



How-to Guide: Prevent Ventilator- Associated Pneumonia

Prevent ventilator-associated pneumonia (VAP) by implementing the five components of care called “the Ventilator Bundle”

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Introduction

What is the Institute for Healthcare Improvement (IHI)?

The Institute for Healthcare Improvement (IHI) is a not-for-profit organization leading the improvement of health care throughout the world. IHI helps accelerate change by cultivating promising concepts for improving patient care and turning those ideas into action. Thousands of health care providers participate in IHI’s groundbreaking work.

What is a How-to Guide?

IHI’s How-to Guides address specific health care interventions hospitals and/or entire health systems can pursue to improve the quality of health care while reducing unnecessary death, medical error, and cost. These interventions align with several national initiatives of the Institute of Medicine (IOM), Agency for Healthcare Research and Quality (AHRQ), Centers for Medicare and Medicaid Services (CMS), Joint Commission, Centers for Disease Control and Prevention (CDC), as well as the Department of Health and Human Services’ “Partnership for Patients” initiative.

This material was first developed for the IHI 5 Million Lives Campaign, a voluntary initiative to protect patients from five million incidents of medical harm (December 2006 to December 2008). The 5 Million Lives Campaign was built on the 2004-2006 IHI 100,000 Lives Campaign. Both Campaigns involved thousands of hospitals and communities from around the United States in specific interventions. “Mentor Hospitals” showed marked improvement in one or more of the Campaign interventions and volunteered to teach other hospitals. Many of their successful implementation stories and data have been included in this How-to Guide.

5 Million Lives Campaign Donors

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The Leeds Family
David Calkins Memorial Fund

Contributors

The work of leading organizations has informed the development of this guide. These include National Pressure Ulcer Advisory Panel (NPUAP), Ascension Health, Advancing Excellence in America's Nursing Homes, the New Jersey Hospital Association (NJHA), OSF St. Francis Medical Center, and Owensboro Medical Health System.

Development of the Ventilator Bundle

In early 2001, IHI collaborated with VHA in the Idealized Design of the Intensive Care Unit (IDICU). 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, as this population experiences high levels of mortality and morbidity. In addition, all recognized the importance of teamwork and communication among members of the ICU care team as an essential component in providing excellent patient care and improving outcomes.

Ventilator patients are at high risk for several serious complications: ventilator-associated pneumonia (VAP), venous thromboembolism (VTE), and stress-induced gastrointestinal bleeding. Faculty reviewed the evidence and identified four elements of care for prevention of these events in vented patients that are supported by solid level-one trials:

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

In the spring of 2010, IHI faculty determined that there is support in the evidence for the addition of a fifth element in this work:

- Daily oral care with chlorhexidine.

Faculty found that that overall application of these elements was not occurring reliably. Moving to the “all-or-nothing” measure changed the focus of the improvement effort to a goal of improving all four of the initial elements together, which became known as the IHI Ventilator Bundle. When hospital teams began to shift their improvement efforts from reliability of individual elements to reliability of the bundle (all-or-nothing approach), new ways of working were needed that incorporated reliability principles from other industries.

A surprising result was that ventilator-associated pneumonia (VAP) rates in these ICUs began to decrease dramatically, followed by several ICUs experiencing consecutive months of no VAPs. Faculty and teams speculated—and have confirmed in many cases—that it was the new emphasis on working reliably and as a more coordinated care team that caused VAP rates to decrease, particularly since only two of those four elements of care related directly to VAP prevention.

In general, care bundles are groupings of best practices with respect to a disease process that individually improve care, but when applied together may result in substantially greater improvement. The core elements of the bundle are evidence-based strategies that may prevent or reduce risk of these complications, and the bundle is an effort to design a standard approach to delivering these core elements of care.

Not all possible therapies are included in a particular bundle, as the bundle is not intended to be a comprehensive list of all care that should be provided. For example, several interventions— subglottic suctioning, selective decontamination of the gut, and continuous lateral rotation—are not included in the IHI Ventilator Bundle. This does not imply that these and other activities should not be considered for vented patients as VAP prevention strategies. Because the Ventilator Bundle as designed has led to success in many hospitals, IHI elected not to alter the elements until the spring of 2010 with the addition of daily oral care with chlorhexidine. However, many hospitals had already added items to the bundle on their own and the Ventilator Bundle in Scotland has included oral care since 2009. It is important to ensure that any elements of care added to the bundle are supported by solid level-one evidence and that the bundle does not get “too large” or it becomes more difficult to measure and manage. Care bundles work best when the number of elements is small.

Many hospitals have since implemented the Ventilator Bundle in their ICUs and have reported significant decreases in VAPs or long periods of time (one year, two years, or longer) with no VAPs in these patients. As a result of these successes, we recommend implementation of the Ventilator Bundle for preventing VAP.

Defining the Problem

Ventilator-associated pneumonia (VAP) is a nosocomial lung infection that occurs in patients receiving mechanical ventilation and for whom the infection was not the reason for ventilation (i.e., the infection commenced after ventilation). VAP is identified according to the Centers for Disease Control and Prevention (CDC) definition by using a combination of radiologic, clinical, and laboratory criteria (NHSN Manual: Patient Safety Component Protocols) and is usually suspected when a patient on mechanical ventilation develops a new or progressive pulmonary infiltrate with fever, leukocytosis, and purulent tracheobronchial secretions. Pneumonia is considered as ventilator associated if the patient was intubated and ventilated at the time or within 48 hours before the onset of infection. The CDC definition notes, “There is no minimum period of time that the ventilator must be in place in order for the PNEU [sic] to be considered ventilator-associated.” (NHSN Manual: Patient Safety Component Protocols, p.15.)

Definition and criteria should be reviewed locally, in consultation with internal experts such as infection disease experts and physicians who care for ventilated patients (typically pulmonologists/intensivists). Hospitals treat different populations in their intensive care units and will thus be measuring VAP in different types of patients. For example, trauma centers may include vented trauma patients, which not all hospitals have, and some hospitals include long-term ventilator patients in their ICUs while others do not. Attempts to benchmark performance will depend largely upon the definition that hospitals adhere to in their diagnostic strategies and the populations treated. This does not mean that there is no such entity as ventilator-associated pneumonia or that clinicians cannot improve upon the care that they deliver to patients at risk for developing pneumonia. Once a definition is settled upon at an institutional level by involved personnel, performance improvement can be gauged with respect to prevention as long as that standard is applied regularly.^{1,2,3,4,5}

¹ Meduri GU. Diagnosis and differential diagnosis of ventilator-associated pneumonia. *Clin Chest Med.* 1995;16(1):61-93.

² Fagon JY, Chastre J, Hance AJ, et al. Evaluation of clinical judgment in the identification and treatment of nosocomial pneumonia in ventilated patients. *Chest.* 1993;103(2):547-553.

³ Fabregas N, Ewig S, Torres A, et al. Clinical diagnosis of ventilator-associated pneumonia revisited: Comparative validation using immediate post-mortem lung biopsies. *Thorax.* 1999;54(1):867-873.

⁴ Chastre J, Fagon JY. Ventilator-associated pneumonia. *Am J Respir Crit Care Med.* 2002;165(7):867-903.

⁵ Niederman MS, Torres A, Summer W. Invasive diagnostic testing is not needed routinely to manage suspected ventilator-associated pneumonia. *Am J Respir Crit Care Med.* 1994;150(2):565-569.

The Case for Preventing Ventilator-Associated Pneumonia

Preventing pneumonia of any kind is certainly a laudable goal. However, there are some reasons to be particularly concerned about the impact of pneumonia associated with ventilator use.

- VAP is the leading cause of death among hospital-acquired infections, exceeding the rate of death due to central line infections, severe sepsis, and respiratory tract infections in the non-intubated patient. Perhaps the most concerning aspect of VAP is the high rate of associated mortality. Hospital mortality of ventilated patients who develop VAP is 46%, compared to 32% for ventilated patients who do not develop VAP.⁶
- In addition, VAP prolongs time spent on the ventilator, length of ICU stay, and length of hospital stay after discharge from the ICU.⁷
- Strikingly, VAP adds an estimated cost of \$40,000 to a typical hospital admission.⁸
- A recent Compendium of Strategies to Prevent Healthcare-Associated Infections in Acute Care Hospitals published by SHEA-IDS (in partnership with The Joint Commission, Association for Professionals in Infection Control and Epidemiology, and the American Hospital Association) emphasizes the importance of reducing these infections and includes a guideline of practice recommendations to address them.⁹

An Example from...

