An APIC Guide

2009

Guide to the Elimination of Ventilator-Associated Pneumonia

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Financial Support for the Distribution of this Guide Provided by Smiths Medical in the Form of an Unrestricted Educational Grant

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ISBN: 1-933013-43-5

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Conflict of Interest

Authors and reviewers of this Guide were asked to complete an APIC Conflict-of-Interest Disclosure Statement.

Linda R. Greene, RN, MPS, CIC has nothing to disclose.

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Michelle R. Farber, RN, CIC has nothing to disclose.

Robert A. Garcia, BS, MT(ASCP), CIC has nothing to disclose.

Teresa M. Fulton, RN, MSN, CIC, CNLCP serves on I-Flow corporate speakers bureau.

Guide Overview

The purpose of this guide is to provide evidence-based practice guidelines for the elimination of ventilator-associated pneumonia (VAP).

Pneumonia accounts for approximately 11% to 15% of all hospital-associated infections (HAIs) and 27% and 24% of all infections acquired in the medical intensive care unit (MICU) and coronary care unit (CCU), respectively.[1] The primary risk factor for the development of hospital-associated bacterial pneumonia is mechanical ventilation (with its requisite endotracheal intubation). Rates of VAP vary depending on the type of ICU, and may range from zero to 16 per 1000 ventilator days. Highest rates were identified in trauma ICUs, as reported in the 2008 National Healthcare Safety Network (NHSN) report.[2]

The VAP Infection Prevention and Control Program

An effective facility-wide infection prevention and control program is comprised of many components and interventions that can reduce the risk of VAP in acutely ill patients. This guide will provide strategies and tools that can be used for VAP prevention. Recent quality improvement initiatives suggest that many cases of VAP might be prevented by careful attention to the process of care. The successful management of patients on ventilators is necessary to ensure the best possible outcomes for individual patients while reducing the morbidity and mortality associated with these infections.

Components of a Successful Program

Accountability for VAP prevention activities is outlined in the *2008 Strategies to Prevent Ventilator-Associated Pneumonia in Acute Care Hospitals* and is outlined here.[3]

1. The hospital's chief executive officer and senior management are responsible for ensuring that the healthcare system supports an infection prevention and control program to effectively prevent VAP.
2. Senior management is accountable for ensuring that an adequate number of trained personnel are assigned to the infection prevention and control program.
3. Senior management is accountable for ensuring that healthcare personnel, including licensed and nonlicensed personnel, are competent to perform their job responsibilities.
4. Direct healthcare providers (e.g., physicians, nurses, aides, and therapists) and ancillary personnel (e.g., environmental services and equipment processing personnel) are responsible for ensuring that appropriate infection prevention and control practices are used at all times (including hand hygiene, standard and transmission-based or expanded precautions, cleaning and disinfection of equipment and the environment, aseptic technique when suctioning secretions and handling respiratory therapy equipment, patient positioning, sedation and weaning protocols, and oral care).
5. Hospital and unit leaders are responsible for ensuring that personnel are accountable for their actions.
6. The person who manages the infection prevention and control program is responsible for ensuring that an active program to identify VAP is implemented, that data on VAP are analyzed and regularly provided to those who can use the information to improve the quality of care (e.g., unit staff, clinicians, and hospital administrators), and that evidence-based practices are incorporated into the program.
7. Healthcare personnel are accountable for ensuring that appropriate training and educational programs to prevent VAP are developed and provided to medical staff, patients, and families.

The role of the infection preventionist in the effort to reduce the incidence of VAP includes policy and best practice subject matter expertise, provision of surveillance data and risk assessment, consultation on infection prevention interventions, and facilitation of VAP-related improvement projects. It is important that the infection preventionist communicates and networks with all members of the patient care team regarding VAP-related infection prevention. Providing subject matter expertise to those involved with clinical management of the patients, including physicians, physician assistants, and nurse practitioners, is essential. An understanding of the elements of surveillance definitions compared with clinical definitions is important. Anesthesiologists, respiratory care, hospitalists, emergency department physicians, and medical residents are examples of individuals involved in intubation. Nursing staff and other members of the healthcare team are responsible for care of the patient on a ventilator. Therefore, success of a prevention project requires that these personnel are fully engaged and committed to this important patient safety initiative. Obtaining the resources that will engage direct care providers in the VAP quality/performance improvement activities is a critical component of intervention development. Key players must be held accountable for compliance with the prevention strategies and interventions. This can be facilitated through monitoring and reporting of the results of the intervention on a consistent basis, and instituting additional improvements when appropriate.

Basic Infection Prevention and Antimicrobial Stewardship

Although this guide focuses on infection prevention related to VAP use, it is necessary to look at more global interventions that have an impact on HAIs such as VAP. The basics of infection prevention and control are necessary underpinnings of programs, policies, and protocols that impact HAIs (appropriate hand hygiene, environmental and equipment considerations, compliance with standard and transmission-based precautions, etc.).

One component of HAI prevention deserves added attention in this guide. As highlighted in the Centers for Disease Control and Prevention's (CDC) Campaign to Prevent Antimicrobial Resistance in Healthcare Settings, a program for antimicrobial stewardship in any healthcare setting (acute or long-term care) has potential for positive impact on all HAIs. The combination of effective antimicrobial stewardship with a comprehensive infection control program has been shown to limit the emergence and transmission of antimicrobial-resistant bacteria. A secondary goal of antimicrobial stewardship is to reduce healthcare costs without adversely impacting quality of care.

Antimicrobial stewardship can play a role in minimizing the potential adverse outcomes of these occurrences. Inappropriate choice and utilization of antimicrobials has well documented adverse effects on patients and can lead to development of multidrug resistance in the healthcare setting. Preparing a facility- or unit-based antibiogram can demonstrate the changes in antimicrobial resistance and susceptibility patterns that develop over time, and can be used to track and monitor changes. It should be noted that rates of hospital-acquired pneumonia (HAP) due to multidrug-resistant (MDR) pathogens have increased dramatically in hospitalized patients, especially in ICU and transplant patients. Multidisciplinary development of evidence-based practice guidelines incorporating local microbiology and resistance patterns can improve antimicrobial utilization. Guideline implementation can be facilitated through provider education and feedback on antimicrobial use and patient outcomes.[4]

The CDC/Healthcare Infection Control Practices Advisory Committee (HICPAC) *Management of Multidrug-Resistant Organisms in Healthcare Settings, 2006* (MDRO Guide) recommends that "systems are in place to promote optimal treatment of infections and appropriate antimicrobial use." Protocols for initial empiric therapy have emerged as a potentially effective means of avoiding unnecessary antibiotic administration while increasing the likelihood of initially appropriate therapy. It is beyond the purview of this Guide to explore appropriate empiric and therapeutic antibiotic selections for VAP. However, guidelines from the American Thoracic Society can be accessed online at http://ajrccm.atsjournals.org/cgi/content/full/171/4/388.[5]

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Problem Identification

VAP is associated with increased lengths of ICU and hospital stay, increased mortality rates, and increased costs. In a metaanalysis of research articles published between 1990 and March 1, 2004, morbidity (as evidenced by increased length-of-stay [LOS] in the ICU), mortality, and costs associated with VAP were evaluated. Analysis of LOS reports demonstrated that VAP was associated with a mean increase in ICU length-of-stay of 6.1 days.

The authors reviewed nine reports related to mortality, four of which did not attribute significant mortality to the diagnosis. The remaining five studies reported an excess mortality that varied from 15% to 50% when compared with control cases.[1] Luna et al. reported that mortality rates vary with patient population and infecting organism; mortality increases when the infecting organism is MDR.[2] Other sources report increased mortality associated with untreated or inadequately treated infection. Increased costs associated with VAP were dependent on length-of-stay, with a range of approximately $10,000 to $40,000. Table 3-1 summarizes the findings of several studies that investigated the effects of VAP on morbidity, mortality, and/or cost.

Findings from other studies include variability of mortality rates associated with HAP, due to underlying disease and etiology. Mortality attributed to HAP is highly dependent on the institution of appropriate antibiotic therapy, virulence of pathogen, and host defenses, with case fatality rates being highest in mechanically ventilated patients with high severity of illness and infection caused by nonfermentative Gram-negative bacilli.[3,4] Additionally, HAP attributable to MDR microorganisms was significantly associated with mortality.[5]

Table 3-1. Studies Investigating the Effect of VAP on Morbidity, Mortality, and Cost

Publication Date	Investigator	Study	Number of Patients with VAP	Effect of VAP on Morbidity	Effect of VAP on Mortality	Cost Associated with VAP	Comment
2008	Brilli et al.[6]	The business case for preventing VAP in pediatric intensive care unit patients	13 (retrospective matched case-control study)	↑ mean hospital LOS; mean attributable ↑ in LOS due to VAP 8.7 days	Not studied	$51,157 (attributable VAP costs)	
2005	Kollef et al.[7]	Epidemiology and outcomes of HAP: results from a large U.S. database of culture-positive pneumonia	499 (retrospective matched cohort study)	↑ LOS	29.3%	$150,841 (mean hospital charge)	Study compared community-acquired pneumonia (CAP), healthcare-associated pneumonia (HCAP), HAP, and VAP
2005	Cocanour et al.[8]	Cost of a VAP in a shock trauma ICU	70 (case control study)	↑ ventilator days and ICU LOS		$57,000 (excess hospital cost)	
2005	Safdar et al.[1]	Clinical and economic consequence of VAP	Not applicable	Significantly longer ICU LOS	Mortality rate doubled in patients with VAP	$13,647 (estimated attributable VAP cost, using upper limit of LOS)	

Publication Date	Investigator	Study	Number of Patients with VAP	Effect of VAP on Morbidity	Effect of VAP on Mortality	Cost Associated with VAP	Comment
2003	Warren et al.[3]	Outcome and attributable cost of VAP among ICU patients in a suburban medical center	819 (prospective cost analysis)	↑ incidence of sepsis, ICU LOS, hospital LOS	↑ mortality	$11,897 (attributable cost of VAP)	
2002	Rello et al.[4]	Epidemiology and outcomes of VAP in a large U.S. database	842 (retrospective matched cohort study)	↑ duration of mechanical ventilation, ICU LOS, total hospital LOS	No significant difference	$40,000 (increase in inpatient billed charges)	
2001	Bregeon et al.[5]	Is VAP an independent risk factor for death?	39 (matched-pair case-control study)	Not studied	VAP is not an independent risk for ↑ mortality	Not studied	Renal failure, bone marrow failure, and treatment with corticosteroids were independent risk factors for mortality
2001	Bercault et al.[9]	Mortality rate attributable to ventilator-associated nosocomial pneumonia in an adult ICU	135 (prospective matched, risk-adjusted cohort study)	↑ ICU LOS	↑ mortality risk (absolute risk ↑ 5.8%; relative risk ↑ 32.3%)		
1999	Heyland et al.[10]	The attributable morbidity and mortality of VAP in the critically ill patient	175 (prospective matched cohort study)	↑ ICU LOS (4.3 days)	↑ mortality risk (absolute risk ↑5.8%; relative risk ↑32.3%)	Not studied	Included patients ventilated for ≥48 hours; attributable risk of VAP appears to vary with patient population and infecting organism

Pathogenesis and Epidemiology of VAP

Pneumonia Definitions

Pneumonia is classified as community-acquired (CAP), healthcare-associated (HCAP), HAP, or VAP. VAP is a sub-classification of HAP, if the patient is hospitalized during the period of mechanical ventilation. CAP is defined as pneumonia for which the first positive bacterial culture is obtained within 48 hours of admission to the hospital and the patient does not have risk factors for HAP. HCAP occurs when the patient's first positive bacterial culture is obtained within 48 hours of admission and the patient has any of the following risk factors: admission source indicates a transfer from another healthcare facility; patient has received hemodialysis, wound, or infusion therapy as an outpatient; patient was previously hospitalized for at least 3 days within the past 90 days prior to current admission; or the patient is immunocompromised due to underlying disease or therapy (HIV, chemotherapy). HAP is pneumonia in which the patient's first positive bacterial culture is obtained more than 48 hours after admission to the hospital.

