**e-Appendix 1: Detailed descriptions of data extraction and SAS code**

**e-Table 1: NV-HAP Surveillance Definition**

|  |
| --- |
| *Clinical features of NV-HAP* |
| ≥ 3 days hospitalization and not receiving mechanical ventilation |  |
| Worsening oxygenation sustained for ≥2 calendar days | * Drop in pulse oximetry from ≥95% on ambient air to <95% on ambient air, or
* New initiation of supplemental oxygen, or
* Escalation of supplemental oxygen:
	+ increase in flow rate of ≥3l/min for nasal cannula, ≥4l/min for face mask, or
	+ Escalation of oxgyen delivery device).
* Escalation of devices was in accordance with the following hierarchy: mechanical ventilation > BIPAP > non-rebreather > high flow nasal cannula > oxygen conserving device > simple face mask > nasal cannula > none.
 |
| Fever, ORAbnormal white blood cell count (WBC) | Temperature ≤36 or ≥38 °C, orWBC <4,000 or ≥12,000 cells/mm3 |
| *Recognition/response by clinical team* |
| Performance of chest imaging | Evidence of order or procedure code for chest X-ray or computerized tomography of the chest |
| Initiation of new antibiotics | Administration of selected antimicrobials (e-Table 3) not previously administered in past 2 days and continued for ≥3 days (changes in antibiotics permitted during the 3-day period so long as each new agent was not used in the preceding 2 days).  |

**e-Table 2: Criteria for increase in supplemental oxygen requirement and device hierarchy**

|  |  |
| --- | --- |
| If patient has the following first device for ≥2 calendar days (including hospital days 1 and 2): | Respiratory deterioration is then deemed present **if last device on both the next two days** is greater than the first device for the two baseline days and the first + last device on the first baseline day: |
| Room air and SpO2 ≥95% | Room air with SpO2 < 95% or escalation to any oxygen delivery device, **sustained for≥2 calendar days**. The second calendar day of respiratory deterioration can either be the same **last device** as the first day of respiratory deterioration or a higher level device (column 1 of this table arrays devices in order of escalation)  |
| Room air and SpO2 ≥90% | Escalation to any new oxygen delivery device, sustained for ≥2 calendar days |
| Nasal cannula | Nasal cannula with increase in **median flow rate** by ≥3 liters per minute sustained for ≥2 calendar days, or escalation to any more intense device (face mask, non-rebreather, oxymizer, high-flow, BIPAP, ventilator) sustained for ≥2 calendar days |
| Simple Mask | Increase in **median Flow Rate** by ≥4 liters per minute sustained for ≥2 calendar days, or escalation to any more intense device (non-rebreather, oxymizer, high-flow, BIPAP, ventilator) sustained for ≥2 calendar days |
| Oxymizer | Escalation to any more intense device (non-rebreather, high-flow, BIPAP, ventilator) sustained for ≥2 calendar days |
| Non-rebreather | Escalation to any more intense device (high-flow, BIPAP, ventilator) sustained for ≥2 calendar days |
| High-flow | Escalation to any more intense device (BIPAP, ventilator) sustained for ≥2 calendar days |
| BIPAP | Escalation to ventilator sustained for ≥2 calendar days |
| Ventilator | Exclude from analysis (study is focused on non-ventilated patients) |

Criteria to define respiratory deterioration are outlined in the above table but they all follow a framework of looking for two days of stable oxygenation followed by 2 days of impaired oxygenation relative to the 2 baseline days. **Impaired oxygenation can be marked by a decrease in daily maximum SaO2 in a patient on room air alone, escalation from room air to the use of an oxygen delivery device, an increase in flow rate for a given oxygen delivery device, or escalation from a less efficient to a more efficient oxygen delivery device.** Details are specified in e-Table 2.