Bloomington Hospital - Bloomington, IN

Cost savings:

Before implementation of the Ventilator Bundle, our hospital was averaging 8 VAP/year in our medical/surgical unit. Since the implementation of this work, we had no VAPs from September 2005 - April 2008. We had 1 VAP in 2008 and 1 VAP in 2009. Using an estimate of \$40,000/VAP, the hospital has saved \$1.2 million from January 2006 - December 2009 in the medical/surgical ICU alone.

⁶ Ibrahim EH, Tracy L, Hill C, et al. The occurrence of ventilator-associated pneumonia in a community hospital: Risk factors and clinical outcomes. *Chest*. 2001;20(2):555-561.

⁷ Rello J, Ollendorf DA, Oster G, et al. VAP Outcomes Scientific Advisory Group. Epidemiology and outcomes of ventilator-associated pneumonia in a large US database. *Chest*. 2002;22(6):2115-2121.

⁸ Tablan OC, Anderson LJ, Besser R, et al. CDC; Healthcare Infection Control Practices Advisory Committee. Guidelines for preventing health-care-associated pneumonia, 2003: Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. *MMWR Recomm Rep*. 2004;53(RR-3):1-36.

⁹ Yokoe DS, Mermel LA, Classen, D, et al. A compendium of strategies to prevent healthcare-associated infections in acute care hospitals. *Infect Control Hosp Epidemiol*. 2008; 29:S12-S21.

Potential Impact of the Ventilator Bundle

Applying IHI's Ventilator Bundle in the care of ventilated patients can markedly reduce the incidence of VAP. We have observed an average 45% reduction in the incidence of VAP in a prior ICU collaborative improvement project at IHI. Moreover, there is a trend toward greater success among teams that comply fully with the elements of the bundle. That is, teams that unflinchingly implement every bundle element on every patient, every time, have gone months without a single case of pneumonia associated with the ventilator. In the IHI 100,000 Lives Campaign, over 30 hospitals reported more than one year of data with no VAP in their measured population (n.b., not all hospitals reporting measured the same population due to local differences in patients).

The reasons for the success are most likely due to the effect of the underlying interventions, as well as to the teamwork that is developed while carrying out the required care reliably. With regard to specific interventions, consider that in a randomized controlled trial of 86 intubated patients on mechanical ventilation assigned to semi-recumbent (45 degrees) or supine position, there were 18% fewer confirmed cases of VAP ($p=0.018$).¹⁰

In another study, Kress et al. conducted a randomized controlled trial in 128 adults on mechanical ventilation and demonstrated that for patients whose sedation was interrupted daily until the patient was awake, as compared to patients whose sedation was interrupted only at the clinician's discretion, the duration of ventilation was decreased from 7.3 days to 4.9 days ($p=0.004$).¹¹

These findings and others have contributed to the construction of the Ventilator Bundle and to its success in preventing VAP.

¹⁰ Drakulovic MB, Torres A, Bauer TT, et al. Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: A randomised trial. *Lancet*. 1999;354(9193):1851-1858.

¹¹ Kress JP, Pohlman AS, O'Connor MF, et al. Daily interruption of sedative infusions in critically ill patients undergoing mechanical ventilation. *N Engl J Med*. 2000;342(20):1471-1477.

Preventing Ventilator-Associated Pneumonia: Five Components of Care

1. Elevation of the Head of the Bed

Elevation of the head of the bed is an integral part of the Ventilator Bundle and has been correlated with reduction in the rate of ventilator-associated pneumonia. The recommended elevation is between 30 and 45 degrees.

Drakulovic et al. conducted a randomized controlled trial in 86 mechanically ventilated patients assigned to semi-recumbent or supine body position. The trial demonstrated that suspected cases of ventilator-associated pneumonia had an incidence of 34%, while in the semi-recumbent position suspected cases had an incidence of 8% ($p=0.003$). Similarly, confirmed cases were 23% and 5% respectively ($p=0.018$).¹²

While it is not immediately clear whether the intervention aids in the prevention of ventilator-associated pneumonia by decreasing the risk of aspiration of gastrointestinal contents or oropharyngeal and nasopharyngeal secretions, this was the ostensible reason for the initial recommendation.

Another reason that the intervention was suggested was to improve patients' ventilation. For example, patients in the supine position will have lower spontaneous tidal volumes on pressure support ventilation than those seated in an upright position. Although patients may be on mandatory modes of ventilation, the improvement in position may aid ventilatory efforts and minimize atelectasis.

Some concerns with regard to this position have included patients sliding down in bed and, if skin integrity is compromised, shearing of skin. Others have commented on the possibility of patient discomfort. Although it is difficult to assess for these concerns in a controlled manner, anecdotal experience is that neither has been a complaint of care from providers or from patients, once they are off the ventilator and able to speak.

Another randomized controlled trial was completed in the Netherlands that challenged the feasibility of keeping the head of the bed elevated in mechanically ventilated patients. While the purported benefits were not directly challenged, there was great evidence to suggest that keeping the head of the bed at 45 degrees is a more challenging task than would be otherwise imagined. This work underscores the difficulty of keeping the head of the bed elevated and the low reliability with which care teams have been able to maintain this standard under routine conditions.¹³

¹² Drakulovic MB, Torres A, Bauer TT, Nicolas JM, Nogue S, Ferrer M. Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: A randomised trial. *Lancet*. Nov 27 1999;354(9193):1851-1858.

¹³ van Nieuwenhoven CA, Vandenbroucke-Grauls C, van Tiel FH, et al. Feasibility and effects of the semirecumbent position to prevent ventilator-associated pneumonia: A randomized study. *Crit Care Med*. 2006 Feb;34(2):396-402.

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What changes can we make that will result in improvement?

Hospital teams across the United States have developed and tested process and system changes that allowed them to improve performance on elevation of the head of the bed. These measures, taken together, support the implementation of the Ventilator Bundle. Some of these changes are:

- Implement a mechanism to ensure head-of-the-bed elevation, such as including this intervention on nursing flow sheets and as a topic at multidisciplinary rounds.
- Create an environment where respiratory therapists work collaboratively with nursing to maintain head-of-the-bed elevation.
- Involve families in the process by educating them about the importance of head-of-the-bed elevation and encourage them to notify clinical personnel when the bed does not appear to be in the proper position.
- Use visual cues so it is easy to identify when the bed is in the proper position, such as a line on the wall that can only be seen if the bed is below a 30-degree angle.
- Include this intervention on order sets for initiation and weaning of mechanical ventilation, delivery of tube feedings, and provision of oral care.
- Post compliance with the intervention in a prominent place in your ICU to encourage change and motivate staff.

2. Daily Sedative Interruption and Daily Assessment of Readiness to Extubate

Using daily sedative interruptions and assessing the patient's readiness to extubate are an integral part of the Ventilator Bundle and have been correlated with reduction in the rate of ventilator-associated pneumonia.

Kress et al. conducted a randomized controlled trial in 128 adult mechanically ventilated patients receiving continuous infusion of sedative agents in a medical intensive care unit. Patients were randomized to receive daily interruption of sedation until awake versus management at the clinician's discretion. Daily interruption resulted in a highly significant reduction in time spent on mechanical ventilation. The duration of mechanical ventilation decreased from 7.3 days to 4.9 days ($p=0.004$).

In the trial, an investigator interrupted the sedation each day until the patients were awake and could follow instructions or until they became uncomfortable or agitated and were deemed to require the resumption of sedation. A nurse evaluated the patients each day throughout the period when infusions were stopped until the patients were either awake or uncomfortable and in need of resumed sedation. This nurse immediately contacted a study physician when a patient awakened, at which time the study physician examined the patient and decided whether to resume the infusions. The sedative infusions were started again after the patient was awake or, if agitation prevented successful waking, at half the previous rates and were adjusted according to the need for sedation. For complete details as well as handling special circumstances such as use of paralytic agents, please refer to the actual trial.¹⁴

Based on this study, it appears that lightening sedation decreases the amount of time spent on mechanical ventilation and therefore the risk of ventilator-associated pneumonia. In addition, weaning patients from ventilators becomes easier when patients are able to assist themselves at extubation with coughing and control of secretions.