According to this source, VAP is pneumonia that develops in a mechanically ventilated patient with a first positive bacterial culture beyond 48 hours after hospital admission or tracheal intubation, whichever occurred first.[11] It is noted

that this definition of VAP differs from the NHSN surveillance definition of VAP, as the NHSN definition does not require a 48-hour period of intubation and ventilation before pneumonia can be considered ventilator-associated.

HAP, whether or not associated with mechanical ventilation, is generally a secondary endogenous infection. Although exogenous sources of infectious microorganisms exist, it is typically the patient's own colonizing flora that is implicated in infection.

In the healthy individual, the lower respiratory tract is a sterile site and the body possesses many defense mechanisms to maintain that state. Mechanical barriers, humoral and cell-mediated immunity, and phagocyte activity act to defend against bacterial invasion of lung tissue. Human saliva contains components that demonstrate antimicrobial properties and helps to regulate the composition of oral flora.

Factors that may interfere with the host's defenses and predispose to respiratory infection include alterations in level of consciousness, cigarette smoke, alcohol intake, viral infections, sepsis, endotracheal tubes, nasogastric tubes, respiratory therapy devices, hypoxemia, acidosis, toxic inhalations, pulmonary edema, uremia, malnutrition, immunosuppressive agents, and mechanical obstruction.[12] Inadequate salivary flow in intubated patients causes xerostomia, which may contribute to mucositis and colonization of the oropharynx with Gram-negative bacteria.[13] Advanced age predisposes the individual to development of pneumonia due to a less efficient cough reflex and changes in humoral immunity and cell-mediated immune function. The patient who is immunosuppressed due to disease state or treatment modality is also at increased risk for development of infection.

The intubated patient is often a critically ill individual with many risk factors that contribute to the development of pneumonia. Risk factors for VAP can be classified as modifiable or nonmodifiable, as well as patient-related and treatment-related.

Nonmodifiable risk factors for VAP include male gender, preexisting pulmonary disease, coma, AIDS, head trauma, and multi-organ system failure. Nonmodifiable treatment-related risk factors include neurosurgical procedures, intracranial pressure monitoring, re-intubation, and transportation out of an ICU. Intubation and mechanical ventilation are prerequisites for the diagnosis of VAP. Modifiable risk factors include duration of ventilation; risk varies over time, being greatest early in the ventilator period and decreasing as ventilator LOS progresses. Nasotracheal intubation is associated with the development of sinusitis and should be avoided. Supine position is also associated with an increased risk of VAP, especially in the presence of simultaneous enteral feeding. Enteral feeding itself is a risk factor for VAP, mainly due to an increased risk of aspiration. But, because the alternative, parenteral nutrition, is associated with even greater risk (of bloodstream infection), it is advised to feed critically ill patients enterally as early as possible.[14–16] Oropharyngeal colonization has been identified as a risk factor for the development of VAP. Evidence indicates that the oropharynx acts as a reservoir for bacteria that are subsequently aspirated into the lower respiratory tract. Colonization of the oropharynx progresses rapidly in ICU patients and occurs more frequently in patients who go on to develop VAP. Additionally, bacteria in dental plaque act as a major contributor to infection of the respiratory tract. Stress ulcer prophylaxis, in the form of H2-antagonists and antacids, has been recognized as a risk factor for VAP. Some studies indicate that prior antibiotic therapy is a risk factor for VAP, and antibiotics predispose patients to colonization and subsequent infection with antibiotic-resistant organisms.[17–20]

VAP is divided into early- and late-onset disease. Early-onset VAP occurs during the first 4 days of the patient's admission and is often caused by *Streptococcus pneumonia*, *Haemophilus influenza*, or *Moraxella catarrhalis*. By comparison, late-onset VAP occurs beyond 4 days after admission and is more commonly caused by *Pseudomonas aeruginosa, Acinetobacter* or *Enterobacter* spp., or methicillin-resistant *Staphylococcus aureus* (MRSA). Many of the organisms associated with late-onset VAP are resistant to multiple antibiotics or have MDR strains. *Staphylococcus aureus* is isolated in 20% to 40% of cases and is especially common in persons taking drugs by injection; in patients with neurological

Table 3-2. Host Defenses (Pulmonary)

Location	Defense Mechanism
Upper Airways	
Nasopharynx	Nasal hair Turbinates Upper airway anatomy Mucociliary apparatus IgA secretion
Oropharynx	Saliva Sloughing of epithelial cells Bacterial interference Complement production
Conducting Airways	
Trachea, bronchii	Coughing, epiglottic reflexes Airway branching Mucociliary apparatus Immunoglobulin production Airway surface liquid
Lower Airways	
Terminal airways, alveoli	Alveolar lining fluid Cytokines Alveolar macrophages Polymorphonuclear leukocytes Cell-mediated immunity

(From Breese Hall C, Mcbride J. Bronchiolitis. In Mandell G, Bennett J, Dolin R, eds. *Principles and Practice of Infectious Diseases.* Philadelphia: Churchill Livingstone, 2005:820.)

disease, thermal injury, or wound infection; and in patients who have received prior antibiotic therapy or have had a prolonged stay in the ICU. Compared with patients with VAP caused by methicillin-susceptible *Staphylococcus aureus* (MSSA), those in whom the causative organism is MRSA are often older and are significantly more likely to have had previous chronic lung disease, antibiotic therapy, steroid therapy, and greater than 6 days of mechanical ventilation.

Bacteremia, shock, and mortality are usually higher in the MRSA group. In many patients, VAP is caused by multiple organisms (polymicrobial). Aerobic Gram-negative bacilli, including *Escherichia coli*, *Klebsiella pneumonia*, *Enterobacter* spp., *Serratia* spp., *Pseudomonas aeruginosa*, and *Acinetobacter* spp., are most frequently isolated, particularly in patients with late-onset disease or those with serious underlying disease.[21,22] According to the NHSN's annual summary[23] of resistant pathogens associated with HAIs, the following organisms were identified as causing VAP (in order of most to least frequent with percentage of isolates in parentheses):

Staphylococcus aureus (24.4%)
Pseudomonas aeruginosa (16.3%)
Enterobacter spp. (8.4%)
Acinetobacter baumannii (8.4%)
Klebsiella pneumonia (7.5%)
Escherichia coli (4.6%)
Candida spp. (2.7%)
Klebsiella oxytoca (2.2%)
Coagulase-negative *Staphylococcus* (1.3%)

Other unspecified organisms accounted for 23.1% of causative organisms (see Table 3-3). The epidemiology and pathogenesis of VAP is changing as hospitalized patients are now older and have more comorbidities, immune system dysfunction, invasive procedures, and exposure to antibiotics. Patients are more mobile and more likely to reside in short- and long-term care facilities, increasing their potential for colonization, person-to-person transmission, and infection with MDR pathogens.

Summary of epidemiologic and pathogenic points.[15,24]

- The incidence of VAP is 3- to 10-fold greater than pneumonia in nonventilated patients.
- VAP occurs in 8% to 28% of patients undergoing mechanical ventilation.
- In the healthy individual, the lower respiratory tract is a sterile body site.
- The body possesses several defense mechanisms to prevent contamination of the lungs.
- Disease processes, treatment modalities and personal habits or practices (i.e., cigarette smoke, alcohol intake) can impair the body's natural defense mechanisms, predisposing the individual to lower respiratory infection.
- Mechanical ventilation is the primary risk factor for development of VAP for several reasons:
  - The endotracheal tube itself acts as a conduit from the upper respiratory tract to the lower respiratory tract.
  - Secretions collect on and around the endotracheal cuff; leakage of this fluid is the primary mechanism of infection of the lower respiratory tract.
  - Sedation of patients who are mechanically ventilated inhibits the natural ability to clear secretions.
  - Patients undergoing mechanical ventilation are frequently fed via the nasogastric route, providing a source of fluid for aspiration and micro-aspiration.
  - Critically ill patients, especially those who are unstable with regard to neurologic or cardiac status, are often maintained in a supine position.
  - Activity is frequently limited during the period of mechanical ventilation.
- VAP risk is greatest early on in ventilation, and diminishes over time.
- VAP is frequently bacteriological in origin, especially in the immunocompromised patient.
- Colonization of the oropharynx and dental surfaces act as a reservoir of bacteria that ultimately gain access to the lower respiratory tract in patients undergoing mechanical ventilation.

Table 3-3. Organisms Associated with VAP

Early-Onset VAP (within first 4 days of admission)	**Late-Onset VAP (after day 4)**	**CDC NHSN 2006–2007 Summary Data**
Streptococcus pneumonia	*Pseudomonas aeruginosa*	*Staphylococcus aureus* (24.4%)
Haemophilus influenza	*Acinetobacter* spp.	*Pseudomonas aeruginosa* (16.3%)
Moraxella catarrhalis	*Enterobacter* spp.	*Enterobacter* spp. (8.4%)
	Methicillin-resistant *Staphylococcus aureus*	*Acinetobacter baumannii* (8.4%)
		Klebsiella pneumonia (7.5%)
		Escherichia coli (4.6%)
		Candida spp. (2.7%)
		Klebsiella oxytoca (2.2%)
		Coagulase-negative *Staphylococcus* (1.3%)
		Other (23.1%)

- Sources of pathogens for HAP include healthcare devices, the environment (air, water, equipment, and fomites), and commonly the transfer of microorganisms between the patient and staff or other patients, most frequently via the hands of healthcare workers. Nevertheless, most HAP is considered to be a secondary endogenous infection (resulting from the patient's own colonizing flora).
- Rates of *Legionella pneumophila* pneumonia vary considerably among hospitals, and disease occurs more commonly with serogroup 1 when the water supply is colonized or there is ongoing construction.
- Inhalation or direct inoculation of pathogens into the lower airway, hematogenous spread from infected intravenous catheters or other infectious sites, and bacterial translocation from the gastrointestinal tract lumen are uncommon pathogenic mechanisms.
- Infected biofilm in the endotracheal tube with subsequent embolization to distal airways may be important in the pathogenesis of VAP.
- The stomach and sinuses may be potential reservoirs of hospital-acquired pathogens that contribute to bacterial colonization of the oropharynx, but their contribution is controversial, may vary by the population at risk, and may be decreasing with the changing pathogenesis of HAP.
- VAP is divided into early- and late-onset illness:
  - Early-onset VAP is typically caused by antibiotic-susceptible bacteria, including *Streptococcus pneumonia, Haemophilus influenza,* and *Moraxella catarrhalis*.
  - Late-onset VAP is more likely to be caused by antibiotic-resistant bacteria, including *Pseudomonas aeruginosa, Acinetobacter* spp., *Enterobacter* spp., and MRSA.
  - Early-onset VAP that occurs in patients who have had healthcare exposure (treatment in a dialysis or wound care center, hospital admission of more than 3 days in the past 90 days, or residence in a long-term care facility) is more likely to follow the microbiological pattern of late-onset VAP.
- The prevalence of MDR pathogens varies by patient population, hospital, and type of ICU, which emphasizes the need for local surveillance data.
- Rates of polymicrobial VAP are especially high in patients with acute respiratory distress syndrome (ARDS).
- In the immunocompromised patient, infection with viral or fungal agents is more common than in the patient whose immune status is competent.

