Ventilator-Associated Pneumonia Bundled Strategies: An Evidence-Based Practice

Sheila O’Keefe-McCarthy, RN, MN, Cecilia Santiago, RN, MN, Gemma Lau, RN, MN

ABSTRACT

Background: Ventilator-associated pneumonia (VAP) is an ongoing challenge for critical care nurses as they use current evidence-based strategies to decrease its incidence and prevalence. Mechanical intubation negates effective cough reflexes and impedes mucociliary clearance of secretions, causing leakage and microaspiration of virulent bacteria into the lungs. VAP is responsible for 90% of nosocomial infections and occurs within 48 hours of intubation. VAP is a major health care burden in terms of mortality, escalating health care costs, increased length of ventilator days and length of hospital stay.

Aim: (1) To provide a review of the literature on VAP bundle (VAPB) practices. (2) To describe the etiology and risk factors and define bundled practices. (3) To discuss an explanatory framework that promotes knowledge translation of VAPBs into clinical settings. (4) To identify areas for further research and implications for practice to decrease the incidence of VAP.

Methods: Electronic searches in MEDLINE, EMBASE, CINAHL, PsycINFO, and Cochrane Collaboration were conducted using keywords specific to VAP. The inclusion criteria were: (1) Studies were original quantitative research published in an English peer-reviewed journal for the years 1997 to 2007. (2) Each study included an examination of bundled practices. (3) The clinical outcomes of critically ill adults with VAP were assessed. The studies were identified from the bibliographies of key references. Six studies were accepted based on the inclusion criteria. Each contributing author conducted the review and analysis of selected studies independently. The findings were compared and contrasted by all authors to establish consensus.

Results: Evidence shows that VAPB practices decrease VAP rates. Bundled practices result in decreased ventilator days, intensive care unit length of stay, and mortality rates. A strong association was seen, with an increased clinician compliance with VAPB protocols with decreased VAP rates.

Conclusions and Implications: Methodologically robust randomized controlled trials are required to examine the efficacy of VAPBs and determine causality between VAPBs and clinical outcomes. Organizational commitment is needed to adopt a conceptual framework that promotes effective knowledge translation, incorporating factors of evidence, context, and facilitation of VAPBs into clinical settings. Instituting nurse-led intervention champion leaders to facilitate reliable and consistent implementation of VAPBs into practice is warranted.

KEYWORDS ventilator-associated pneumonia, bundled strategies, evidence-based practice, knowledge translation, PARIHS framework

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INTRODUCTION

Ventilator-associated pneumonia (VAP) continues to be a common and potentially fatal complication of ventilator care (Chulay 2005), often encountered within high-tech, high-touch environments characteristic of an intensive care unit (ICU). Ventilated and intubated patients present critical care registered nurses (RNs) with the unique challenge to incorporate evidence-informed practices surrounding the delivery of high-quality care. Bundled practices are composed of individual preventive strategies for preventing the incidence and prevalence of VAP and improving outcomes of patients (Pruitt & Jacobs 2006).

In this article, we will present a brief overview of the etiology, types, and risk factors associated with VAP. Second, we will discuss the evolution of VAP bundle (VAPB) practices. Third, we will analyze the findings of the literature review of VAPB practices concerning treatment of VAP. We will then discuss effective ways to implement knowledge transfer of VAPB strategies into practice. We suggest that effective implementation of VAPB depends on the organizational commitment and its readiness when combined with instituting nurse champion leaders as facilitators of change. This approach ensures reliable and consistent delivery and management of the bundled practice. We recommend adopting the Promoting Action on Research Implementation in Health Services (PARIHS) framework and the Plan-Do-Check-Act (PDCA) quality improvement methodology.

The factors of evidence, context, and facilitation, described in the PARIHS framework (Rycroft-Malone 2004), have the essential ingredients needed in developing and implementing the components of the process in getting research into practice. In addition, the PDCA methodology described by Hampton et al. (2005) is a perspective on the clinical utility of VAPBPs, that is, the process of allowing small cycles of change during program implementation that can assist with the behavior change required for uptake of new strategies into clinical practice. Finally, implications for practice and future research are outlined.

Incidence

Ninety percent of all nosocomial infections (NI) in mechanically ventilated patients are attributed to VAP (Grap et al. 2004) and typically occur within 48 hours of intubation (Kollef 2004). This population has a 6–21 times increased risk of developing NI. Their risk of developing VAP is 28% (Pruitt & Jacobs 2006), and up to 50% for those who remain ventilated for more than 5 days (Dodek et al. 2004). The reported incidence of VAP among intubated and mechanically ventilated patients ranges from 10% to 65% (Dodek et al. 2004). VAP prolongs the length of ICU stay, increases health care costs, and increases risk of death in this critically ill adult population (Cason et al. 2007).