Sedative interruptions are not without certain risks, however. For instance, there is a fear that patients who are not deeply sedated may have an increased potential for self-extubation. With experience however, this has not been shown to be the case; in fact, intubated patients randomized to be treated with no sedation did not have an increased rate of unplanned extubations.¹⁵ In addition, some have suggested that there may be an increased potential for pain and anxiety associated with lightening sedation. Lastly, increased tone and poor synchrony with the ventilator during the maneuver may risk episodes of desaturation.

Despite these concerns, a comparison of patients receiving sedation interruption versus those patients whose sedation was managed at a clinician's discretion demonstrates that patients receiving sedation interruption exhibit fewer overall complications. The Kress study data were reviewed in a post-hoc

¹⁴ Kress JP, Pohlman AS, O'Connor MF, Hall JB. Daily interruption of sedative infusions in critically ill patients undergoing mechanical ventilation. *N Engl J Med.* 2000;342(20):1471-1477.

¹⁵ Thomas Strøm, Torben Martinussen, Palle Toft. A protocol of no sedation for critically ill patients receiving mechanical ventilation: a randomised trial. *Lancet* 2010; 375: 475–80.

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analysis and seven distinct complications associated with mechanical ventilation and critical illness were identified: 1) ventilator-associated pneumonia; 2) upper gastrointestinal hemorrhage; 3) bacteremia; 4) barotrauma; 5) venous thromboembolic disease; and 6) cholestasis or 7) sinusitis requiring surgical intervention. Patients undergoing daily interruption of sedative infusions experienced 13 complications (2.8%) vs. 26 complications (6.2%) in those patients subjected to conventional sedation techniques ($p = .04$). The authors concluded that daily interruption of sedative infusions reduced intensive care unit length of stay and, in turn, decreased the incidence of complications of critical illness associated with prolonged intubation and mechanical ventilation.¹⁶

Patients who receive sedation interruption do not appear to be at risk for worse psychological outcomes after critical illness compared with conventional therapies.¹⁷

There is some evidence that daily weaning assessments reduce the duration of mechanical ventilation.^{18,19}

What changes can we make that will result in improvement?

Hospitals' improvement teams from across the United States have developed and tested process and system changes that have allowed them to improve performance on daily sedative interruptions and daily assessment of readiness to extubate. Daily sedation interruption and daily assessment of readiness to extubate are separate, though at times interdependent, processes. Separating the elements can focus a team's work on developing protocols, order sets, standard work for sedation interruption, and weaning assessment. For measurement of compliance with the Ventilator Bundle, though, we count these as one. These measures, taken together, support the implementation of the Ventilator Bundle. Some of these changes are:

- Implement a protocol to lighten sedation daily at an appropriate time to assess for neurological readiness to extubate. Include precautions to prevent self-extubation such as increased monitoring and vigilance during the trial.
- Include a sedative interruption strategy in your overall plan to wean the patient from the ventilator; if you have a weaning protocol, add sedative interruption to that strategy.
- Assess compliance each day on multidisciplinary rounds.

¹⁶ Schweickert WD, Gehlbach BK, Pohlman AS, Hall JB, Kress JP. Daily interruption of sedative infusions and complications of critical illness in mechanically ventilated patients. *Crit Care Med*. 2004 Jun;32(6):1272-1276.

¹⁷ Kress JP, Gehlbach B, Lacy M, Pliskin N, Pohlman AS, Hall JB. The long-term psychological effects of daily sedative interruption on critically ill patients. *Am J Respir Crit Care Med*. 2003 Dec 15;168(12):1457-1461. Epub 2003 Oct 2.

¹⁸ Esteban A. A comparison of four methods of weaning patients from mechanical ventilation. *N Eng J Med*. 1995;332:345-350.

¹⁹ Ely EW. Effect on the duration of mechanical ventilation of identifying patients capable of breathing spontaneously. *N Engl J Med*. 1996;335:1864-1869.

- Consider implementation of a sedation scale such as the Richmond Agitation Sedation Scale (RASS)²⁰ scale to avoid oversedation.
- Post compliance with the intervention in a prominent place in your ICU to encourage change and motivate staff.

²⁰ Sessler CN, Gosnell M, Grap MJ, et al. The Richmond Agitation-Sedation Scale: Validity and reliability in adult intensive care patients. *Am J Respir Crit Care Med.* 2002;166:1338-1344.

3. Peptic Ulcer Disease (PUD) Prophylaxis

Stress ulcerations are the most common cause of gastrointestinal bleeding in intensive care unit patients, and the presence of gastrointestinal bleeding due to these lesions is associated with a five-fold increase in mortality compared to ICU patients without bleeding. Applying peptic ulcer disease prophylaxis is therefore a necessary intervention in critically ill patients. A concern about prophylactic therapy for stress ulceration has been the potential for increased risk of nosocomial pneumonia. Agents that raise gastric pH may promote the growth of bacteria in the stomach, particularly gram-negative bacilli that originate in the duodenum.

The extent to which reflux of gastric contents and secretions occurs even in healthy individuals suggests that critically-ill ventilated patients are susceptible to aspiration events. Worse, critically-ill intubated patients lack the ability to defend their airway. Esophageal reflux and aspiration of gastric contents along the endotracheal tube may lead to endobronchial colonization and pneumonia or may precipitate pneumonia due to the decreased bacterial killing in the low-acid environment. Elevating the head of the bed should reduce the amount of aspiration patients have.^{21,22}

Nevertheless, a meta-analysis of studies published prior to 1990 did not find an increased incidence of hospital-acquired pneumonia with elevation of gastric pH, although there was a trend towards a reduced rate of pneumonia with the prophylactic use of sucralfate as compared with pH-altering drugs. The American Thoracic Society/Infectious Disease Society of America guidelines concluded that because there is a trend for reduced VAP with sucralfate, but a slightly higher rate of gastric bleeding compared with the use of H₂ antagonists, the use of either an H₂ antagonist or sucralfate is acceptable.^{23,24}

PUD prophylaxis in the Ventilator Bundle is that provided with medications; H₂ blockers are preferred over sucralfate. Proton pump inhibitors (PPIs) may be efficacious, and an alternative to sucralfate or H₂ antagonist. They have become the standard of care in many ICUs now that the formulations are available in intravenous form (prior to the introduction of IV pantoprazole in 2001, they were only available orally). The evidence is that PPIs are at least as good as H₂ blockers, and possibly better. Proton pump inhibitors tend to provide more consistent pH control than histamine H₂ receptor antagonists. There is a paucity of data comparing these regimens, but the evidence that does exist indicates it is as good as H₂ blockers.^{25,26}

²¹ Cook DJ, Fuller HD, Guyatt GH, et al. Risk factors for gastrointestinal bleeding in critically ill patients. *N Engl J Med*. 1994;330(6):377-381.

²² Navab F, Steingrub J. Stress ulcer: Is routine prophylaxis necessary? *Am J Gastroenterol*. 1995;90(5):708-712.

²³ Cook DJ, Laine LA, Guyatt GH, Raffin TA. Nosocomial pneumonia and the role of gastric pH: A meta-analysis. *Chest*. 1991;100(1):7-13.

²⁴ American Thoracic Society; Infectious Diseases Society of America. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. *Am J Respir Crit Care Med*. 2005;171(4):388-416.

²⁵ Steinberg KP. Stress-related mucosal disease in the critically ill patient: Risk factors and strategies to prevent stress-related bleeding in the intensive care unit. *Crit Care Med*. 2002;30(6 Suppl):S362-S364.