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Surveillance Definitions

The definition of VAP is often a subject of controversy and may be the most subjective of all the device-associated infection definitions. It is important for the infection preventionist to note that there is a distinction between clinical and surveillance definitions. The clinical diagnosis of VAP is often made when the patient has a new or progressive lung infiltrate plus at least two of the following three criteria: fever, purulent sputum, or leukocytosis. For surveillance purposes, most hospital epidemiologists and infection preventionists use the VAP definition published by the NHSN. The NHSN surveillance definition utilizes three categories of criteria, including clinical, radiological, and microbiological data when indicated. The use of this standardized surveillance definition enables the organization to utilize data for comparative purposes. However, despite the use of a common definition, significant inter-observer variability has been noted. Helping clinicians understand that differences exist between clinical and surveillance definitions is an important step in engaging members of the healthcare team in VAP prevention improvement plans.[1–3]

NHSN Definitions of VAP

NHSN definitions utilize three specific types of pneumonia: clinically defined pneumonia (PNU1), pneumonia with specific laboratory findings (PNU2), and pneumonia in immunocompromised patients (PNU3). Listed in the following text are general comments applicable to all specific types of pneumonia, along with abbreviations used in the algorithms.

The NHSN definitions can be found online at: http://www.cdc.gov/nhsn/PDFs/pscManual/6pscVAPcurrent.pdf. Figure 4-1 summarizes the definitions.

The NHSN reviews comments on VAP and has followed comments on the APIC Listserv. Clarification of the definition was provided in the May 2007 NHSN newsletter, found online at http://www.cdc.gov/ncidod/dhqp/nhsn_newsletters.html.

A pneumonia should be considered an HA-VAP if it is the result of "aspiration during or near the time of intubation." The authors noted that the CDC has been clear on this subject since National Nosocomial Infections Surveillance System (NNIS)/NHSN began collecting data using the revised pneumonia criteria in January 2002. Pneumonia due to intubation should be evaluated in order to develop preventative strategies and is considered an HAI.

The following questions and answers are posted in response to participants in a quality improvement project in New York State; available online at: http://jeny.ipro.org/showthread.php?t=2025.

VAP Prevention (VAPP) Project FAQs

Question I: If the patient is intubated pre-admission, how should we determine the VAP?

If the patient was symptom-free at the time of the intubation by the paramedic or emergency department and meets the NHSN criteria/algorithm for VAP, it is a positive device-associated pneumonia. However, if the patient was intubated and received care at another hospital and subsequently transferred to your facility, then you need to apply the 48-hour rule. Only pneumonias appearing 48 hours post-admission would be considered a VAP.

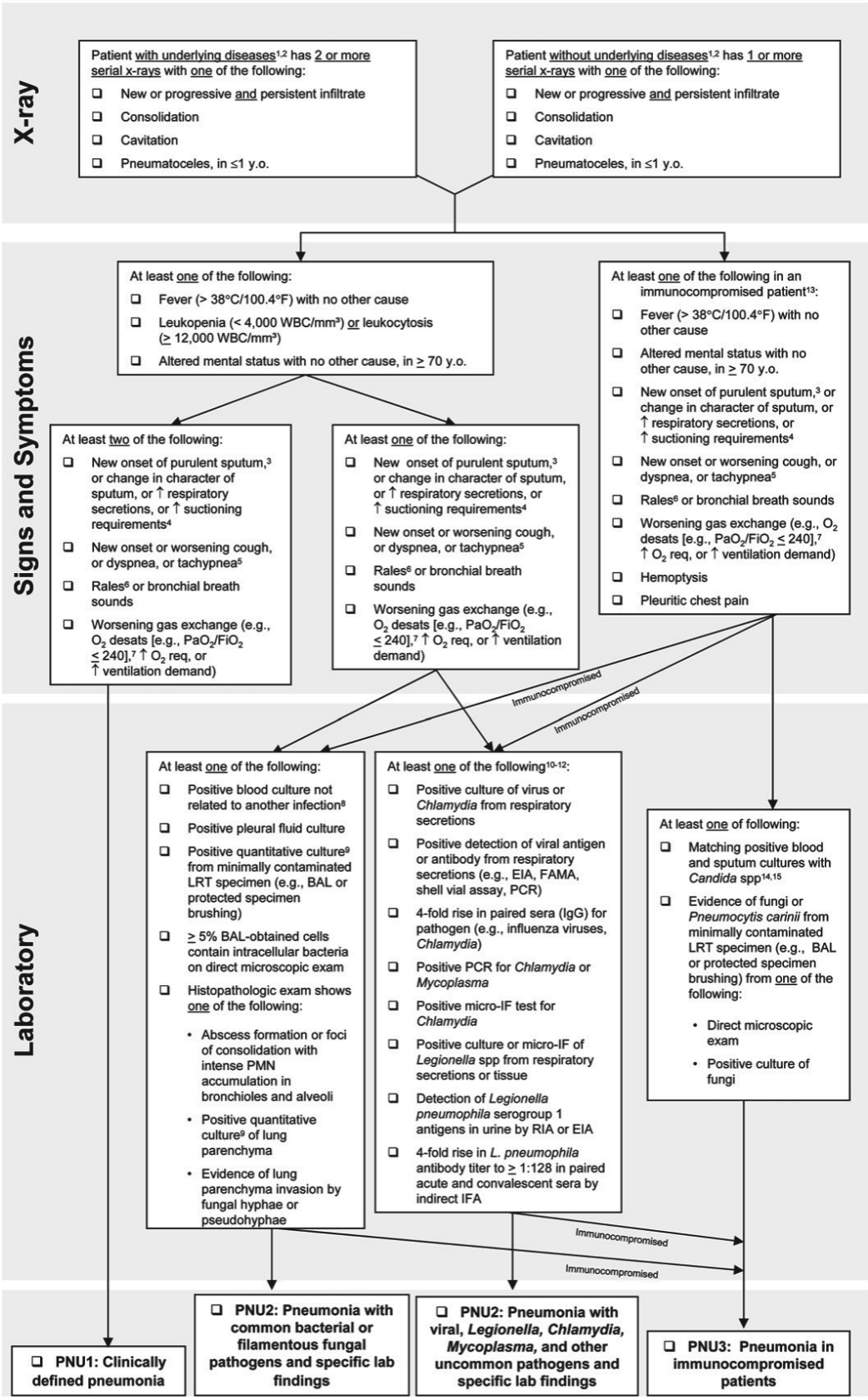

Figure 4-1. Pneumonia flow diagram. (From CDC/NHSN Manual, March 2009.)

Question II: If a VAP occurs within 48 hours of intubation, is it considered hospital-acquired?

Yes, the development of a VAP can occur within 48 hours of intubation.

Question III: What is the minimum time frame?

There is no minimum period of time that the ventilator must be in place in order for the pneumonia to be ventilator-associated except for the transferred patient in example in Question I.

Question IV: Do we call it a VAP if the patient aspirated on intubation?

If the patient was symptom-free and had obvious aspiration at the time of the intubation, it is a hospital-associated event. If the patient met VAP criteria, the answer is yes.

Question V: What is the definition of a VAP?

It is a pneumonia that occurs in a patient who was intubated *and* ventilated at the time of, or within 48 hours before, the onset of pneumonia.

Question VI: I rarely have a VAP defined as a PNU2 or PNU3. What am I doing wrong?

You are not doing anything wrong. In general, the majority of VAPs identified through surveillance fall into PNU1. This is because most VAPs are clinically diagnosed without specific lab findings to confirm the exact etiology that would place them into the PNU2 category.

Question VII: Why do we use PNU1, PNU2, and PNU3?

PNU1 is the domain where all "clinically" defined pneumonias are tracked; clinically defined meaning the use of chest x-rays along with the patient's signs and symptoms. PNU2 tracks the pneumonias with specific lab confirmation (positive blood or pleural cultures, quantitative cultures, polymerase chain reaction, antibodies, etc.) and PNU3 tracks the pneumonias in immunocompromised patients.

Question VIII: Is it correct that the first step is a chest x-ray finding?

Correct. You are looking for a new or progressive and persistent infiltrate, consolidation, cavitation, or pneumatoceles. The other clarification comes with determining if the patient is with or without underlying disease. If the patient does not have underlying disease, one or more serial x-rays with one of the findings is enough. If the patient does have underlying disease, two or more serial x-rays with findings are necessary.

In patients with pulmonary or cardiac disease, the diagnosis of pneumonia may be difficult. Again, in these difficult cases with underlying disease, serial chest x-rays must be examined to help separate infectious from noninfectious causes (e.g., pulmonary edema).

Other helpful tips:

- Pneumonia has a rapid onset and progression but it does not resolve quickly.
- X-ray changes related to pneumonia can persist for several weeks.
- If the x-ray changes resolve quickly, it suggests that the patient does not have pneumonia, but rather a noninfectious process.

Question IX: Since radiologists frequently will not put a diagnosis on x-rays, should we provide education?

It is always important to provide all members of the clinical team with information and education on clinical care requirements, practices, and information. However, radiologists do not diagnose. They usually do not know the patient and may have limited history of that patient. Their focus is on thoroughly analyzing and describing the x-ray findings. It is the attending physician's responsibility, frequently in conjunction with other providers, to make the determination based on the x-ray report in conjunction with the history, physical assessment, and other findings.

Other helpful tips:

In addition to infiltration, consolidation, cavitation, and pneumatocele ≤1 year, the following other x-rays descriptions can also be indicative of pneumonia:

- Focal opacification
- Patchy density
- Air space disease

There is no minimum period of time that the ventilator must be in place in order for the pneumonia to be considered ventilator-associated. The definition includes patients who are intubated and ventilated at the time of, or within 48 hours before, the onset of pneumonia.

1. Physician diagnosis of pneumonia alone is not an acceptable criterion for HCAP.
2. Although specific criteria are included for infants and children, pediatric patients may meet any of the other pneumonia specific site criteria.
3. VAP (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 among 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 among 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 HCAP in the elderly, infants, and immunocompromised patients because 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 HCAP. (See Fig. 4-1 and http://www.cdc.gov/ncidod/dhqp/nhsn_newsletters.html.)
5. HCAP can be characterized by its onset: early or late. Early-onset pneumonia occurs during the first 4 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 MRSA. Viruses (e.g., influenza A and B or respiratory syncytial virus) can cause early- and late-onset nosocomial pneumonia, whereas yeasts, fungi, legionellae, and *Pneumocystis carinii* are usually pathogens of late-onset pneumonia.
6. Pneumonia due to gross aspiration (e.g., in the setting of intubation in the 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 HCAP may occur in critically ill patients with lengthy hospital stays. When determining whether to report multiple episodes of HCAP 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 HCAP.

References

[1] Horan TC, Andrus M, Duceck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008;35:309–332.