**e-Table 3: Select antimicrobials and new antibiotic criteria**

|  |
| --- |
| Amikacin |
| Amoxicillin |
| Amoxicilllin/clavulanate |
| Ampicillin |
| Ampicillin-sulbactam |
| Azithromycin |
| Aztreonam |
| Carbenicillin |
| Cefaclor |
| Cefadroxil |
| Cefazolin |
| Cefdinir |
| Cefepime |
| Cefiderocol |
| Cefixime |
| Cefotaxime |
| Cefotetan |
| Cefoxitin |
| Cefpodoxime |
| Cefproxil |
| Ceftaroline |
| Ceftazidime |
| Ceftazidime-avibactam |
| Ceftolozane-tazobactam |
| Ceftriaxone |
| Cefuroxime |
| Cephalexin |
| Cilastin/Imipemen |
| Ciprofloxacin |
| Clarithromycin |
| Clavulanate/ticarcillin |
| Clindamycin |
| Colistin |
| Dalbavancin |
| Dalfopristin/quinopristine |
| Delafloxacin |
| Dicloxacillin |
| Doripenem |
| Doxycycline |
| Eravacycline |
| Erithromycin |
| Ertapenem |
| Gatifloxacin |
| Gentamicin |
| Imipenem |
| Imipenem/Relebactam |
| Lefamulin |
| Levofloxacin |
| Linezolid |
| Meropenem |
| Meropenem/Vaborbactam |
| Metronidazole |
| Minocycline |
| Moxifloxacin |
| Nafcillin |
| Omadacycline |
| Oritavancin |
| Oseltamivir |
| Oxacillin |
| Penicillin |
| Peramivir |
| Piperacillin  |
| Piperacillin-tazobactam |
| Plazomicin |
| Polymyxin B |
| Tedizolid |
| Telavancin |
| Telithromycin |
| Tetracycline |
| Ticarcillin |
| Tigecycline |
| Tobramycin |
| Trimethoprim-sulfamethoxazole |
| Vancomycin - IV only |

New antibiotic criteria: We have two scenarios:

1. We require new antibiotics started on the first day of respiratory deterioration or the day following respiratory deterioration and continued for at least 3 calendar days. First day of new antibiotics must be on hospital day 3 or greater.
2. New antibiotics started and continued for 1 or 2 days is also acceptable if the patient dies on the day after the second day of respiratory deterioration. Different scenarios for timing of antibiotic start and date of death are:
	* + 1. If day of death is on second day of impaired oxygenation then 2 days of antibiotics acceptable if antibiotics were stared on the first day of impaired oxygenation; 1 day of antibiotics acceptable if antibiotics were started on the second day of impaired oxygenation.
			2. If day of death is on the third day after the first day of impaired oxygenation then 2 days of antibiotics acceptable if antibiotics were stared on the first day of impaired oxygenation; 1 day of antibiotics acceptable if antibiotics were started on the second day of impaired oxygenation.
			3. If day of death is on the fourth day after the first day of impaired oxygenation then at least 3 days of antibiotics required if antibiotics were stared on the first day of impaired oxygenation; 2 days of antibiotics acceptable if antibiotics were started on the second day of impaired oxygenation.

Data definitions were programmed in SAS, NV-HAP Surveillance Definitions and statistical code, (2022), GitHub repository, <https://github.com/charlespwd/project-title>

**e-Appendix 2: Consensus chart review guide**

**NV-HAP Surveillance Tool Manual Chart Validation**

**DATA COLLECTION FORM INSTRUCTIONS**

(Updated 06/07/2021 MAC)

General Information:

Thank you for serving as an expert reviewer for our study. This document provides a general overview of the goals of chart review and specific instructions. Please contact Sarah Stern at Sarah.Stern1@va.gov with any questions.