Questions arise as to whether PUD prophylaxis is appropriate due to risk of *C. difficile*. Use of any gastric acid suppressive agent could be a risk factor for *C. difficile*, and ICU patients might be receiving several things that increase the risk of *C. difficile*. PPIs and H2 blockers have been associated with *C. diff* in community-acquired disease, and although there do not appear to be reports in the literature about ICU-acquired *C. diff* associated with this, it stands to reason that there may be an association in hospital-acquired *C. diff*. For ventilated patients in the ICU setting, stress ulcer prophylaxis may be more beneficial than the potential for this risk. As with any clinical intervention, the risk/benefit analysis must occur to ensure that the patient receives care that has greater potential benefit than risk.²⁷

It is important to note that this is not a requirement to provide prophylaxis in cases where the physician believes the risks outweigh the benefits. In such cases, as long as there is dialogue among the clinical team regarding the appropriateness of the intervention and the reasons for an alternate decision are documented, the intent of the Ventilator Bundle has been met.

What changes can we make that will result in improvement?

Hospital teams across the United States have developed and tested process and system changes that allowed them to improve performance on peptic ulcer disease prophylaxis. These measures, taken together, support the implementation of the Ventilator Bundle. Some of these changes are:

- Include peptic ulcer disease prophylaxis as part of your ICU order admission set and ventilator order set. Make application of prophylaxis the default value on the form.
- Include peptic ulcer disease prophylaxis as an item for discussion on daily multidisciplinary rounds. Count this item as “met” if the discussion occurs and is documented, even if there is a decision not to provide this intervention.
- Empower pharmacy to review patients in the ICU to ensure that some form of peptic ulcer disease prophylaxis is provided for all appropriate ICU patients.
- Post compliance with the intervention in a prominent place in your ICU to encourage change and motivate staff.

²⁶ Conrad SA, Gabrielli A, Margolis B, et al. Randomized, double-blind comparison of immediate-release omeprazole oral suspension versus intravenous cimetidine for the prevention of upper gastrointestinal bleeding in critically ill patients. *Crit Care Med.* 2005;33(4):760-765.

²⁷ Dial S, Delaney JA, Barkun AN, Suissa S. Use of gastric acid-suppressive agents and the risk of community-acquired *Clostridium difficile*-associated disease. *JAMA.* 2005;294(23):2989-2995.

4. Deep Venous Thrombosis (DVT) Prophylaxis

Applying deep venous thrombosis prophylaxis is an appropriate intervention in all patients who are sedentary; however, the higher incidence of deep venous thrombosis in critical illness justifies greater vigilance.

The risk of venous thromboembolism is reduced if prophylaxis is consistently applied. A clinical practice guideline issued as part of the Seventh American College of Chest Physicians Conference on Antithrombotic and Thrombolytic Therapy recommends prophylaxis for patients undergoing surgery, trauma patients, acutely ill medical patients, and patients admitted to the intensive care unit. The level of cited evidence was that of several randomized controlled trials.²⁸

While it is unclear if there is any association between DVT prophylaxis and decreasing rates of ventilator-associated pneumonia, our experience is that VAP rates decreased most dramatically in hospitals where all elements of the Ventilator Bundle were implemented, including this one. The intervention remains excellent practice in the general care of ventilated patients.

Important considerations include that the risk of bleeding may increase if anticoagulants are used to accomplish prophylaxis. When prophylactic anticoagulation cannot be used because of high risk of bleeding, sequential compression devices may be used. Often, sequential compression devices are not applied reliably to patients when they go to or return from procedures negating their effectiveness.

What changes can we make that will result in improvement?

Hospital teams across the United States have developed and tested process and system changes that allowed them to improve performance on deep venous thrombosis prophylaxis. These measures, taken together, support the implementation of the Ventilator Bundle. Some of these changes are:

- Include deep venous thrombosis prophylaxis as part of your ICU order admission set and ventilator order set. Make application of prophylaxis the default value on the form.
- Include deep venous thrombosis prophylaxis as an item for discussion on daily multidisciplinary rounds. Count this item as “met” if the discussion occurs and is documented, even if there is a decision not to provide this intervention.
- Empower pharmacy to review orders for patients in the ICU to ensure that some form of deep venous thrombosis prophylaxis is in place at all times on ICU patients.
- Post compliance with the intervention in a prominent place in your ICU to encourage change and motivate staff.

²⁸ Geerts WH, Pineo GF, Heit JA, et al. Prevention of venous thromboembolism: The Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. *Chest*. 2004;126(3 Suppl):338S-400S.

5. Daily Oral Care with Chlorhexidine

IHI added this fifth element of care to the Ventilator Bundle in May 2010 following continued review of the literature and use of the element in the Ventilator Bundle in Scotland for over a year.

Dental plaque biofilms are colonized by respiratory pathogens in mechanically ventilated patients. Dental plaque develops in patients that are mechanically ventilated because of the lack of mechanical chewing and the absence of saliva, which minimizes the development of biofilm on the teeth. Dental plaque can be a significant reservoir for potential respiratory pathogens that cause ventilator-associated pneumonia. Chlorhexidine antiseptic has long been approved as an inhibitor of dental plaque formation and gingivitis. As early as 1996, DeRiso and colleagues published a study which provided evidence to support the use of 0.12% chlorhexidine oral rinse as a prophylactic measure to reduce nosocomial respiratory tract infections in cardiac surgery patients.²⁹

Since that time there has been much discussion about the utilization of chlorhexidine as an important adjunct to oral hygiene, but there have been few studies published that provide firm evidence that the use of chlorhexidine as a decontamination antiseptic reduces the incidence of ventilator-associated pneumonia. Chlorhexidine has been studied in two strengths: 0.12% and 0.2%. The US Food and Drug Administration recommends 0.12% oral chlorhexidine for use as mouth rinse. In a meta-analysis by Chan and colleagues published in 2007 in the *British Medical Journal*, eleven studies were evaluated for effect of oral decontamination on the incidence of ventilator-associated pneumonia and mortality in mechanically ventilated adults. Results of that analysis concluded that oral decontamination of mechanically ventilated adults using chlorhexidine is associated with a lower risk of ventilator-associated pneumonia.³⁰

There is little, if any, evidence of other oral care processes having an effect on the development of VAP, but it makes sense that good oral hygiene and the use of antiseptic oral decontamination reduces the bacteria on the oral mucosa and the potential for bacterial colonization in the upper respiratory tract. This reduction in bacteria has been shown to reduce the potential for the development in ventilator-associated pneumonia for patients on mechanical ventilation.³¹

²⁹ DeRiso AJ, Ladowski JS, Dillon TA, Justice JW, Peterson AC. Chlorhexidine gluconate 0.12% oral rinse reduces the incidence of total nosocomial respiratory infection and nonprophylactic systemic antibiotic use in patients undergoing heart surgery. *Chest*. 1996;109:1556-1561.

³⁰ Chan EY, Ruest A, O'Meade M, Cook DJ. Oral decontamination for prevention of pneumonia in mechanically ventilated adults: Systematic review and meta-analysis. *BMJ*. 2007; 334(7599):889. Epub 2007 Mar 26.

³¹ Munro CL, Grap MJ, Jones DI, McClish DK, Sessler CN. Chlorhexidine, tooth brushing and preventing ventilator-associated pneumonia in critically ill adults. *Am J Crit Care*. 2009 Sep;18(5):428-437.

How-to Guide: Prevent Ventilator-Associated Pneumonia

What changes can we make that will result in improvement?

Hospital teams across the United States have developed and tested process and system changes that allowed them to improve performance on daily oral care with chlorhexidine. These measures, taken together, support the implementation of the Ventilator Bundle. Some of these changes are:

- Include daily oral care with chlorhexidine as part of your ICU order admission set and ventilator order set. Make application of prophylaxis the default value on the form.
- Include daily oral care with chlorhexidine as an item for discussion on daily multidisciplinary rounds. Count this item as “met” if the discussion occurs and is documented, even if there is a decision not to provide this intervention.
- Post compliance with the intervention in a prominent place in your ICU to encourage change and motivate staff.
- Educate the RN staff about the rationale supporting good oral hygiene and its potential benefit in reducing ventilator-associated pneumonia.
- Develop a comprehensive oral care process that includes the use of 0.12% chlorhexidine oral rinse.
- Schedule chlorhexidine as a medication, which then provides a reminder for the RN and triggers the oral care process delivery.