[2] Centers for Disease Control and Prevention. Outline for healthcare-associated infection surveillance. Available online at http://www.cdc.gov/ncidod/dhqp/nhsn_documents.html and http://www.cdc.gov/ncidod/dhqp/pdf/nhsn/OutlineForHAISurveillance.pdf. Accessed April 13, 2009.

[3] Centers for Disease Control and Prevention. NHSN manual: Patient safety component protocols. Available online at http://www.cdc.gov/ncidod/dhqp/nhsn_documents.html and http://www.cdc.gov/ncidod/dhqp/pdf/nhsn/NHSN_Manual_PatientSafetyProtocol_CURRENT.pdf. Accessed April 13, 2009.

Risk Assessment

In order to focus surveillance efforts, it is important to conduct a risk assessment for VAP. The purpose of performing an infection control risk assessment (ICRA) is to guide the development of a surveillance, prevention, and control program plan that is based on ICU-specific or specialty unit-specific data. To develop a VAP risk assessment, the following elements must be available:

- Historical data from the ICU or specialty areas
- Demographics of the patient population
- Results of monitoring or other quality improvement activities

Baseline VAP Risk Assessment

Surveillance performed for the VAP risk assessment provides the information needed to identify whether VAP is increasing, decreasing, or remaining the same in an ICU, on a designated specialty unit, in a clinical service, or in an otherwise defined population. Processes used to capture the data must be standardized so that statistical evaluation is relevant and comparative over time. When facilities utilize the NHSN definition, it is important that the definition be applied consistently over time. Facilities that utilize the NHSN definition may evaluate their performance based on comparative data that are available online at http://www.cdc.gov/ncidod/dhqp/pdf/nhsn/2008NHSNReport.pdf.

Also note that NHSN-defined VAP is not comparable to data mined from administrative data.

Conducting the VAP Risk Assessment

The following steps outline tips for conducting a VAP risk assessment and may be helpful for organizations.

I. Assess compliance with patient care practices

1. Does the organization routinely collect data on process measures related to VAP? Process measures may include: • *Hand hygiene compliance* • *Sedation interruption* • *Assessment of readiness to wean* • *Maintenance of semirecumbent positioning* • *Oral care*	Yes	No
2. If so, do the results of these data demonstrate compliance to recommended practices?	Yes	No
3. Are results of the measures reported to senior leadership, nursing leadership, and care providers?	Yes	No
4. Are there written policies, protocols, or pathways that describe the recommended practices for prevention of VAP?	Yes	No

If there are no data to demonstrate adherence to patient care practices, the following process measures may be helpful. These process measures have been recommended in Coffin S et al.[1]

It is important to emphasize that the responsibility for process monitoring should be part of the clinical leader's responsibilities and should not be the sole responsibility of the infection preventionist.

1) Compliance with hand hygiene guidelines for all clinicians who deliver care to patients undergoing ventilation:

a. Collect hand hygiene data on a sample of healthcare personnel from all disciplines providing hands-on care to patients undergoing ventilation, including physicians, nurses, respiratory therapists, and others who may provide direct care.
b. Identify time frame in which to collect this sample (e.g., weekly, daily for specified period of time).

Preferred measure for hand hygiene compliance

I. Numerator: number of observed appropriate hand hygiene episodes performed by healthcare personnel
II. Denominator: number of observed opportunities for hand hygiene
III. Multiply by 100 so that the measure is expressed as a percentage

Example:

Month 2008	Unit	Number of appropriate hand hygiene episodes observed	Number of observed opportunities	Percentage compliance
January	MICU	67	100	67%
February	MICU	68	100	68%
March	MICU	87	100	87%

2) Compliance with daily sedation interruption and assessment of readiness to wean:

Assessment should be performed by chart review of a sample of all patients currently undergoing ventilation. Evidence of daily documentation on the patient's chart, bedside paperwork, or electronic medical record of a sedation interruption and assessment of readiness to wean should be present unless clinically contraindicated. Perform assessments at regular intervals.

Preferred measure of compliance with sedation interruption and assessment of readiness to wean

I. Numerator: number of patients undergoing ventilation with daily documentation of consideration of sedation interruption and assessment of readiness to wean or contraindication
II. Denominator: number of patients undergoing ventilation
III. Multiply by 100 so that the measure is expressed as a percentage

3) Compliance with regular antiseptic oral care (e.g., every 2 to 4 hours, tooth brushing every 6 hours):

Assessment should be performed by chart review of a sample of all patients currently undergoing ventilation. Perform assessments at regular intervals.

Preferred measure of assessment of compliance with antiseptic oral care

I. Numerator: number of patients undergoing ventilation with daily documentation of regular oral care according to product instructions
II. Denominator: number of patients undergoing ventilation
III. Multiply by 100 so that the measure is expressed as a percentage

4) Compliance with semirecumbent positioning for all eligible patients:

Assessment should be performed for all patients currently undergoing ventilation by direct observation of the position of the head of bed. Perform assessments at regular intervals. Exclude patients who are not eligible for semirecumbent positioning (e.g., select neurosurgery patients, increased intracranial pressure, severe hypotension, patients who require Trendelenburg position).

Preferred measure of assessment of semirecumbent positioning compliance

I. Numerator: number of patients undergoing ventilation who are in a semirecumbent position (30- to 45-degree elevation of the head of the bed) at the time of observation
II. Denominator: number of patients undergoing ventilation who are eligible to be in a semirecumbent position
III. Multiply by 100 so that the measure is expressed as a percentage

Overall assessment of patient care processes: Is there an effective organizational program that reflects compliance to recommended practices?

II. Outcome Assessment

Assess baseline outcome data (see section on definitions in previous section).

Step 1. Decide on the time period for your analysis. It may be a month, a quarter, 6 months, a year, or some other period.

Step 2. Select the patient population for analysis; for example, the type of location (MICU, surgical ICU [SICU]).

Step 3. Select the infections to be used in the numerator. They must be site-specific and must have occurred in the selected patient population. Their date of onset must be during the selected time period.

Step 4. Determine the number of device days to be used as the denominator of the rate. Device days are the total number of days of exposure to the ventilator in the selected population during the selected time period.

If information is not available electronically, the collection of denominator data may be facilitated by the respiratory therapy department or clinical staff. The number of patients who are on a ventilator should be collected at the same time each day.

The outcome measure should be stratified by type of ICU. Determine how the rate for that particular ICU or step-down unit relates to comparative data from the NHSN. What percentile is the specific ICU in comparison with NHSN data? Percentiles from organizations that are NHSN members will be automatically reported when VAP rates are generated through the output options menu. Other organizations can compare rates with NHSN data by utilizing the most recent NHSN published data. If NHSN criteria are not used, compare rates over time. *Rates cannot be used for comparison purposes and can only be compared to one's own progress over time*.

Table 5-1. VAP Monitoring Form

VAP MONITORING FORM

STONY BROOK UNIVERSITY MEDICAL CENTER
HEALTHCARE EPIDEMIOLOGY

Patient demographics

Date Admit: Transfer From: Place Intubation: Service:

Date Intubated: Date Extubated:

Date Trached: Date mechanical vent. discontinued:

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ventilator Days																
Purulent Sputum																
Crackles/ Wheezes																
Temperature <37°C = 98.6°F																
Temperature >38.3°C = 101°F																
ET Present E = ET																
T = Trach																
Presence of Inline Suction Cath.																
Use of External Suction Cath.																
Frequency of Suctioning																
External Feeding (specify site)																

Legend: √ = Applicable / Present
0 = Not Applicable / Absent

PRISM

(From Francina Singh, RN, BScN, MPH, CIC, Stony Brook University Medical Center, Stony Brook, NY.)

Table 5-1. VAP Monitoring Form *(continued)*

VAP MONITORING FORM

STONY BROOK UNIVERSITY MEDICAL CENTER
HEALTHCARE EPIDEMIOLOGY

Patient demographics

Date Admit: Transfer From: Place Intubation: Service:

Date Intubated: Date Extubated:

Date Trached: Date mechanical vent. discontinued:

DATE	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
Ventilator Days																
Purulent Sputum																
Crackles/ Wheezes																
Temperature <37°C = 98.6°F																
Temperature >38.3°C = 101°F																
ET Present E = ET																
T = Trach																
Presence of Inline Suction Cath.																
Use of External Suction Cath.																
Frequency of Suctioning																
External Feeding (specify site)																

Legend: √ = Applicable / Present
0 = Not Applicable / Absent

PRISM

Table 5-2. Example of Utilizing Published Data to Calculate the Cost of an HAI

Year	Unit	Total number of VAPs	Total excess cost per case	Total excess costs attributable to VAP
2008	SICU	18	$9,969[2]	18 cases X $9,969 = $ 179,442

Year	Unit	Total number of VAPS	Total excess length-of-stay per case	Total excess length-of-stay attributable to VAP
2008	SICU	18	6 days[3]	108 days excess LOS

III. Financial Impact

Determine the financial impact of a VAP.

Organizations may elect to use published data or calculate the financial impact based on actual excess costs. It is helpful to partner with the finance department to determine the actual incremental cost of a VAP. The incremental cost is the difference between the average cost for similar admissions without an infection and the average cost for admissions with an infection. For example, if the average cost for a patient with a VAP is $52,000 and the average cost for a similar admission with no infection is $32,000, then the incremental cost for the VAP is $20,000. Tools such as APIC'S HAI cost calculator tool provide tables and graphs which may assist the infection preventionist in calculating the cost of specific HAIs such as VAP.

IV. Information from Quality and Risk Assessment Activities

Data from mortality reviews, sentinel events (unexpected death due to VAP), and other information from quality reviews should be included in the risk assessment.

V. Evaluating the Risk Assessment and Developing a Surveillance Plan

Once the VAP risk assessment is completed, it is used as part of the overall organizational risk assessment. Note that the risk assessment should be conducted by a multidisciplinary team.

Table 5-3. Example of Infection Control Risk Assessment: Blank

Device-Associated Infections	Benchmark	High Risk	High Volume	Potential Negative Outcome	National Initiative	Financial Incentive	Risk Rating
Urinary tract infection (UTI)							
VAP							
Surgical site infection (SSI)							

Relative risk 0–3: 3 = high risk, 0 = no risk .
(From Shannon Oriola, RN, COHN, CIC, Sharp Metropolitan Medical Center, San Diego, CA.)

Using the Tool

The following is a hypothetical example of how the tool may be used based on the information obtained in the risk assessment steps:

Benchmark: VAP rate is in 90th percentile compared with NHSN data.
Assessment: Risk score is 3. VAP is a high outlier compared with NHSN data.

High risk: VAP is associated with significant morbidity and mortality. Internal process measures show poor compliance to hand hygiene and other process measures.
Assessment: Risk score is 3.

High Volume: The number of cases has risen since last year and ventilator utilization ratio is well above NHSN data.
Assessment: Risk score 3.

Potential negative outcome: Morbidity and mortality reviews demonstrate attributable mortality.
Assessment: Risk score 3.

National Initiative: This is not part of publicly reported data. Currently not associated with Centers for Medicare and Medicaid Services (CMS) measures.
Assessment: Risk score 0.

Financial incentives: Excess cost $179,000. Excess LOS 108 days.
Assessment: Risk score 2.