We will randomly select a representative sample of 250 NV-HAP surveillance events (determined by electronic surveillance program in SQL) amongst VA patients between 1/1/2015-Present. The database associated with the form will be pre-populated with *structured* data for each instance. Reviewers will use the VA’s national user interface for EHRs ([CAPRI](https://www.va.gov/vdl/application.asp?appid=133), https://www.va.gov/vdl/application.asp?appid=133) to access charts from across the nation. Reviewers will use a standardized data collection tool in Microsoft Access record *unstructured* information about each case. The following information will be abstracted by reviewers:

1. Presence of *unstructured* features included in the CDC-NHSN PNEU criteria (Box 1)
2. Presence of *unstructured features* included in the NVHAP event criteria (Box 2)
3. Presence of assertion of pneumonia per treating clinician documentation within 2 calendar days of index date.
4. The treating clinician’s perceptions (Including: admission diagnosis, presence of a clinical deterioration, clinician recognition of a deterioration, perceived cause, and presence of pneumonia in discharge diagnoses)
5. Reviewers’ assessment of the cause of clinical deterioration and whether or not NVHAP was present

**Box 2 ­– NVHAP Surveillance Event Definition**

See “Definition 7” from Ji et al [JAMA Network Open, (2019), e1913674, 2(10)](https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2753253). Item 1 (deoxygenation) is used to identify a possible candidate event and date (NVHAP Day 1). Items 2 – 4 must occur within 2 days (NVHAP Day 1 – 2). Items 1 – 4 required.

1. Deoxygenation sustained for ≥2 days. Defined as *any* of:
	1. Drop in saturations from ≥95% on ambient air to <95% on ambient air
	2. Initiation of supplemental oxygen
	3. Escalation of supplemental oxygen (increase in flow rate or device: RA < NC < facemask < HFNC/non-invasive mechanical ventilation [BiPAP] < mechanical ventilation)
2. Fever (>38.0°C or >100.4°F) **OR** Leukopenia (≤4000 WBC/mm3 ) **OR** Leukocytosis (≥12,000 WBC/mm3 )
3. Initiation of new antibiotics that were not given in the previous 2 calendar days
4. Chest imaging obtained (CXR or CT scan)

**Box 1 ­– CDC-NHSN PNEU Criteria**

See [NHSN Patient Safety Component Manual Ch. 6 Table 1 (pdf page 94)](https://www.cdc.gov/nhsn/pdfs/pscmanual/pcsmanual_current.pdf) summarized below. Items 1-3 must be present and occur during the specified timeframes.

1. Chest imaging (≥ 2 images within 7 days\*).
	1. Initial qualifying image must occur during the infection window period (IWP)\*\*
	2. Imaging study must demonstrate infiltrate, consolidation, or cavitation that is new and persistent, or new and progressive.\*\*\* [[a]](#_[a]_Guidelines_for)
2. At least *one* of the following (must occur during IWP\*\*)
	1. Fever (>38.0°C or >100.4°F)
	2. Leukopenia (≤4000 WBC/mm3 ) **OR** Leukocytosis (≥12,000 WBC/mm3 )
	3. For adults ≥ 70 years old, altered mental status with no other recognized cause
3. At least *two* of the following (Must occur during NVHAP days 1-2)
	1. New onset of purulent sputum, change in sputum character, increased respiratory secretions, or increased suctioning requirements
	2. New or worsening cough, dyspnea, or tachypnea (RR>25)
	3. Rales (“crackles”) or bronchial breath sounds (including “rhonchi”)
	4. Worsening gas exchange (see Box 2, item 1)

\* If a patient does **not** have underlying cardiopulmonary disease, then only 1 chest image is required. However, when multiple imaging test results are available during the IWP, persistence of imaging test evidence of pneumonia is a requirement for all patients (even those without underlying cardiopulmonary disease).

\*\* Infection Window Period (IWP): Defined as 7-day window including Index Date and 3 days before and 3 days after Index Date (Table 2 below). CDC-PNEU criteria including the first positive imaging study must occur during this timeframe to meet criteria.

\*\*\* An infiltrate (see [[a]](#_[a]_Guidelines_for) for definition) that is new on earlier image and resolves on later image within 7 days does not qualify for pneumonia.