Forming the Team

IHI recommends a multidisciplinary team approach to ventilator care. Improvement teams should be heterogeneous in make-up, but homogeneous in mindset. The value of bringing diverse personnel together is that all members of the care team are given a stake in the outcome and work to achieve the same goal. In ventilator care, the team should include intensive care physicians, intensive care nurses, respiratory therapists, and pharmacists.

All the stakeholders in the process must be included, in order to gain the buy-in and cooperation of all parties. For example, teams without nurses are bound to fail. Teams led by nurses and therapists may be successful, but often lack leverage; physicians must also be part of the team.

Some suggestions to attract and retain excellent team members include using data to define and solve the problem; finding champions within the hospital who are of sufficiently high profile to lend the effort immediate credibility; and working with those who want to work on the project, rather than trying to convince those who do not.

The team needs encouragement and commitment from an authority in the intensive care unit. Identifying a champion increases a team’s motivation to succeed. When measures are not improving fast enough, the champion re-addresses the problems with staff and helps to keep everybody on track toward the aims and goals.

Eventually, the changes that are introduced become established. At some point, however, changes in the field or other changes in the ICU will require revisiting the processes that have been developed. Identifying a “process owner,” a person who is responsible for the functioning of the process now and in the future, helps to maintain the long-term integrity of the effort.

An Example from...

Our Lady of Lourdes Memorial Hospital – Binghamton, NY

The key to our success is the teamwork demonstrated by our Respiratory Therapists, Pulmonologists, and our ICU nurses. It is routine for this team, on a daily basis, to begin sedation vacation, and then a breathing trial to ascertain whether a patient is a candidate to initiate a weaning trial.

Setting Aims

Improvement requires setting aims. An organization will not improve without a clear and firm intention to do so. The aim should be time-specific and measurable; it should also define the specific population of patients that will be affected. Agreeing on the aim is crucial; so is allocating the people and resources necessary to accomplish the aim.

An example of an aim that would be appropriate for reducing ventilator-associated pneumonia can be as simple as, “Decrease the rate of VAP by implementing all elements of the Ventilator Bundle for more than 95% of ventilator patients in the ICU within one year.”

Teams are more successful when they have unambiguous, focused aims. Setting numerical goals clarifies the aim, helps to create tension for change, directs measurement, and focuses initial changes. Once the aim has been set, the team needs to be careful not to back away from it deliberately or “drift” away from it unconsciously.

Using the Model for Improvement

In order to move this work forward, IHI recommends using the Model for Improvement. Developed by Associates in Process Improvement, the Model for Improvement is a simple yet powerful tool for accelerating improvement that has been used successfully by hundreds of health care organizations to improve many different health care processes and outcomes.

The model has two parts:

- Three fundamental questions that guide improvement teams to 1) set clear aims, 2) establish measures that will tell if changes are leading to improvement, and 3) identify changes that are likely to lead to improvement. (The second question can also be part of the process of improvement.) If data is collected in real time it is a powerful tool to improve reliability by acting like a checklist. The early feedback of data to the clinicians is also very powerful in improving reliability.
- The Plan-Do-Study-Act (PDSA) cycle to conduct small-scale tests of change in real work settings — by planning a test, trying it, observing the results, and acting on what is learned. This is the scientific method, used for action-oriented learning.

An Example from...

St. Luke's Hospital – Cedar Rapids, IA

Another key to success was implementation of Plan-Do-Study-Act, which allowed us to apply concepts of reliability and increase our compliance with 100% of all five components of the bundle occurring 100% of the time. Adding event review when a VAP is suspected allows time for the team to evaluate implementation of the bundle, and to reflect on any changes in practice or tests of change that might be needed.

Implementation: After testing a change on a small scale, learning from each test, and refining the change through several PDSA cycles, the team can implement the change on a broader scale — for example, test medication reconciliation on admissions first.

Spread: After successful implementation of a change or package of changes for a pilot population or an entire unit, the team can spread the changes to other parts of the organization or to other organizations.

You can learn more about the [Model for Improvement](http://www.ihl.org) on www.ihl.org. See an example completed PDSA Worksheet on the following page.



PDSA Worksheet

CYCLE: 1

DATE: 6/10/11

Project: Ventilator-Associated Pneumonia - Daily Goals Assessment

Objective for this PDSA Cycle: Test the use of a daily assessment form to achieve compliance with the Ventilator Bundle.

Plan:

Questions: Will the use of the Daily Goals Assessment form ensure total Ventilator Bundle compliance?

Predictions: Using the Daily Goals Assessment form during daily rounds will help ensure total compliance with all elements of the Ventilator Bundle appropriate for patient.

Plan for change or test – who, what, when, where:

What: Use the Daily Goals Assessment form at daily rounds for one day.

Who: Mike (physician in charge of rounds) and others who attend rounds.

Where: Patient rooms

When: Tomorrow

Plan for collection of data – who, what, when, where:

Who: Mike (physician in charge of rounds) leaves form on patient chart, nurse on improvement team reviews form for compliance with all Ventilator Bundle components.

What: Record compliance with all Ventilator Bundle elements.

When: During daily rounds

Where: Daily Goals Assessment form on patient chart

Do:

Carry out the change or test. Collect data and begin analysis.

On Monday, the form was used during daily rounds. A form was completed and placed on each patient chart during the rounding process.

Study:

Complete analysis of data: 50% of the patients had all elements of the bundle in place at the time of rounds.

How did or didn't the results of this PDSA cycle agree with the predictions that we made earlier?

The form made it easier to document bundle compliance, but its use did not improve it on first day.

Summarize the new knowledge we gained by this cycle:

We need to do some additional tests to improve compliance with the bundle so that on next rounds the numbers are improved.

Act:

List actions we will take as a result of this cycle: Team will meet to develop additional tests.

Plan for the next cycle (adapt change, another test, implementation cycle?): We will use the form again tomorrow to track our data.

Getting Started

Hospitals will not successfully implement the Ventilator Bundle overnight. If they do, chances are that they are doing something suboptimally. A successful program involves careful planning, testing to determine if the process is successful, making modifications as needed, retesting, and careful implementation.

- Select the team and the venue. Many hospitals will have only one ICU, making the choice easier.
- Assess the current state in your hospital. Does the respiratory therapy department have a process in place now for ventilator care to prevent pneumonia? If so, work with the department to begin preparing for changes.
- Contact the infectious diseases department. Learn about your ventilator-associated pneumonia rate and how frequently the hospital reports it to regulatory agencies.
- Organize an educational program. Teaching the core principles to the respiratory therapy department as well as to the ICU staff (doctors, nurses, therapists, and others) will open many people's minds to the process of change.
- Introduce the Ventilator Bundle to the key stakeholders in the process.

First Test of Change

Once a team has prepared the way for change by studying the current process and educating the key stakeholders, the next step is to begin testing the Ventilator Bundle at your institution.

- Begin using the bundle with one patient from the time of initiation of mechanical ventilation.
- Work with each nurse and respiratory therapist who cares for the patient to be sure they are able to follow the recommended elements of care in the bundle.
- Make sure that the approach is carried over from shift to shift, to eliminate gaps in teaching and utilization.
- Process feedback and incorporate suggestions for improvement.
- Once the bundle has been applied to one patient in the first PDSA test of change, increase utilization to the remainder of the ICU.
- Engage in subsequent PDSA cycles to refine the process and make it more reliable.

Measurement

There is only one way to know if a change represents an improvement: measurement.

See Appendix B for detailed information about the recommended process and outcomes measures for this intervention.

1. VAP Rate per 1,000 Ventilator Days

The total number of cases of ventilator-associated pneumonia for a particular time period, reported as a rate per 1,000 ventilator days.

For example, if in February there were 12 cases of VAP, the number of cases would be 12 for that month. We want to be able to understand that number as a proportion of the total number of days that patients were on ventilators. Thus, if 25 patients were ventilated during the month and each, for purposes of example, was on mechanical ventilation for 3 days, the number of ventilator days would be $25 \times 3 = 75$. The Ventilator-Associated Pneumonia Rate per 1,000 ventilator days then would be $12/75 \times 1000 = 160$.

$$\frac{\text{Total no. of VAP Cases}}{\text{Ventilator Days} \times 1000} = \text{VAP Rate per 1,000 Ventilator Days}$$

Tip for measurement

If you are implementing the Ventilator Bundle in one intensive care unit, collect the VAP rate for that unit only so that you can measure the results. Your infection control department may have hospital-wide data on this and may be able to assist you with segmenting out the area in which you start the work.