Infection Control Risk Assessment

Table 5-4. Example of Infection Control Risk Assessment

Device-Associated Infections	Benchmark	High Risk	High Volume	Potential Negative Outcome	National Initiative	Financial Incentive	Risk Rating
UTI (ICU)	0	1	3	1	3	2	10
VAP	3	3	3	3	0	2	14
CLAB (ICU)	0	3	3	3	3	3	15

Relative risk 0–3.

Organizations may elect to predetermine a score that would indicate a high priority based on the risk assessment (e.g., risk rating above 10) or they may choose to identify those measures with the highest scores.

References

[1] Coffin S, Klompas M, Classen D, et al. Strategies to prevent ventilator-associated pneumonia in acute care hospitals. *Infec Control and Hosp Epidemiol* 2008;29:S31–S40.

[2] Stone PW, Braccia D, Larson E. Systematic review of economic analyses of health care-associated infections. *Am J Infect Control* 2005;33(9):501–509.

[3] Rello J, Ollendor D, Oster G, et al. Epidemiology and outcomes of ventilator-associated pneumonia in a large U.S. database. *Chest* 2002;122:2115–2121.

Surveillance Plan

"Surveillance is a systematic method of collecting, consolidating, and analyzing data concerning the distribution and determinates of a given disease or event, followed by the dissemination of that information to those who can improve the outcomes."[1] It is a dynamic and essential element of an effective infection prevention and control program.

The surveillance plan is, in part, determined by the ICRA, completed at least annually, providing direction for the infection prevention and control program for the facility. The risk assessment is a global assessment of infection-related vulnerability that is specific to a particular institution and is based on geographic location, services provided, populations served, and environmental issues.

In addition to the identification of potential infection-related hazards, the ICRA outlines interventions and strategies for abatement of risk, process measures to assess compliance with those interventions and strategies, outcome measures for the determination of effectiveness of the interventions and strategies, and an indication of prioritization of risk and abatement. Just as the infection prevention and control program surveillance plan is a dynamic entity, so, too, is the risk assessment.

When developing a surveillance program, the following steps are essential:

1. Selection of surveillance methodology; for example, total house, targeted, or a combination methodology. Targeted surveillance represents the method that maximizes infection prevention and control resources by focusing on particular care units, invasive procedures, and organisms of epidemiological significance. Targeted surveillance programs and plans typically focus on high-volume, high-risk procedures and on those HAIs and adverse outcomes that are potentially preventable (e.g., VAP).
2. Definition of the population(s) at risk for a particular infection or adverse outcome based on the facility ICRA. Criteria used to define the outcome should reflect generally accepted definitions of the disease or event monitored. Published criteria for identification of HAIs are available. In the case of VAP, the NHSN definition is utilized to define the outcome. Criteria utilized to define a surveillance case are not necessarily diagnostic criteria. The infection preventionist must determine prioritization of events or indicators to monitor based on the ICRA. In some instances, the choice is determined by state-mandated, infection reporting requirements or by regulatory bodies. High-volume, high-risk procedures or processes merit attention in the surveillance plan.
3. Criteria used to conduct surveillance must remain consistent in order to collect meaningful data. Unless criteria and measurement methodologies remain consistent over time, data collected will be of little value in assessing the need for and the impact of interventions and strategies designed to improve outcomes. If benchmark data are to be used for comparison, it is important to maintain intra-agency consistency. If NHSN benchmark data will be used for comparison with the facility's outcome data, NHSN surveillance criteria must be utilized.
4. Once the at-risk population and surveillance criteria have been determined, data elements that will be collected must be identified. Data elements will depend on the event being monitored and should include case identifiers and those elements that will allow the infection preventionist to determine if a case meets the established criteria. Data collection may be either concurrent or retrospective. Each method has advantages as well as disadvantages. Concurrent data collection has the potential to initiate interventions while there is an opportunity to affect the patient's outcome; retrospective surveillance may provide more

comprehensive data, as the medical record will be more complete. Sources of surveillance data may include the medical record, admission records, microbiologic and radiologic reports, records of device days, and pharmacy reports, among others.

5. Determination of data analysis methods or the statistical measures that will be used to analyze the data collected. If rates and ratios are utilized, numerator and denominator data must be defined. Whenever possible, the same methodology as a nationally validated surveillance system should be used as a comparison. This comparison presupposes alignment of surveillance criteria, as well as the data collection methodology. Numerator data will be cases of adverse outcome; denominator data will represent a measurement of risk for that outcome. In the case of VAP, the numerator will be cases of VAP and the denominator will be ventilator days (representing the period of risk). Calculation of a rate also includes multiplication by a factor of 1000 in the case of device-associated infection.
6. Data for the indicator(s) chosen will be collected consistently in an appropriate time frame; for example, a month, a quarter, a year. For events that occur with some frequency, monthly reporting may be appropriate; for those outcomes that occur rarely, a longer observation period will provide data that are more meaningful.
7. The final, and perhaps most valuable, step in the surveillance plan is the reporting back of data collected to those who can have an impact on the outcome. The following example describes denominator and numerator collection methodologies, as well as an example of a simple report.[1,2]

Determining Denominator Days for VAP

Denominator data for VAP will be ventilator days. Typically, the number of patients with invasive devices (ventilators, central venous access devices, and indwelling urinary catheters) is counted at the same time each day. A ventilator is defined as a device to assist or control respiration continuously, inclusive of the weaning period, through a tracheostomy or by endotracheal intubation. 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.

Example

In the Rosewood General Hospital MICU, device days are counted at 2400 hours daily. During the month of July, there were 5 patients who were intubated and mechanically ventilated:

Patient A: intubated at 2200 hours on July 6, remained intubated and mechanically ventilated until 0730 hours on July 15 = 9 ventilator days

Patient B: intubated at 0800 hours on July 9, remained intubated and mechanically ventilated until 2330 hours on July 9 = 0 ventilator days

Patient C: intubated at 0900 hours on July 9, remained intubated and mechanically ventilated until 1000 hours on July 31 = 22 ventilator days

Patient D: intubated at 0100 hours on July 12, remained intubated and mechanically ventilated until 2330 hours on July 25 = 13 ventilator days

Patient E: intubated at 1330 hours on July 12, remained intubated and mechanically ventilated until 0600 hours on August 6 = 20 ventilator days (in July)

Table 6-1. Example Device Days Log: Rosewood General Hospital, July

Date	Foley Catheter Days	Central Line Days	Ventilator Days
1	5	2	0
2	6	2	0
3	4	2	0
4	3	3	0
5	8	3	0
6	5	3	1
7	5	3	1
8	5	3	1
9	5	1	2
10	5	5	2
11	8	5	2
12	8	5	4
13	8	5	4
14	8	5	4
15	2	5	3
16	0	5	3
17	6	7	3
18	7	5	3
19	4	2	3
20	9	7	3
21	4	1	3
22	2	1	3
23	1	0	3
24	5	4	3
25	8	7	2
26	6	5	2
27	9	8	2
28	10	9	2
29	4	2	2
30	5	4	2
31	7	6	1
Total	172	125	64

The number of ventilator days for the unit for the month of July is 64.

In this example from Rosewood General Hospital, all invasive devices are included on the data collection form. This compilation of information may make data collection and documentation simpler, depending on the data collection methodology of a particular unit. In other instances, device days may be collected separately

Table 6-2. Example VAP Data and Rates: Rosewood General Hospital

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VAP cases	2	0	1	1	2	1	1	0	1	2	0	1
Vent days	105	78	92	73	300	139	64	85	90	123	167	201
VAP rate	19.0	0	10.8	13.6	6.6	7.2	15.6	0	11.1	16.2	0	4.9
Quarterly VAP rate	10.9			7.8			8.4			6.1		

(ventilator devices, central catheters, and indwelling urinary catheters) and those numbers may be tracked on separate forms. Often, the respiratory therapy department will monitor ventilator days, but those numbers may not be collected in the same manner as described by CDC (i.e., counting numbers of patients undergoing mechanical ventilation at the same time each day).

In the MICU, during the month of July, Patient A met criteria for pneumonia on July 12. Because Patient A was intubated and mechanically ventilated on July 12, the pneumonia is described as ventilator-associated. No other mechanically ventilated patients met the pneumonia criteria in July.

Rate calculation: 1 VAP/64 ventilator days × 1000 (factor) = .0156 × 1000 = 15.6. Thus, the VAP rate for Rosewood General Hospital's MICU for the month of July is 15.6, or 15.6 VAP cases for every 1000 ventilator days. Because the number of ventilator days for this MICU is relatively small, it may be more meaningful to expand the time period for reporting purposes. Quarterly data reporting would probably provide a more accurate VAP surveillance representation. Table 6-2 and Figures 6-1 and 6-2 summarize 12 months of VAP rates.

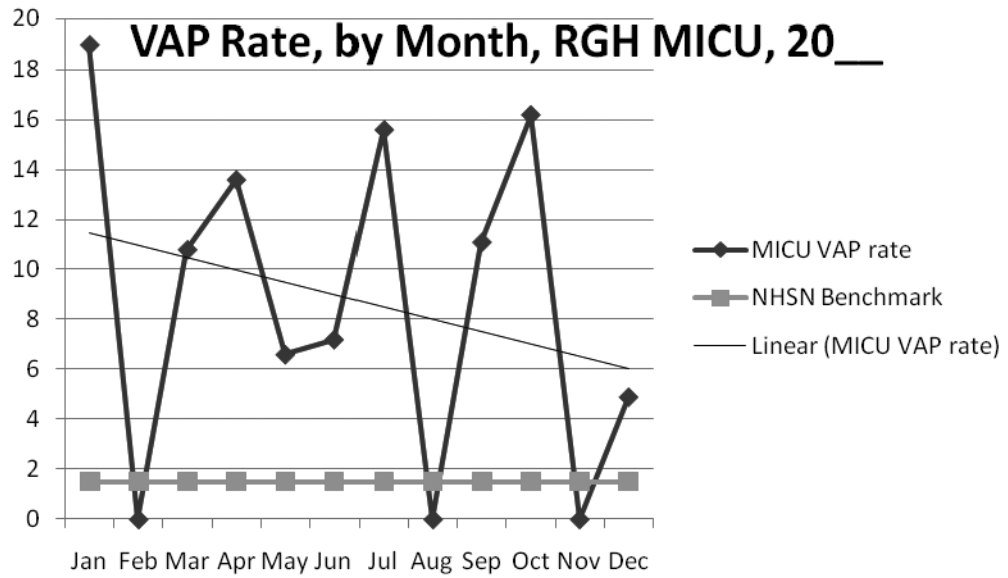

Figure 6-1. Data represented in graph form, by month, with trend line.

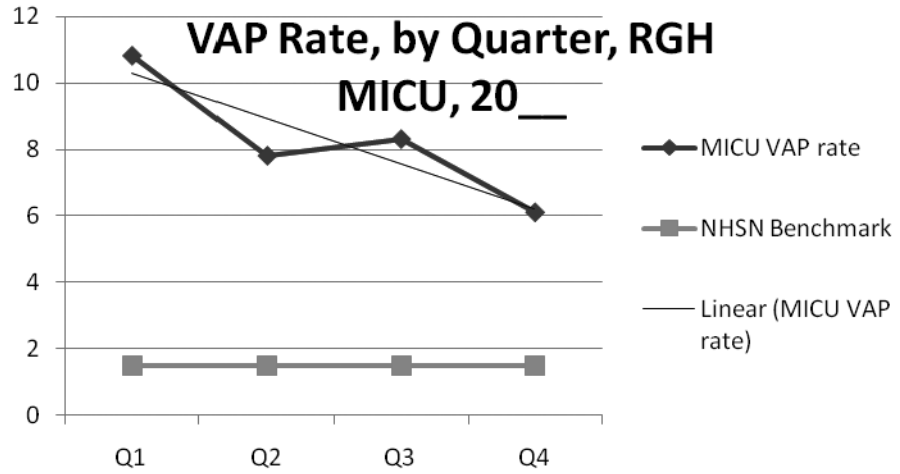

Figure 6-2. Data represented in graph form, by quarter with trend line.