**Index Date**

Instructions for Chart Review:

|  |  |
| --- | --- |
| **Information Field** | **Instructions for Field Collection** |
| **Step 1:** Open the chart in Capri using site, last name, and last 4 of SSN |
| SiteLast Name, First NameLast4ssnAgeIndex DateAdmit Date,Discharge Date | This information is prepopulated for each case |
| Reviewer | Confirm that the reviewer selected matches your initials |
| Date Reviewed | Enter the date that you (the reviewer) did the review for this particular case |
| **Step 2:** Review notes (filter by date from Admit to Discharge) and fill fields below as you goOpen the clinical documents tab and filter to view notes from Admit date to discharge date - review H&P - review notes from date of event and up to 2 days after (MD > consults > RN > RT > other ) - review discharge summary |
| Admit Dx | Working admit Dx asserted by primary team during 2 day window (hospital day 1 or 2) |
| Pneumonia diagnosed on Admit? | Check box if there is clinical assertion of pneumonia by treating team within 2 calendar days of hospitalization (hospital day 1 or 2) |
| Underlying cardiopulmonary disease | Check box if there is underlying chronic cardiopulmonary disease (e.g. COPD, CHF, ARDS, ILD, lung malignancy, etc.). Do not include comorbidities such as HTN, CAD, asthma that would not produce imaging findings that could mimic pneumonia. |
| Clinical deterioration/ setback present? | Check box if there is evidence of any incident that negatively influences patient’s clinical trajectory associated with index date |
| Symptom onset >2 days from admit | This pertains to symptoms included in CDC/NHSN list of symptoms or that could be clinically related to a diagnosis of pneumonia (ie **not** diarrhea or abdominal pain) |
| Change in sats or device/flow? | Review notes on NVHAP days 1-2 for evidence of any of the following:* 1. Drop in saturations from ≥95% on ambient air to <95% on ambient air
	2. Initiation of supplemental oxygen
	3. Escalation of supplemental oxygen (increase in flow rate or device: Room air < nasal cannula < facemask < high-flow nasal cannula ~ non-invasive mechanical ventilation [BiPAP] < mechanical ventilation)
 |
| Deterioration perceived by clinician? | Did the clinicians assert there was a clinical change (of any kind) |
| Clinician leading dx | What does the clinician attribute the declining oxygenation event to (ex: “pulmonary edema”) |
| Clinician diagnosis of pneumonia | Check box if treating clinician asserts diagnosis of pneumonia within 2 days following index date (NVHAP day 1-2). Do they SAY it, not “were they THINKING it?” |
| Discharge dx pneumonia | check box if pneumonia is listed anywhere in discharge summary regardless of type |
| Clinician perception Summary | Briefly summarize clinician’s thought process in formulating treatment plan. ex: “thought to be pulmonary edema vs HAP” |
| For the following clinical criteria, presence is “yes” if there was an occurrence any time **during NVHAP days 1-2** (event date is NVHAP day 1) |
| Fever | Prepopulated if present during IWP. “yes” if temperature >38.0°C (100.4°F) |
| WBC | Prepopulated if present during IWP. “yes” if WBC ≤4000 or ≥12,000  |
| AMS | check box if there is evidence of altered mental status (regardless of perceived contributing factors) |
| Change in sputum? | Includes new onset or change in character, increased respiratory secretions, or increased suctioning requirements |
| Cough/dyspnea | New onset or worsening cough, dyspnea, or shortness of breath  |
| Abnormal breath sounds | Abnormal lung sounds including Rales, crackles, bronchial breath sounds, rhonchi. Exampl words that DO NOT count include “diminished” or “coarse”.  |
| Tachypnea (RR>25) | Prepopulated if present during IWP. “yes” if respiratory rate was >25 in vitals |
| New/change in antibiotics | Prepopulated. “yes” if there was initiation of or change in antibiotics during NVHAP days 1-2 that was not given during the previous 2 calendar days\* If unclear: go to the Meds tab, click Med Admin History (BCMA), right click to search by date range, search 2 days prior to index date and 3 days including/after index date (NVHAP days -2, -1, 1, 2, and 3) for evidence of new antibiotics or a change in antibiotics on NVHAP days 1-2.  |
| **Step 3:** Review imaging reports- review chest imaging on NVHAP day 1 and 3 days before and after (NVHAP days -3, -2,-1, **1**, 2, 3, 4). The “infection window period”. - if an infiltrate is identified, review chest imaging up to 7 days after the first positive image for evidence of resolution |
| Chest Imaging Obtained? | Click box if there was *any* type of chest imaging (Chest X-Ray or CT Chest) on NVHAP days -3 to +4 |
| 2+ images obtained? | Click box if there were Two or more POSITIVE serial chest imaging results Within 7 days, starting at the first day of chest imaging within the infection window period. Note that if the initial image was POSITIVE and subsequent images note that the finding was improved but not resolved, that this still counts as a POSITIVE follow-up imaging study. |
| Chest imaging result | Select the appropriate image interpretation by the clinical team (either in clinical notes OR in radiology report. * If clinical team asserts infiltrate present but radiology report does not, this counts as an infiltrate).
* Options: “no infiltrate";"new & persistent/progressive infiltrate";"new infiltrate no comparison";"old infiltrate"; “infiltrate that resolved”