2. Ventilator Bundle Compliance

In our experience, teams begin to demonstrate improvement in outcomes when they provide all five components of the Ventilator Bundle. Therefore, we choose to measure compliance with the entire Ventilator Bundle, not just parts of the bundle.

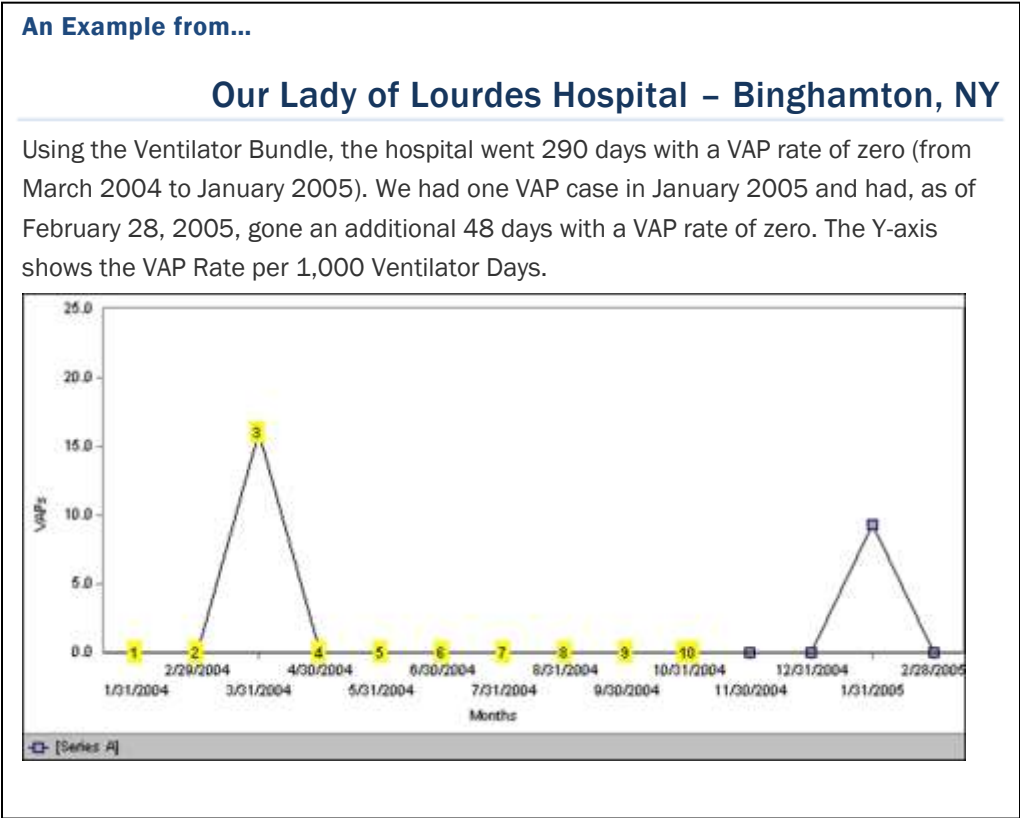
On a given day, select all the ventilated patients and assess them for compliance with the Ventilator Bundle. If even one bundle component is missing, the case is not in compliance with the bundle. For example, if there are 7 ventilated patients, and 6 patients have all 5 bundle elements completed, then 6/7 (86%) is the compliance with the Ventilator Bundle. If all 7 ventilated patients had all 5 elements completed, compliance would be 100%. If all 7 were missing even a single element, compliance would be 0%.

$$\frac{\text{No. ventilated patients receiving ALL 5 Ventilator Bundle elements}}{\text{No. patients on ventilators for the day of the sample}} = \text{Reliability of Ventilator Bundle Compliance}$$

Track Measures Over Time

Improvement takes place over time. Determining if improvement has really occurred and if it is a lasting effect requires observing patterns over time. Run charts are graphs of data over time and are one of the single most important tools in performance improvement. Using run charts has a variety of benefits:

- They help improvement teams formulate aims by depicting how well (or poorly) a process is performing.
- They help in determining when changes are truly improvements by displaying a pattern of data that you can observe as you make changes.
- They give direction as you work on improvement and information about the value of particular changes.



Barriers That May Be Encountered

- **Fear of change**

All change is difficult. The antidote to fear is knowledge about the deficiencies of the present process and optimism about the potential benefits of a new process.

- **Communication breakdown**

Organizations have not been successful when they failed to communicate with staff about the importance of ventilator care, as well as when they failed to provide ongoing teaching as new staff become involved in the process.

An Example from...

Claxton-Hepburn Medical Center – Ogdensburg, NY

- Provided both formal and informal education to all involved disciplines on VAP, as well as evidence-based strategies proven to reduce VAP occurrence.
- Shared feedback with providers regarding successes in reducing VAP.

- **Physician and staff “partial buy-in”** (i.e., “Just another flavor of the week?”)

In order to enlist support and engage staff, it is important to share baseline data on VAP rates and to share the results of improvement efforts. If the run charts suggest a large decrease in VAP compared to baseline, issues surrounding “buy-in” tend to fade.

- **Unplanned extubations**

Perhaps the most risky aspect of lightening the sedation that the patient is receiving daily is the chance that patients might self-extubate. This risk can be diminished by ensuring that the process is adequately supervised and that appropriate restraints are applied to the patient’s arms in a comfortable fashion.

Work to Achieve a High Level of Compliance

Our analysis of the hospitals that have used the Ventilator Bundle to date shows that the greater the level of compliance with implementing all five elements of the bundle, the better the reduction in the VAP rate.

Several hospitals have achieved greater than 95% compliance with the bundle. Those hospitals tend to have the fewest cases of VAP. For example, some unpublished data from IHI initiatives (prior to the addition of the fifth element in the bundle) shows the following:

Level of Reliability (compliance with all bundle elements):	Reduction in VAP Rate:
Unchanged	22%
<95% compliance	40%
>95% compliance	61%

Tips for Gathering Data

Use a data collection form that allows you to track compliance with the bundle elements over time. Using a data collection form makes it easier to create run charts each month as well. One hospital, Dominican Hospital (Santa Cruz, CA), uses a Ventilator Bundle Checklist to help track the process. (See Appendix A.)

Note that the checklist is particularly effective if used in conjunction with a Daily Goals Assessment form that can be completed during daily rounds on the patient. (See Appendix A.)

Tips and Tricks: Ventilator-Associated Pneumonia

In addition to the specific recommendations in the How-to Guide for each element of the bundle and recommendations regarding where to begin, here are a few strategies that have proven most effective for the best-performing hospitals:

- **Customize the program.**

Making this initiative fit into the patterns and habits at your institution is essential. Teams will be most effective if they engage doctors, nurses, and respiratory therapists to work with them to develop key aspects of the implementation at their respective institutions. For example, it is critical that teams determine some set of criteria by which they will define ventilator-associated pneumonia in their institution even with use of the CDC definition. Once this has been established, all stakeholders will share a common understanding of what exactly qualifies as a VAP and what does not.

- **Measure, but do not become pre-occupied with measurement.**

Working on VAP (or any clinical performance program) requires measurement, but measurement should not become the pre-occupation of the teams engaging in the work. While feedback on performance and compliance may drive further efforts forward, if teams become too focused on measurement details it can hinder the overall program. It is best to design rules that assist your team in making your plans work; for example, assign credit for completion of bundle elements where your team has determined there are true contraindications to bundle elements. Undue attention on unusual cases or special circumstances will impede success. Plan for the majority.

- **Decide early about the method of data collection you will use.**

Some teams have preferred to use a sampling approach to assess compliance with the Ventilator Bundle. For example, some teams use spot checks of compliance three times per week, whereas other teams have chosen daily assessments of compliance at designated times. Regardless of the method, be sure to maintain the standard over time for accurate results.

