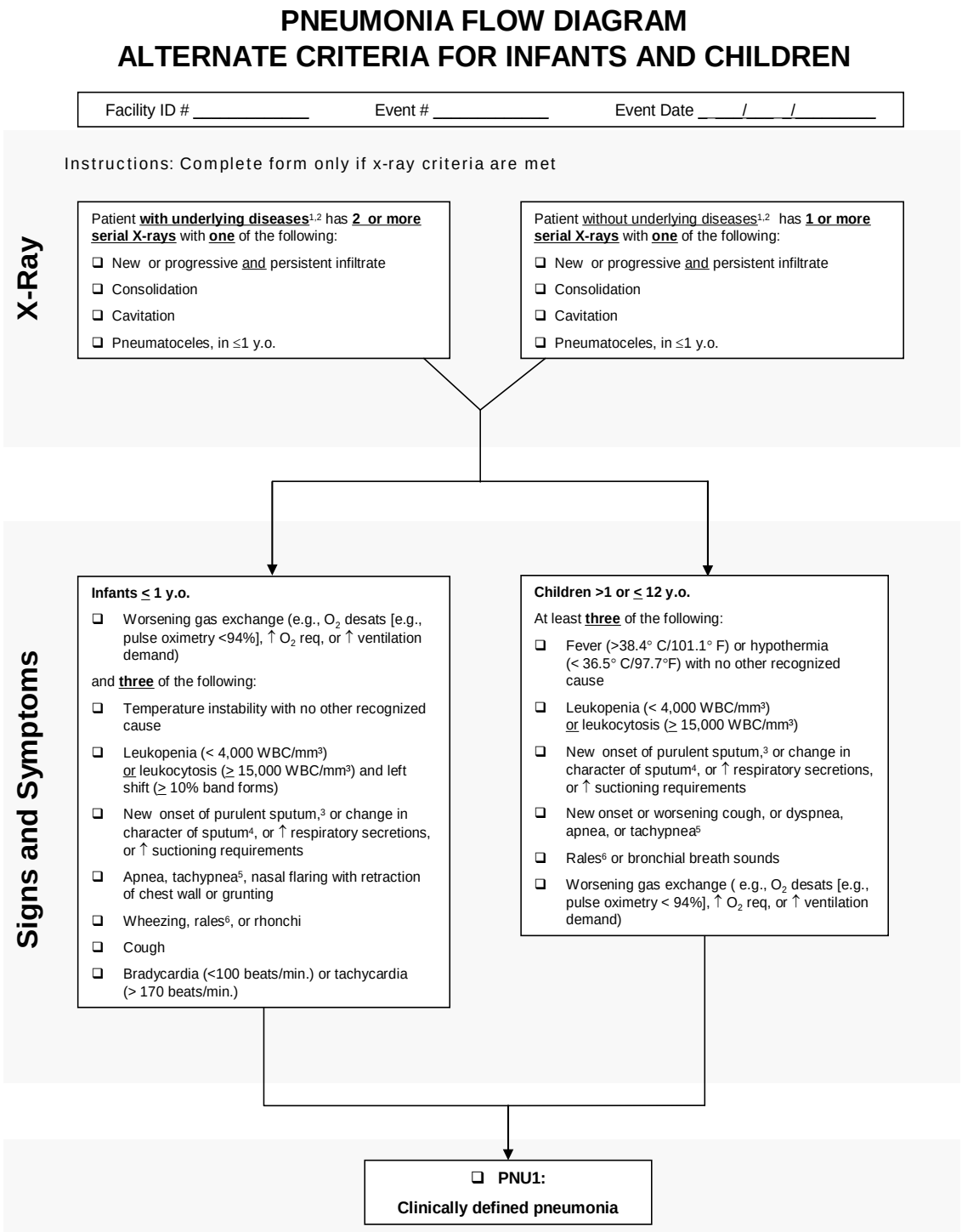

Table 6: Threshold values for cultured specimens used in the diagnosis of pneumonia

Specimen collection/technique	**Values**
Lung parenchyma*	$\geq 10^4$ cfu/g tissue
Bronchoscopically (B) obtained specimens	
Bronchoalveolar lavage (B-BAL)	$\geq 10^4$ cfu/ml
Protected BAL (B-PBAL)	$\geq 10^4$ cfu/ml
Protected specimen brushing (B-PSB)	$\geq 10^3$ cfu/ml
Nonbronchoscopically (NB) obtained (blind) specimens	
NB-BAL	$>10^4$ cfu/ml
NB-PSB	$\geq 10^3$ cfu/ml

cfu = colony forming units
g = gram
ml = milliliter

COMMENT:
* Open-lung biopsy specimens and immediate post-mortem specimens obtained by transthoracic or transbronchial biopsy

Numerator Data: The *Pneumonia (PNEU)* from (CDC 57.111) is used to collect and report each VAP that is identified during the month selected for surveillance. The *Instructions for Completion of Pneumonia Form* (Tables of Instructions, Tables 4 and 2a) includes brief instructions for collection and entry of each data element on the form. The pneumonia form includes patient demographic information and information on whether or not mechanically assisted ventilation was present. Additional data include the specific criteria met for identifying pneumonia, whether the patient developed a secondary bloodstream infection, whether the patient died, and the organisms isolated from cultures and their antimicrobial susceptibilities.

REPORTING INSTRUCTIONS:

- If no VAPs are identified during the month of surveillance, the Report No Events box must be checked on the appropriate denominator summary screen, e.g., 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 Key Terms). Ventilator days, which are the number of patients managed with a ventilatory device, are collected daily, at the same time each day, according to the chosen location using the appropriate form (CDC 57.116, 57.117, and 57.118). 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 (e.g., ventilator days from respiratory therapy), these sources may be used as long as the counts are not substantially different (+/- 5%) from manually-collected counts, validated for a minimum of 3 months.

Data Analyses: The SIR is calculated by dividing the number of observed infections by the number of expected infections. The number of expected infections, in the context of statistical prediction, is calculated using PNEU rates from a standard population during a baseline time period as reported in the NHSN Report.

NOTE: The SIR will be calculated only if the number of expected HAIs (numExp) is ≥ 1.

$$\text{SIR} = \frac{\text{Observed (O) HAIs}}{\text{Expected (E) HAIs}}$$

While the PNEU 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 infection among the location types. For example, you will be able to obtain one PNEU SIR adjusting for all locations reported. Similarly, you can obtain one PNEU SIR for all specialty care areas in your facility.

The VAP rate per 1000 ventilator days is calculated by dividing the number of VAPs by the number of ventilator days and multiplying the result by 1000. 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, as well as by each birthweight category in NICUs.

[1]Klevens RM, Edward JR, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. Public Health Reports 2007;122:160-166.

[2] Dudeck MA, Horan TC, et. al. National Healthcare Safety Network (NHSN) Report, Data Summary for 2010, Device-associated Module. Available at http://www.cdc.gov/nhsn/PDFs/dataStat/2011NHSNReport.pdf

[3] Centers for Disease Control and Prevention. Guidelines for preventing health-care-associated pneumonia, 2003: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. MMWR 2004;53(No. RR-3).