Etiology of VAP

Intubation impedes the body’s natural defense against respiratory infections. The placement of an endotracheal tube (ETT) negates effective cough reflexes that protect the airway from invasive pathogens. An ETT prevents mucociliary clearance of secretions and depresses epiglottic reflexes; thus, the entry of virulent bacteria (either from excess secretions or from aspirated esophageal or stomach contents) pools and leaks around the inflated ETT cuff (Vincent 2004) infiltrating the lungs and causing pneumonia.

VAP can occur early or late during a patient’s course of intubation and mechanical ventilation. Early onset occurs within 48 to 96 hours of intubation (Pruitt & Jacobs 2006). Most common microorganisms include Streptococcus pneumoniae, Haemophilus influenzae, and Moraxella catarrhalis. Late-onset VAP occurs 5 or more days after intubation. Staphylococcus aureus, Acinetobacter baumannii, Pseudomonas aeruginosa, Klebsiella pneumoniae, and Enterobacter are some of the most prevalent microorganisms reported for late-onset VAP (Pruitt & Jacobs 2006).

Risk Factors

The risk factors associated with VAP include agents that can impair the patient’s defense system and those that can increase possible aspiration of oral secretions. Endotracheal, nasogastric, and enteral feeding tubes; supine positioning; impaired mental status; and sedation can increase risk of colonization of the oropharynx and subsequent migration of oral secretions to the subglottic area, causing pneumonia.

Bacterial colonization can predispose a person with preexisting comorbidities, such as malnutrition, chronic obstructive lung disease (COPD), poor oral hygiene, or chronic sinusitis. Treatment regimes such as gastric alkalinization with routine use of H2 receptor blockers are another risk factor. Instances of an overgrowth of virulent organisms such as prolonged antibiotic use, inadequate hand washing, prolonged periods of mechanical ventilation, invasive procedures, and contact with other patients are all potential risk factors for VAP (Hixson et al. 1998; Fitch et al. 1999; Schleder et al. 2002; Flanders et al. 2006; Pruitt & Jacobs 2006; see Table 1).

BACKGROUND

The way in which critical care nurses deliver health care has changed in recent years. The evidence-based
TABLE 1
Risk factors of VAP

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Risk Factor</th>
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<tr>
<td>Endotracheal intubation</td>
<td>Continual or over sedation</td>
</tr>
<tr>
<td>Nasogastric tubes</td>
<td>Preexisting comorbidities</td>
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<tr>
<td>Enteral feeding tubes</td>
<td>Treatment regimes—gastric</td>
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<tr>
<td></td>
<td>alkalinization</td>
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<tr>
<td>Supine positioning</td>
<td>Prolonged antibiotic use</td>
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<tr>
<td>Impaired mental status</td>
<td>Ineffective hand washing</td>
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<tr>
<td>Length of mechanical ventilation</td>
<td>Hospital environment and equipment</td>
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<tr>
<td>Invasive procedures</td>
<td>Contact with other patients/hospital staff</td>
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</tbody>
</table>

movement has made research an integral component of effective clinical practice. The intention of evidence-based safety is to provide and improve health care, resulting in positive patient outcomes. Bundling of strategies was first conceptualized by Berenholtz et al. (2002) in their seminal study that indicated best-evidence interventions that could prevent mortality and morbidity in ICUs. The authors identified six interventions. One was the prevention of VAP.

Leaders at the Institute for Healthcare Improvement (IHI; IHI 2006) in the United States created an initiative aimed at saving 100,000 lives and reducing VAP incidence in critical care. The ventilator bundle consists of combined care delivery interventions that have reduced the risk of VAP, particularly when they are implemented together. The IHI (2006) ventilator bundle is the basis for focused team care, enhancing the use of protocols and guidelines to bring about optimal patient outcomes (Evans 2005). These are safety interventions related to disease process and are based on evidence and best practice. The interventions are deployed at the point of patient care, in partnership with interdisciplinary health care teams and leaders, thereby maximizing the potential for a successful implementation of patient safety initiatives.

IHI leaders define VAPB as a “group of evidence-based practices that, when implemented together, should result in dramatic reductions in the incidence of ventilator-associated pneumonia” (IHI 2006, p. 5). Bundled practices are the precautionary steps that practitioners can reliably and collectively implement to enhance positive patient outcomes. The science, that is, the evidence-informed rationale supporting each bundle component is sufficient to be regarded as the standard of care (IHI 2006). Resar and colleagues (2005) propose that all elements must be implemented within a certain time and space so that effective delivery of VAP bundled practices is ensured. Measuring these elements provides for an effective tool to ensure safe health care for mechanically ventilated patients. Research indicates that experiences with VAP bundled practices correlate with a significant decrease in VAP rates (Resar et al. 2005; Youngquist et al. 2007).