- **Emphasize compliance with all elements of the bundle.**

Approach the work with the knowledge that “picking and choosing” bundle elements will not work. Discourage the tendency to select interventions that seem easy at the expense of more difficult options also included in the bundle. Your aim is 100% compliance with every bundle element for every patient; partial compliance is the equivalent of non-compliance. Remember, though, to give credit for compliance if a bundle element is not given for clinically appropriate reasons, provided that the discussion with the team occurred and it is clearly documented.

- **Post updates to results regularly and prominently.**

Enthusiasm for the project will wane over time if clinical staff perceives that the leadership's enthusiasm has diminished. It is essential to regularly update all involved staff in the work on the monthly level of compliance and the monthly change in VAP rates. Not only will this show dedication to the project; when the momentum becomes apparent, clinical staff will be aware of the progress.

Frequently Asked Questions: Ventilator-Associated Pneumonia

Can I implement most of the Ventilator Bundle, but exclude some items?

While this is possible, it is not recommended. In fact, the goal of bundling therapies together aims to create a linkage between practices that makes the overall process more effective. Certainly, in terms of monitoring compliance with the Ventilator Bundle, “picking and choosing” items would be unwise.

How can you compare ventilator-associated pneumonia rates between institutions?

The practice of comparing rates of disease entities or patterns of therapy across institutions is commonly known as “benchmarking.” Benchmarking, while presently utilized by many oversight agencies to track performance, may not be a valid method to compare performance between facilities because of differences in patient population, resource availability, or severity of illness.

Fortunately, none of the work required to improve the care of ventilated patients requires a comparison of rates between institutions. In addition, as long as you establish methods in your institution to determine the patterns and methods of your regular data collection, your results will be consistent over time with respect to your own performance and your own improvement, which is our primary interest. Presumably, any improvements you make would be reflected in any benchmarking work that you do for other agencies. You should also learn what strategies hospitals reporting improvement have used; even if their definition or their population is a bit different from yours, if they have measured consistently over time they may have some great lessons from which you can learn.

We’re having difficulty implementing head-of-the-bed compliance. What are some tips?

- Place a reminder poster on the wall at the head of the patient's bed.
- Perform spot checks and present aggregate data for the percent compliance in your ICU to staff visibly and regularly.
- Make head-of-the-bed elevation part of a daily goals sheet for each patient.
- Bring a protractor into the ICU to show staff exactly what 45 degrees elevation looks like. Once you have measured 45 degrees for that bed, place a piece of colored tape on the wall behind the bed and verify compliance during vent checks.
- If you are using an ICU flow sheet (electronic or paper), include a box for documentation of head-of-bed angle (every 4-6 hours, for example).

What are the inclusion and exclusion criteria for the Ventilator Bundle? For the individual bundle elements?

No specific exclusion criteria exist, but good clinical judgment should be exercised in conjunction with a close reading of the evidence cited in the How-to Guide. Likewise, no specific inclusion criteria are available. Instead, teams interested in improving their performance should develop these standards in conjunction with their clinical staff and apply them uniformly over time. In so doing, teams will have an accurate standard whereby they can measure their own progress in comparison to the only standard that is truly meaningful: their own data.

As an example, some institutions have proposed criteria for excluding patients from various parts of the bundle. One institution excludes patients from interruption of sedation if any of the following criteria apply:

- Open abdominal wound in which fascia is not closed, unless ordered by a physician.
- Intracranial Pressure > 20, unless ordered by a physician.
- Severe O2 desaturation while on FiO2 > 90%, unless ordered by a physician.

Workable inclusion criteria, exclusion criteria, measurement systems, and protocols all require customization at the local level to be effective. The only key factor in all of these decisions is that the standards, once decided, are adhered to over time.

I am looking for policy/procedures on how to conduct a sedative interruption? Can anyone help me with this?

The best resource to understand the procedures used is the original article (Kress JP, Pohlman AS, O'Connor MF, Hall JB. Daily interruption of sedative infusions in critically ill patients undergoing mechanical ventilation. *N Engl J Med.* May 18 2000;342(20):1471-1477). In the study, an investigator interrupted the sedation each day until the patients were awake and could follow instructions or until they became uncomfortable or agitated and were deemed to require the resumption of sedation. A nurse evaluated the patients each day throughout the period when infusions were stopped until the patients were either awake or uncomfortable and in need of resumed sedation. This nurse immediately contacted a study physician when a patient awakened, at which time the study physician examined the patient and decided whether to resume the infusions. The sedative infusions were started again after the patient was awake or, if agitation prevented successful waking, at half the previous rates and were adjusted according to the need for sedation. For patients receiving paralytic agents, a slightly modified procedure was used.

Some people use sedation scales to manage over sedation. Is this a reasonable substitute for the interruption of sedation in the bundle?

The use of subjective and objective criteria may be helpful in maintaining the desired level of sedation, despite changes in medical personnel and sedation goals. Although no true reference measure or criterion exists for sedation assessment, several subjective patient assessment scoring systems have been developed, including the following:

- Motor Activity Assessment Scale (MAAS), the Sedation-Agitation Scale (SAS), and the Richmond Agitation-Sedation Scale (RASS).
- Devlin JW, Boleski G, Mlynarek M, et al. Motor Activity Assessment Scale: A valid and reliable sedation scale for use with mechanically ventilated patients in an adult surgical intensive care unit. *Crit Care Med.* 1999;27:1271.
- Riker RR, Picard JT, Fraser GL. Prospective evaluation of the Sedation-Agitation Scale for adult critically ill patients. *Crit Care Med.* 1999;27:1325.
- Ely EW, Truman B, Shintani A, et al. Monitoring sedation status over time in ICU patients: reliability and validity of the Richmond Agitation-Sedation Scale (RASS). *JAMA.* 2003;289:2983.

However, these scales are not substitutes for the standard of interruption of sedation. In the Kress trial, patients were in fact subjected to both a sedation scale and interruption of sedation.

Should I include patients with tracheostomy in the Ventilator Bundle?

The Ventilator Bundle has primarily been tested on intubated patients, rather than those with tracheostomies, so we not have specific evidence to adequately tell you the effect of the Ventilator Bundle on this population. These patients may still benefit from the Ventilator Bundle components depending upon acuity. You should decide locally whether these patients should be included in your measurement, depending on factors such as these.

Should we apply the Ventilator Bundle to long-term or chronically ventilated patients?

The Ventilator Bundle was developed and tested in the intensive care setting, and the evidence supporting the elements are primarily in those populations. Some bundle elements may not be appropriate for these patients. For example, a patient with long-term ventilation is not likely to be sedated, may not need long-term DVT prophylaxis if ambulatory, and may be eating and have less risk of PUD. We would recommend that you not include this type of patient in Ventilator Bundle compliance measures.

Why is subglottic suctioning not included in the Ventilator Bundle?

The Ventilator Bundle was not developed with the goal of preventing VAP (see Development of the Ventilator Bundle), so some care processes commonly used to reduce risk of VAP were not included. This does not mean that these are not good practices to apply. Subglottic suctioning may be a very effective therapy for reducing the incidence of VAP. Recent studies have demonstrated efficacy of this approach. A meta-analysis assessed the effect of subglottic secretion drainage on the incidence of VAP and found that subglottic suctioning reduced the incidence of VAP by nearly half (risk ratio 0.51; 95% CI 0.37-0.71). Part of the aim of a bundle strategy is to implement solutions that are rapidly and readily available to hospitals. In addition, there is a tendency among providers to do all possible interventions, when a select few might be effective to minimize risks. Given the experience with the Ventilator Bundle that demonstrates near zero rates of VAP for prolonged periods of time with the 5 strategies that are included in the bundle when reliably applied, we have not added to the bundle. In addition, we encourage teams to maximize their implementation of the existing items in the Ventilator Bundle first before adding other approaches. The solution may in fact be doing just these items very well, instead of doing additional items fairly well.

Why are PUD and DVT prophylaxis part of the Ventilator Bundle when neither directly decreases VAP?