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Prevention Strategies

Most prevention strategies focus on three main issues: aspiration, colonization of the aerodigestive tract, and contaminated equipment. Because few studies have evaluated the prevention of VAP in children, the majority of these recommendations stem from studies that were performed in adults.[1]

Reduction of Bacterial Colonization

Perhaps the most effective means of preventing VAP caused by exogenous microorganisms is consistent and thorough hand hygiene. Hand hygiene forms the underpinnings of an effective infection prevention and control program. All healthcare personnel should perform hand antisepsis before and after contact with patients. Hand antisepsis should also be performed before and after contact with the patient's respiratory equipment and items in the patient's room, and after contact with respiratory secretions. Gloves should be worn if contact with respiratory secretions or contaminated objects is anticipated, and appropriate hand antisepsis should be performed before and after glove use.

The Endotracheal Tube

Intubation and mechanical ventilation increase the risk of HCAP 6- to 21-fold, and should be avoided whenever possible.[2] Noninvasive positive pressure ventilation, using either a full face mask or a nasal mask, can decrease the risk of aspiration around an artificial airway but is only useful for short-term ventilation.

Orotracheal tubes are preferred over nasotracheal intubation to prevent sinusitis and reduce the risk of VAP. Nasal obstruction with an endotracheal tube may prevent the clearance of secretions from the sinuses, resulting in the development of sinusitis. However, causality between sinusitis and VAP has not been firmly established.[3] A cuffed endotracheal tube with at least 20 cm of H_2O should be maintained to reduce the chance that the patient will aspirate secretions that accumulate above the cuff.[4]

Secretions are common in the upper airways of intubated patients and pool above the endotracheal tube cuff, allowing for leakage of contaminated secretions into the lower airway. The effect of using an endotracheal tube that has a separate dorsal lumen, which allows continuous aspiration of the subglottic secretions, has been studied. In a metaanalysis, continuous subglottic secretion drainage was effective in preventing early-onset VAP (VAP developing within 4 days), although none of the studies showed a corresponding effect on mortality rate, LOS in the ICU, or duration of mechanical ventilation.[5]

A more recent article by Bouza et al. involved a randomized control study over a two-year period in major heart surgery patients. The study found that continuous aspiration of subglottic secretions in those patients receiving mechanical ventilation for more than 48 hours reduced the incidence of ventilator-associated pneumonia as well as ICU stay, duration of mechanical ventilation and antibiotic consumption. The study concludes that continuous aspiration of subglottic secretions should be encouraged at least in patients undergoing major heart surgery.[6]

Role of Contamination

Contaminated equipment and environmental contamination are risk factors for VAP. A large number of prospective, randomized trials have shown that the frequency of ventilator circuit change does not affect the incidence of VAP. Condensate collecting in the ventilator circuit becomes contaminated from patient secretions

and can inadvertently be flushed into the lower airway or to in-line medication nebulizers when the patient turns or changes position.[2] Care must be taken to remove condensate from ventilator tubings. Staff should collaborate with the respiratory therapy department to ensure such findings are not the result of a technical issue (e.g., vent setting, filter condition). Passive humidifiers or heat-moisture exchanges have been shown to decrease colonization. However, recommendations for use remain an unresolved issue since there is no evidence proving their effect on VAP.[3]

Recommended strategies to minimize contamination of mechanical ventilator equipment include[1]:

- Use sterile water to rinse reusable respiratory equipment.
- Remove condensate from ventilatory circuits before repositioning the patient. Keep the ventilatory circuit closed during condensate removal.
- Change the ventilatory circuit only when visibly soiled or malfunctioning.
- Store and disinfect respiratory therapy equipment properly. Whenever possible, use steam sterilization (by autoclaving) or high-level disinfection by wet heat pasteurization at >158˚F (>70˚C) for 30 minutes for reprocessing semicritical equipment or devices (e.g., items that come into direct or indirect contact with mucous membranes of the lower respiratory tract) that are not sensitive to heat and moisture. Use low-temperature sterilization methods (as approved by the Office of Device Evaluation, Center for Devices and Radiologic Health, Food and Drug Administration) for equipment or devices that are heat- or moisture-sensitive. After disinfection, proceed with appropriate rinsing, drying, and packaging, taking care not to contaminate the disinfected items in the process. Store items in a clean area away from exposure to dust, excess heat, or moisture.[7]

HICPAC's complete recommendations for sterilization, disinfection, and maintenance of respiratory equipment and categorization according to strength of evidence can be accessed online at http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5303a1.htm.

Decreasing the Duration of Intubation

One of the simplest methods to reduce the risk of VAP is to extubate patients as soon as possible. Numerous randomized and observational studies have shown that the longer an endotracheal tube remains in place, the greater the risk of developing VAP.[4] There is also an incremental cost associated with mechanical ventilation. Dasta et al. calculated a mean incremental cost of mechanical ventilation at $1,522 per day. Interventions that focus on reducing the duration of mechanical ventilation could lead to reductions not only in the incidence of VAP, but in total hospital cost.[8]

The patient's readiness for weaning and the appropriateness of spontaneous breathing trials should be assessed on a daily basis. Strategies such as improved methods of sedation and the use of protocols to facilitate and accelerate weaning have been recommended to reduce the incidence of VAP. Kress et al. conducted a randomized, controlled trial in 128 adult mechanically ventilated patients receiving continuous infusion of sedative agents in a MICU. Daily interruption resulted in a significant reduction in time spent on mechanical ventilation. The duration of mechanical ventilation decreased from 7.3 days to 4.9 days ($p = .004$).[9] More recent studies have demonstrated that protocol-driven daily spontaneous breathing trials have resulted in improved extubation rates without an increased incidence of re-intubation.[10,11]

Positioning

Supine patient positioning may facilitate aspiration. The risk of aspiration may be reduced by elevating the head of the bed 30 to 45 degrees (semirecumbent positioning). Multivariable analysis of risk factors associated with VAP found up to a 67% reduction in VAP among patients maintained in the semirecumbent position compared

Figure 7-1. Sample ventilator bundle collection sheet. (From Institute for Healthcare Improvement.)

Date	Bed/ Patient Initials	Head-of-the-bed	Daily Sedation Vacation	Daily Assessment of Readiness to Wean	Daily Spontaneous Breathing Trial	PUD Prophylaxis	DVT Prophylaxis
		☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐
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		☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐

with a control group who were maintained in a supine position.[12] However, consistency in positioning may play a role in the outcome. A more recent randomized control study assessed the feasibility of maintaining the head of bed elevation on a consistent basis. In this study, backrest elevation was measured continuously with a monitor-linked device during the first week of the study to assess average elevation. Patients who were assigned to the semirecumbent group were not continuously maintained at 45 degrees and rates of ventilator pneumonia were equal in both the semirecumbent and the control groups.[13]

Suggestions for maintaining a semirecumbent position for ventilated patients are posted on the Institute for Healthcare Improvement (IHI) Web site (http://www.ihi.org/IHI/Topics/CriticalCare/IntensiveCare/Changes/ImplementtheVentilatorBundle.htm) as well as http://www.apic.org/eliminationguides.

- Place a reminder poster on the wall at the head of the patient's bed.
- Provide feedback on compliance.

- Add head-of-the-bed elevation to patient's daily goals sheet.
- Mark bed with tape to 45 degrees.
- Mark head-of-the-bed elevation on the ICU record.

Mouth Care

HICPAC recommends the development and implementation of a comprehensive oral hygiene program, potentially with the inclusion of an antiseptic agent, for settings where patients are at risk for HAP. Pathogens colonize the teeth and oral mucosa. Oral suctioning prevents oral secretions from pooling, and tooth brushing removes the plaque that promotes bacterial growth. In a metaanalysis, the incidence of VAP was significantly reduced by oral antiseptics such as chlorhexidine (relative risk [RR] 0.56, 95% confidence interval [CI] 0.39–0.81), but not oral applications of antibiotics.[14] Strong studies have demonstrated VAP reduction when institutions have added a comprehensive oral–dental care program as components to their bundle.[15–17] These protocols did not contain use of an antibacterial such as chlorhexidine. Garcia published a comprehensive review on the role of oral and dental colonization in which he notes that the cumulative evidence strongly supports new interventions as part of a comprehensive oral and dental care plan, and that oral colonization may be an under-appreciated risk in the development of VAP.[18]

Figure 7-3 can help you assess and document an oral hygiene program.

Nutrition

Enteral feeding tubes can increase the risk of aspiration.[1] Care providers should monitor the patient's tolerance of gastric feedings, auscultate for bowel sounds, and measure abdominal girth frequently. Residual gastric volume should be measured at least every 4 hours during continuous feedings and before each intermittent feeding to decrease the likelihood of gastric distension and aspiration. Less than 200 mL is generally considered an acceptable amount of gastric residual volume. Several studies have found an association between the aspiration of gastric contents and VAP, suggesting that the avoidance of gastric over-distention may reduce this occurrence.[19]

Measures aimed at avoiding gastric over-distention include reducing the use of narcotics and anticholinergic agents, using gastrointestinal motility agents, supplying enteral nutrition with smaller bore feeding tubes, and administering feeding solutions directly into the small bowel instead of the stomach. A metaanalysis found that small bowel feeding was associated with a reduction in gastroesophageal regurgitation, an increase in calories absorbed, and a shorter time to achieving the target dose of nutrition.[20] Small bowel feeding was associated with an overall reduction in pneumonia. There are currently no formal recommendations on the optimal type of feeding.[1]

Mobility

Although the complications of immobility are well described in the literature, critically ill patients are often subjected to prolonged periods of bed rest. Mechanical ventilation is not a contraindication to getting patients out of bed. Some reviewers have concluded that a mobility protocol for critically ill patients may provide the structure and impetus to progress patient activities in a systematic manner that prevents bed rest–related complications. Future research is needed to illuminate the best methods and timing to optimize the functional abilities of critically ill patients.[21]

A mobility protocol is provided in Figure 7-4 as an example for systematically advancing patient activity.