**[a] Guidelines for reports to qualify for “infiltrate”:**1. First review the findings [NOT the indication] and look for any note of the following (Must have at least 1)
	* Airspace disease
	* Bronchogram, Bronchopneumonia
	* Consolidation, Consolidative process
	* Density
	* Increased interstitial markings, Increased lung markings
	* Infiltrate, Infiltration, Infiltrative process, Positive infiltrate
	* Inflammation, Inflammatory process
	* Interstitial pneumonia, Interstitial process
	* Haziness
	* Opacity, Opacification
	* Patchiness
	* Pneumonitis
	* Reticulonodular pattern
2. Review the impression for any mention of pneumonia OR infection

Interpretation: “Positive” for infiltrate IF* There is ANY mention of pneumonia or infection
* OR There is at least 1 finding in (1) AND no alternative explanation

Positive examples: * Findings list “consolidation” and Impression includes “possible pneumonia”
* Findings list “interstitial markings” but impression not given
* Findings list “haziness” and impression lists “atelectasis, cannot rule out infectious process”

Negative examples:* Findings list “interstitial markings” and impression lists “consistent with pulmonary edema”
 |
| **Step 4:** Determine whether criteria was met |
| CDC PNEU? | Use CDC PNEU criteria met (Box 1 adaptation). Must meet all of items 1 - 41. Chest imaging Obtained AND New & progressive/persistent infiltrate
2. 2+ images IF Underlying Cardiopulmonary dx
3. At least *one* of the following
	1. Fever
	2. WBC
	3. AMS AND Age > 70
4. At least *two* of the following (a – d)
	1. Change in Sputum
	2. Cough/dyspnea OR tachypnea (RR>25)
	3. Abnormal breath sounds
	4. Change in sats/device/flow
 |
| NVHAP candidate definition (def7) met? | Use NVHAP Surveillance Event Definition (Box 1). Must meet all 4 criteria during NVHAP days 1-2 (named fields must be ticked):1. Change in sats/device/flow
2. Fever OR WBC
3. New/change in Abx
4. Chest Imaging Obtained
 |
| **Step 5:** Reviewers assessment |
| NVHAP per Reviewer? | Select from "No";"Possible";"Probable" |
| Reviewer leading diagnosis | Diagnosis that reviewer thinks is responsible for change in patient’s clinical status |
| Reviewer narrative | Briefly summarize pertinent events of hospitalization, can include details of pertinent studies and treatments and clinical course |
| Bonus: assess whether the patient was intubated or not in relation to the event |
| Intubated <= 2 days pre/post index date? | Check box if patient was intubated during 2 day window including day prior to index date, index date, and day following index date (NVHAP days -1, 1, 2) |
| Vent Start Date | Enter ventilator start date |
| Vent Stop Date | Enter date of first extubation after initiation of this intubation |
| Vent Narrative | Free text any additional pertinent ventilator narrative |