The Ventilator Bundle was designed as part of an overall strategy to improve the care of ventilated patients. The original intent was not to reduce VAP rates, but rather to provide best care for patients on ventilators. It is clear that ventilated patients require PUD prophylaxis to prevent stress ulceration and dangerous gastrointestinal bleeding, and DVT prophylaxis to prevent venous thromboembolism based on solid evidence. The requirement for PUD and DVT prophylaxis remains since it serves to underscore excellent ventilator care and raise awareness surrounding best ventilator practices.

Why is PUD prophylaxis a part of the Ventilator Bundle when it may not decrease VAP or increase the risk?

The Ventilator Bundle was designed as part of an overall strategy to improve the care of ventilated patients. The original intent was not to reduce VAP rates, but rather to provide best care for patients on ventilators.

What You Need to Know about Ventilator-Associated Pneumonia (VAP): A Fact Sheet for Patients and their Family Members

Ventilator-Associated Pneumonia (VAP) is a lung infection that can happen to patients who are on ventilators (machines to help them breathe). This infection is very serious. About 15 percent (1 or 2 out of 10) of patients on ventilators in hospitals get VAP. About half (50 out of 100) the patients with VAP die from it.

Some hospital patients need help breathing, either because they have just had a major operation or because they are very ill. These patients are often placed on a ventilator, a machine that supplies regular breaths through a tube inserted in the patient’s mouth, nose, or through a hole in the front of the neck. Most of these patients recover, and the ventilator can be removed. However, there are proven ways to help prevent VAP — and patients and families can help to make sure these things are done.

A bundle of 5 care steps to prevent VAP:

Doctors and nurses can help prevent VAP by using a bundle of 5 “care steps.” The bundle of care steps are as follows:

- Raise the head of the patient’s bed between 30 and 40 degrees.
- Give the patient medication to prevent stomach ulcers.
- Prevent blood clots when patients are lying very still.
- Check every day to see if patients can breathe on their own.
- Provide daily mouth care with an antiseptic while the patient is ventilated.

Two of the items in the bundle help prevent other serious complications that can occur when a patient is on a ventilator: stomach ulcers and blood clots. However, hospitals find that when all 5 of these steps are done, there are almost no cases of VAP.

How family members can help:

Ask the nurses and doctors these questions:

- Are you going to raise the head of the bed when [patient] is on the ventilator?
- How are you going to prevent stomach ulcers?
- Is [patient] at risk for blood clots and, if so, what will be done to prevent them?
- When can [patient] try breathing on his or her own?
- What kind of mouth care are you doing?

Learn more about ventilator-associated pneumonia on www.ihl.org.

Information provided in this Fact Sheet is intended to help patients and their families in obtaining effective treatment and assisting medical professionals in the delivery of care. The IHI does not provide medical advice or medical services of any kind, however, and does not practice medicine or assist in the diagnosis, treatment, care, or prognosis of any patient. Because of rapid changes in medicine and information, the information in this Fact Sheet is not necessarily comprehensive or definitive, and all persons intending to rely on the information contained in this Fact Sheet are urged to discuss such information with their health care provider. Use of this information is at the reader's own risk.

Appendix A: Sample Tools

Ventilator Bundle Checklist (Individual Patient)

PATIENT: _____

ADMIT DATE: _____

ICU Day

	1	2	3	4	5	6	7	8	9	10
1. Head of the Bed 30°	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Daily Sedative Interruption and Daily Assessment of Readiness to Extubate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. PUD Prophylaxis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. DVT Prophylaxis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Daily Oral Care with Chlorhexidine	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

*Adapted from a tool created by Dominical Hospital (Santa Cruz, CA).

Ventilator Bundle Checklist *(continued)*

Date	Bed/Patient Initials	Head of Bed 30°	Sedative Interruption and Assessment of Readiness to Extubate	PUD Prophylaxis	DVT Prophylaxis	Daily Oral Care with Chlorhexidine
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

*Adapted from a tool created by Dominical Hospital (Santa Cruz, CA).

Ventilator Bundle Checklist (Sample)

Date	Bed/Patient Initials	Head of Bed 30°	Sedative Interruption and Assessment of Readiness to Extubate	PUD Prophylaxis	DVT Prophylaxis	Daily Oral Care with Chlorhexidine
9/25	1206 D. O.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	1208 M. H.	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	1214 M. K.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
9/26	1206 D. O.	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	1208 M. H.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

*Adapted from a tool created by Dominical Hospital (Santa Cruz, CA).

Daily Goals Assessment

PATIENT NAME: _____

ROOM NUMBER: _____

DATE: ____/____/____

---/INITIAL AS GOALS ARE REVIEWED ----

GOAL	NOTES	0700-1500	1500-2300	2300-0700
What needs to be done for the patient to be discharged from the ICU?				
What is this patient's greatest safety risk?				
Pulmonary/Ventilator: Head of Bed 30 Degrees or Greater				
Sedative Interruption and Assessment of Readiness to Extubate				
PUD Prophylaxis				
DVT Prophylaxis				
Oral Care with Chlorhexidine				
Cardiac Rhythm, Hemodynamics				
Volume Status, net goal for 12 MN				
Neuro/Pain Mgt/Sedation				
GI/Nutrition/Bowel Regimen				
Mobilization/OOB				
ID, Cultures, Drug Levels				
Medication Changes (Can any be				

How-to Guide: Prevent Ventilator-Associated Pneumonia

discontinued?)				
Tests/Procedures Today				
Review Scheduled Labs (Can any be discontinued?)				
Morning Labs and PCXR				
Consultations				
Can any catheters/tubes be discontinued?				
Attending Up to Date?				
Family Updated?				
Any Social Issues to Address?				
Emotional/Spiritual Issues Addressed?				
Skin Care Addressed?				
Code Status Addressed?				
Advance Directive in Place?				
Parameters for Calling MD				

*Adapted from the Johns Hopkins University Quality & Safety Research Group Tool Kit.

Appendix B: Recommended Intervention-Level Measures

The following measures are relevant for this intervention. We recommend that you use some or all of them, as appropriate, to track the progress of your work in this area. In selecting your measures, we offer the following advice:

- Whenever possible, use measures you are already collecting for other programs.
- Evaluate your choice of measures in terms of the usefulness of the results they provide and the resources required to obtain those results; try to maximize the former while minimizing the latter.
- Try to include both process and outcome measures in your measurement scheme.
- You may use measures not listed here, and, similarly, you may modify the measures described below to make them more appropriate and/or useful to your particular setting; however, be aware that modifying measures may limit the comparability of your results to others' results.
- Remember that posting your measure results within your hospital is a great way to keep your teams aware of progress and motivated. Try to include measures that your team will find meaningful, and that they would be excited to see.

Process Measure(s):

Ventilator Bundle Compliance
<ul style="list-style-type: none">• <u>Measure Information</u> <p>Comments:</p> <p>Note that this measure is the same as that used in the 100,000 Lives Campaign, although, in preparation of the launch of the 5 Million Lives Campaign, some edits have been made to clarify the instructions.</p>

Outcome Measure(s):

Ventilator-Associated Pneumonia (VAP) Rate in ICU per 1,000 Ventilator Days
<ul style="list-style-type: none">• <u>Measure Information</u> <p>Comments:</p> <p>Note that this measure is the same as that used in the 100,000 Lives Campaign, although, in preparation of the launch of the 5 Million Lives Campaign, some edits have been made to clarify the instructions.</p>

Alignment with Other Measure Sets:

Measure Name	JC	CDC
Ventilator Bundle Compliance	√1	
Ventilator-Associated Pneumonia (VAP) Rate in ICU per 1,000 Ventilator Days		√2

√1 Components of this bundle measure match individual measures in the Joint Commission (JC) National Hospital Quality Measures ICU Measure Set: ICU-1 (Head of Bed Elevation), ICU-2 (PUD Prophylaxis), and ICU-3 (DVT Prophylaxis). The Joint Commission has stopped data collection on these measures but still endorses them; more information can be found on the [Joint Commission website](#).

√2 The number of ventilator-associated pneumonias per 1,000 ventilator days is the standard measure for surveillance by the CDC, and the definitions used in our measure match those in the [CDC's NHSN Ventilator-Associated Pneumonia Event definitions](#).