Technology

Biofilms form on the endotracheal tube causing bacterial contamination. Certain bacteria, such as *Pseudomonas* species, appear to be more capable of forming biofilms in the presence of abnormal airway mucosa. Novel technologies

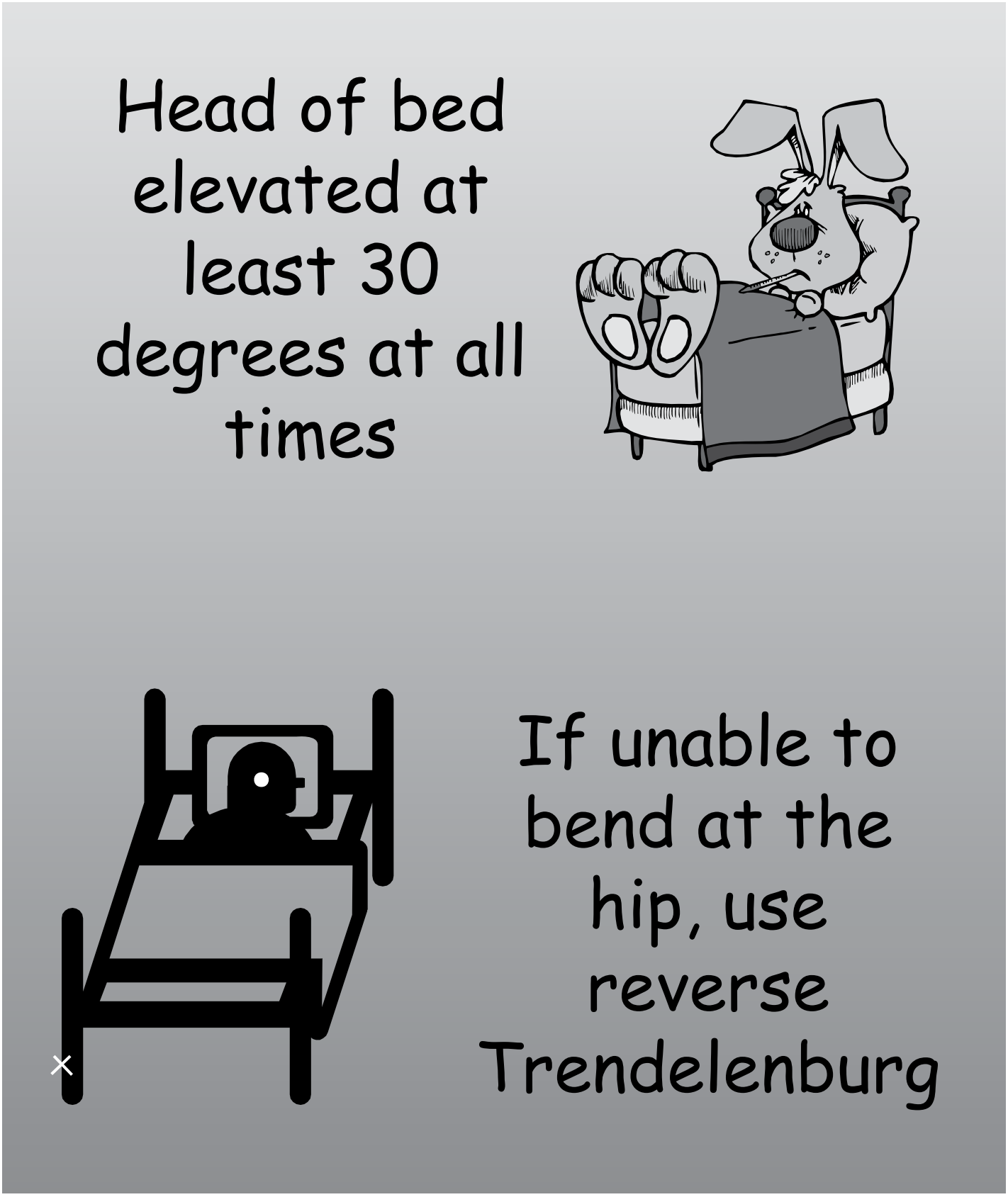

Figure 7-2. Sample head-of-the-bed elevation poster. (From Michelle Farber, RN, CIC, Mercy Community Hospital, Coon Rapids, MN.)

Mouth Care Assessment and Documentation

Patient Name:
Medical Record Number:
Date:

Assessment	Scale 1–4	Comments
Teeth	Clean **1** Plaque/debris in localized area **2** Plaque/debris along gum line **3** Ill-fitting dentures/caries **4**	
Tongue	Pink and moist **1** Coated **2** Shiny/red **3** Blistered/cracked **4**	
Lips	Smooth/moist **1** Dry/cracked **2** Bleeding **3** Ulcerated **4**	
Mucous membranes	Pink and moist **1** Reddened/coated **2** White areas **3** Ulcerated/bleeding **4**	
Total score		

8 or below: Mouth care every 4 hours
9 and above: Mouth care every 2 hours

Activity	Monday Date ____	Tuesday Date ____	Wednesday Date ____	Thursday Date ____	Friday Date ____	Saturday Date ____	Sunday Date ____
Brush teeth Q 12	Initials 0800_____ 2000_____	Initials 0800_____ 2000_____	Initials 0800_____ 2000_____	Initials 0800_____ 2000_____	Initials 0800_____ 2000_____	Initials 0800_____ 2000_____	Initials 0800_____ 2000_____
Provide oral care every 2 to 4 hours with antiseptic Apply mouth moisturizer to oral mucosa and lips	Time and initials _____ _____ _____ _____ _____ _____ _____ _____ _____ _____	Time and initials _____ _____ _____ _____ _____ _____ _____ _____ _____ _____	Time and initials _____ _____ _____ _____ _____ _____ _____ _____ _____ _____	Time and initials _____ _____ _____ _____ _____ _____ _____ _____ _____ _____	Time and initials _____ _____ _____ _____ _____ _____ _____ _____ _____ _____	Time and initials _____ _____ _____ _____ _____ _____ _____ _____ _____ _____	Time and initials _____ _____ _____ _____ _____ _____ _____ _____ _____ _____
Suction orally as necessary							
Comments and daily assessment score							

Figure 7-3. Mouth care assessment and documentation form. (From Linda R. Greene, RN, MPS, CIC, Rochester General Health System, Rochester, NY.)

Intensive Care Progressive Mobility Guidelines

Goal of Early Mobilization:

Promote mechanical ventilator weaning process
Reduce ICU and Hospital LOS
Prevent physical deconditioning
Prevent Ventilator-Associated Pneumonia (VAP)
Prevent Pressure Ulcers
Maintain/achieve preadmission activity level
Enhance Patient physical and psychological well being

Monitor for Physical Therapy / Occupational Therapy Consult:

OT consult on admission, then weekly follow-up evaluation
PT consult when patient is able to cooperate with activity of begins SBT (Spontaneous Breathing Trials)

Document all Mobility on Flow Sheet

Level I Modified Mobility Process

Criteria: Admission to Intensive Care Unit or Progressive Care Unit

- Reposition and Turn Q 2 Hrs
- AROM/PROM
- Splints and/or boots (alternate) for contracture prevention
- HOB @ 30 degrees

Maintain Level I for Pt.'s with:

- > 6 Fr. Arterial Groin Catheter/Line
- Withdrawal of Care within 12 -24 hours

Reassess Q 24 Hours for readiness to progress mobility

Advance mobility using progressive Algorithm Level as Pt. tolerates. Reassess q 12 hours

Exclusion criteria for advancing mobility level:

- Lobar collapse or atelectasis, excessive secretions and/or:
- $FiO_2 \geq 50\%$ with Peep ≥ 10
- $SaO_2 \leq 90\%$ at rest or $\leq 88\%$ with activity
- Progressively deteriorating neurological status
- Severe orthopaedic problems
- Hemodynamic instability $\downarrow SaO_2$ $\downarrow$BP $\downarrow$HR

Hemodynamic Tolerance

5-10 minutes equilibration time is required with each position change to determine hemodynamic instability

Level II (Include Level I Interventions)

- HOB @ 45° to 65° if hemodynamically stable
- Place legs in dependent position
- Advance to Cardiac Chair
- OOB to Chair with assistive device (2 X Daily for 1 hr)
- Time frame for OOB in Chair positioning is ≤ 1 hr

If Pt has large abdomen try a lesser HOB angle when in sitting position

Level III (Include Level I & II Interventions)

- Sit on Side of Bed
- Advance to Standing Position
- Initiate Pivot/Stand to bedside chair @ least 2 X Daily

Level IV (Include Level I, II & III Interventions)

- Independent: OOB, Sit in Chair, Stand, Ambulate

Adapted from:
Ahrens, T., Burns, S., Phillips, J., Vollman, K., & Whitman, J. (2005). Progressive mobility guidelines for critically ill patients. *2005 Advancing Nursing*., Retrieved September 24, 2006 from http://www.totalcare.tv/images/stories/138930_PMG.pdf.

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Figure 7-4. Intensive care progressive mobility guidelines. (From University of Rochester Medical Center, Rochester, NY.)

aimed at limiting the formation of biofilm include a silver-coated endotracheal tube, which was associated with delayed occurrence of VAP in a large randomized trial.[22] No significant differences were observed between the two groups in durations of intubation, ICU stay, hospital stay, mortality, and frequency and severity of adverse events. At the present time, the use silver-coated endotracheal tubes lacks enough evidence to demonstrate cause and effect.[1]

Role of Gastric Acidity

The risk of VAP is increased by decreasing gastric acidity, which can result in greater gastric colonization with pathogenic bacteria. Stress ulcer prophylaxis decreases gastric acidity. Because ventilated patients are at high risk for stress ulcers, prevention of peptic ulcers is a common strategy. A randomized, controlled trial compared three strategies of stress ulcer prophylaxis (ranitidine, aluminum hydroxide/magnesium hydroxide antacid, and sucralfate).[23] The incidence of late-onset (more than 4 days after intubation) pneumonia was significantly lower with sucralfate compared with pH-altering drugs (5% vs. 16% with antacids and 21% with ranitidine). Patients who received sucralfate had a lower median gastric pH and less frequent gastric colonization compared with the other groups. Nevertheless, when patients with pH >4 were evaluated separately, the patients receiving sucralfate still exhibited lower rates of gastric colonization, suggesting that sucralfate may possess intrinsic antibacterial activity. There was a trend toward an increased incidence of gastric bleeding in patients taking sucralfate compared with antacids and ranitidine, but this difference was not statistically significant.

Key Prevention Strategies

- Pay strict attention to hand hygiene and basic infection prevention strategies.
- Avoid unnecessary antibiotics.
- Perform routine antiseptic mouth care.
- Prevent aspiration of contaminated secretions: maintain semirecumbent positioning.
- Shorten duration of mechanical ventilation: apply weaning protocols and optimal use of sedation.
- Avoid routine ventilator changes.
- Remove condensate from ventilatory circuits. Keep the ventilatory circuit closed during condensate removal.
- Disinfect and store respiratory therapy equipment properly.
- Minimize gastric distension.
- Educate healthcare personnel who care for patients undergoing ventilation about VAP.
- Perform direct observation of compliance with VAP-specific process measures.
- Conduct regular surveillance for outcomes measures.

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Putting It All Together

In early 2001, IHI collaborated with VHA (formerly known as Volunteer Hospitals of America) to design a care model in ICUs. A group of faculty, including intensivists and improvement leaders, convened to determine improvement priorities for large-scale ICU redesign and worked with 13 participating ICUs. Care of ventilated patients was identified as a top priority. They identified that ventilator patients are at high risk for several serious complications: VAP, venous thromboembolism (VTE), and stress-induced gastrointestinal bleeding. Four elements of care for prevention of these adverse events in vented patients were supported by solid level-one trials[1]:

1. Elevation of the head-of-the-bed to between 30 and 45 degrees.
2. Daily "sedative interruption" and daily assessment of readiness to extubate.
3. Peptic ulcer disease (PUD) prophylaxis.
4. Deep venous thrombosis (DVT) prophylaxis (unless contraindicated).

Although several hospitals have reported reduced VAP rates through the implementation of a consistent approach to all four elements of the "bundle," IHI has clarified that this is a ventilator bundle and not a VAP bundle. For example, PUD prophylaxis was included because of stress associated with a ventilator and not for VAP prevention. Since these patients are often NPO—can have nothing by mouth—and are in a stressful environment, prevention of peptic ulcers is one complication on which the group chose to work.

Likewise, DVT prophylaxis is an important complication to consider for patients who are mechanically ventilated in the ICU, but does not have a strong link to VAP prevention on its own. The goal was to get the team on the same page by reviewing and implementing the four bundle items for all patients unless contraindicated and, in those cases, ensuring team discussion and documentation.[1] Recently, the Agency for Healthcare Research and Quality (AHRQ) noted that although several improvement leaders assert that setting the target of complete adherence to a bundle of processes "sets the bar high" and motivates overall system redesign rather than targeted single-process interventions, there are currently no data to support this claim. IHI also recommends specific strategies for implementing the "bundles," such as audit and feedback of infection rates and all-or-none measurements, and use of multidisciplinary rounds and setting daily patient goals for ICU patients. The AHRQ document concluded that the very limited published data do not allow evaluation of the effectiveness of these strategies. However, it noted that the recommendations of the "100,000 Lives" campaign are being widely implemented in U.S. hospitals, providing an excellent opportunity for conducting higher quality studies to determine effective implementation strategies.[2]

Educational Programs

Education of healthcare personnel is widely viewed as a fundamental measure in reducing VAP.[3,4] A recent systematic review of educational interventions for HAIs included six studies which described the effects of an educational intervention on VAP rates. All six were pre- and postintervention studies.[5] The review concluded that the implementation of educational interventions may reduce HAIs considerably; however, randomized trials using validated educational interventions are recommended to determine the independent effect of education on reducing these infections. Studies are summarized in Table 8-1.

Table 8-1. Summary of Studies Analyzing the Impact of Educational Interventions on HAI Rates

Location/ Year	First Author	Study Design	Target Population	Setting	Target Infection	Infection Rate Before	After	RR P Value
1993 U.S.	Kellighan[6]	Pre-post intervention	Nursing, respiratory therapy	MSICU	VAP	7 cases/100 patients	3 cases/100 patients	0.36 (0.11–0.65) $p = .02$
2002 U.S.	Zack[7]	Pre-post intervention	Nursing, respiratory therapy	ICU	VAP	12.6/1000 vent. days	5.7/1000 vent. days	0.4 (NR) $p = <.001$
2003 U.S.	Babcock[8]	Pre-post intervention	Nursing, respiratory therapy, MD	ICU	VAP	8.75/1000 vent. days	4.74/1000 vent. days	0.5 (NR) $p = <.001$
2004 Pakistan	Salahuddin[9]	Pre-post intervention	MICU staff	ICU	VAP	13.2/1000 device days	6.5/1000 device days	0.52 (0.30–0.91) $p = .02$
2005 Thailand	Danchaivijitir[10]	Pre-post intervention	Healthcare worker	ICU	VAP	40.5%	24%	0.5 (NR) $p = <.001$
2006 Argentina	Rosenthal[11]	Pre-post intervention	Healthcare worker	ICU	VAP	51.2/1000 vent. days	35.5/1000 vent. days	0.69 (0.49–0.98) $p = .003$

Quality Improvement

Several organizations have reported decreased VAP rates after implementing quality improvement projects, and some of these organizations have reported long periods of time with no VAP. Strategies have varied from single strategy interventions to the implementation of bundles or other multiple interventions. Organizations that have reported continued low sustainable rates of VAP appear to have similarities. The literature reports that organizations that have developed successful strategies to reduce VAPs have utilized multidisciplinary teams to implement evidenced-based changes in practice, have incorporated practice changes into the *routine* standard of care, and have performed ongoing or periodic review of progress to reinforce successful strategies. Bonello et al. report a 41% reduction in VAP rates with the use of bundles and concurrent monitoring in nine Department of Veterans Affairs hospitals.[12] Likewise, O'Keefe-McCarthy et al. reviewed six studies on VAP bundle practices and concluded that there is a strong association with ventilator protocols and reduced VAP.[13] The beneficial effect of utilizing a bundle approach was identified in both teaching and non-teaching hospitals.

Youngquist et al. describe the results of the implementation of a VAP bundle in a community hospital with subsequent reduction in VAP rates, from 6.1 to 2.7 per 1000 ventilator days.[14] The majority of recent articles on quality improvement projects to reduce VAP focus on implementation of a VAP bundle or some modification of the bundle concept. Randomized control studies are needed to validate this approach.

Regardless of the approach, visual cues have been successful in a number of organizations. Examples of visual cues can be found online at http://www.apic.org/eliminationguides.

Structural Issues

Some researchers have suggested that structural issues—which include organizational components such as leadership, staffing, and informatics—may be essential to improving patient outcomes. In a study by Stone and colleagues, which examined outcomes of ICU working conditions, findings revealed that ICUs with higher staffing had lower incidence of central line-associated bloodstream infections (CLABSIs), VAP, and skin ulcers. Review of

outcomes data for more than 15,000 patients in 51 U.S. hospital ICUs showed that those with high nurse staffing levels (the average was 17 registered nurse hours per patient day) had a lower incidence of infections.[15] Reports in the literature also emphasize that engaging committed leaders, including physician and nursing champions, and leveraging executive support are essential to successful programs.

Targeting Zero – Success Stories and Case Studies

As healthcare has attempted to move from silos of care driven by specialized groups to collaborative groups and integrated systems, it is imperative that both processes and products are designed and implemented in the most effective and efficient manner to achieve the desired outcomes. Central to this theme is the philosophy of *Targeting Zero* whereby every healthcare institution should work toward a goal of zero healthcare-associated infections. While not all HAIs are preventable, APIC believes that all organizations should set the aspirational goal of elimination and strive for zero infections. Every HAI impacts the life of a patient and a family, and even one should be considered too many. The following examples demonstrate how the target zero philosophy has been implemented in specific organizations:

Critical Event Analysis

Michelle Farber, RN, CIC, Infection Control Specialist, operationalized the targeting zero philosophy at Mercy Community Hospital in Coon Rapids, MN by implementing the IHI bundles, using an infection prevention and control goal sheet, and fostering interdepartmental relationships. Farber's team standardized the use of an endotracheal tube with separate dorsal lumen for continuous aspiration of subglottic secretions, hardwired practices for monitoring head-of-bed elevation and mouth care, and involved all team members in the process to identify and mitigate risk. When a single VAP occurs, the team uses a Critical Event Analysis tool to identify risk factors and ways in which compliance may have broken down due to processes that could not support prevention. The tool helps focus the group's efforts on the case by looking at the patient's hospital course and reviewing processes of care and compliance to standardized protocols. Each analysis is posted for all to see. This approach has resulted in sustaining reduced incidences of VAP from nine months to more than one year with no VAP. In the event of VAP, the team would take it personally. Farber notes that it is important to not only identify opportunities for improvement but also to celebrate when positive findings occur.

Focus on Teamwork

Dr. Marilyn Kole and her interdisciplinary ICU team at Cape Coral Hospital, a part of the Lee Memorial Health System in Ft. Meyers, FL, knew that targeting zero was possible when they noted the success of another small hospital in reaching and maintaining a zero rate of VAP. She credits her hospital's reduction in VAP to the involvement of everyone on the team in the implementation of evidence-based practices. In addition to staff involvement, Stephen Streed, MS, CIC, System Director of Epidemiology, noted that the team includes patients and families. Patient education, including hand hygiene, is promoted on family rounding. The overall improvement process has increased awareness among staff and built a sense of pride, particularly following the organization's extended success in combating VAP. Ownership has taken root in everyone, not just the clinical staff. If a VAP case were to occur, everyone would be distressed, and staff would conduct an almost root-cause-analysis-level exploration of the individual and the case. Dr. Kole and Streed both recommend that hospitals prioritize and start small.

System Approach to Reducing VAP

When Lisa Tikusis, RN, BSN, CIC, and her team at St. James Hospital in Olympia Fields, IL began their project in 2005; VAP was common in the ICUs. Tikusis and her team took a systems approach to VAP reduction which meant not only implementing best practices, but introducing products that helped support these practices. They started with educational videos for the staff and introduced the VAP bundle. As aspiration is an important

risk factor in the development of VAP, the team realized that prepackaged oral care products would promote standardized mouth care practices and assure consistency. Additionally, because the accumulation of respiratory secretions in the subglottic space is a well-proven cause of VAP, the team decided that their prevention strategy should also include aspiration of secretions from the subglottic space and techniques to avoid leakage between the endotracheal tube and the tracheal wall. They implemented an endotracheal tube with a separate dorsal lumen for continuous aspiration of subglottic secretions in all trauma patients. Tikusis notes that products have to be used in the right setting and that there are learning curves associated with implementation. They made "walking rounds" to assure appropriate implementation of products and practices. Tikusis has realized a nine-fold reduction in VAP rates as a result of this system approach to VAP reduction.

The Power of Persistence

Coretha Weaver, BSN, CIC and the Infection Prevention Team at Erlanger Health System in Chattanooga, Tennessee took on a huge challenge of changing longstanding practices in the care of ventilator patients. Erlanger had not been able to conduct VAP surveillance since 1999 and realized that despite limited resources, prevention of VAP was an important patient safety goal. She and the team persisted at driving a VAP reduction program utilizing existing resources and developing a cross-disciplinary, cross-department team to lead this initiative. They created a VAP reduction training video and required every staff member to view the video or an on line training program. The Infection Prevention staff worked with frontline care providers to incorporate daily practices into the routine standard of care. In addition to education, daily sedation vacation, daily assessment for weaning, standardized mouth care, head of bed protocols and an endotracheal tube with suction lumen and evacuation port were implemented. More than two years after they initiated this program, leadership began to realize and embrace these efforts; allocating additional dollars to these prevention efforts. The VAP rate plummeted; from a baseline of 13 cases per 1,000 vent days to less than 1 case per 1,000 vent days. In July and August of 2008 – there were no VAP cases reported. While the effectiveness can be evaluated by improved patient outcomes; it also affected the bottom line; generating a savings of $528,000 in a single year, based on the estimated cost of VAP.

Key Prevention Strategies

- Pinpoint opportunities: identify early innovators, key units, and target metrics.
- Engage key people: leverage executive support and identify nursing and physician champions.
- Incorporate changes into the routine standard of care: hardwire practices.
- Communicate consistently: disseminate results of process and outcome measures.
- Connect to purpose: help staff understand how simple actions connect to outcomes.
- Review deviations: review all cases to identify opportunities for improvement and system issues.

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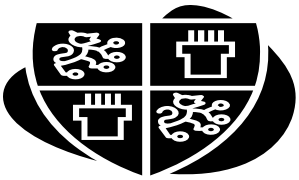

CRITICAL EVENT ANALYSIS

WHAT CAN WE LEARN FROM THIS?

The Patient

Describe patient history.

The Course

Describe clinical course of patient and the hospital-acquired infection detail.

Positive Findings – Celebrate!

Summarize documentation or observed compliance with infection prevention measures.

Opportunities for Improvement

Summarize infection prevention measures that could have prevented infection.

Lessons Learned

Share lessons learned from this patient and how compliance or procedure changes may prevent infection in other patients.

(From Michelle R. Farber, RN, CIC, Mercy Community Hospital, Coon Rapids, MN)