“Safer Health Care Now” is a campaign that was instituted across Canada to improve the safety of Canada’s health care system by adopting bundled practices. One goal of this campaign is to decrease VAP based on recommendations indicated in IHI’s campaign. In all, staff in 61 ICUs participated in the collaborative campaign across Canada and the United States.

LITERATURE REVIEW OF BUNDLED PRACTICES

Purpose
The purpose of this paper is to present results of a literature review of current evidence-based research that is specifically focused on VAP bundled practices and describe the state of science within existing literature. Previous systematic reviews and literature reviews indicated individual interventions that are now considered components of the bundle. In this article, the authors provide an alternative perspective because it shows current literature on bundled strategies to combat VAP.

The review is focused on these questions:
1. What are the similarities and differences between VAPB and ventilator bundles?
2. What are the interventions in VAP and ventilator bundles?
3. What are the strategies used to implement bundles into practice?
4. What are the implications for practice and research on bundled practices that would decrease incidence and prevalence of ventilator-associated pneumonia?

Inclusion Criteria
A study was evaluated and included as relevant if it met the following criteria: (1) original quantitative research published in an English peer-reviewed journal between 1997 and 2007, (2) bundled practices were examined, and (3) clinical outcomes of critically ill adults with VAP were assessed.

Search Strategy
Electronic searches in MEDLINE, EMBASE, CINAHL, PsycINFO, and Cochrane Collaboration were conducted using keywords specific to VAP and quantitative methodology, (ventilator-associated pneumonia, ventilator-acquired pneumonia, pneumonia, nosocomial infection, intubation, adult, ventilator bundles, evidence-based practice, and restricted to quantitative studies).
after abstracts were scanned, papers were excluded if they were not quantitative and did not specifically indicate bundled practices for VAP. For example, studies in which investigators explored integration and or the results of an educational intervention in complying with unit VAP protocols but did not study clinical outcomes of actual bundled practices were excluded from the study. Ten studies were identified and reviewed. Additional studies were identified from the bibliographies of key references. Six studies were accepted based on inclusion criteria.

**Literature Review Process**

Each contributing author conducted the review and analysis of selected studies independently. This included reading of each paper to identify the interventions within the bundles studied; the outcomes measured; similarities, differences, strengths, and limitations among the studies; strategies used to promote uptake of bundles into practice; and areas for future research. The findings were compared and contrasted by all authors to establish consensus.

**FINDINGS AND DISCUSSION**

**Similarities and Differences between VAPBs and Ventilator Care Bundles**

Bundled strategies for mechanically ventilated patients were developed as a method of promoting the delivery of evidence-based care in a systematic and methodical manner while providing the means to evaluate delivery of the care and outcomes (Pronovost & Holzmueller 2004; Crunden et al. 2005). In this section, we will compare and contrast the studies about ventilator care bundles and VAPB.

Ventilator care bundles originated from the IHI recommendations (Resar et al. 2005). The key components of the ventilator care bundles are head of the bed elevation (HOB elevation), daily sedation vacations (temporarily reducing sedation while the patient is ventilated), assessment of readiness to extubate, peptic ulcer disease prophylaxis, and deep vein thrombosis (DVT) prophylaxis. Each of the four components is supported by clinical evidence. In their observational study, Resar and colleagues described that adherence to the ventilator care bundles is followed by a reduction of VAP rates and speculated that a direct relationship exists between ventilator care bundle and clinical improvement of VAP. After this landmark study, some investigators went further and concentrated on bundling strategies that specifically decrease VAP rates and the number of ventilator days (Abbott et al. 2006; Hatler et al. 2006; Youngquist et al. 2007). Consequently, the VAPB was created out of the ventilator care bundle. Ventilator care and VAP bundles are similar because they incorporate a series of interventions related to ventilator care that, when implemented together, should achieve significantly better outcomes than when implemented individually. Common to both is that utilizing the components of the bundles will decrease VAP and that consistent compliance with all parts of the bundle is critical to success.

The difference between the two bundles lies in their components. All components of the VAPB directly affect the clinical outcome of reducing VAP. Abbott and colleagues (2006) suggest that HOB elevation, oral care, ventilator tubing condensate, hand hygiene, and glove use are all important interventions in decreasing VAP rate and the number of ventilator days. Similarly, Hatler et al. (2006) propose that HOB elevation, oral care, turning patients from side to side, and sedation vacation can reduce the frequency of VAP rate and the number of ventilator days. On the other hand, the studies that implemented the ventilator care bundles based on the IHI recommendations all include HOB elevation, sedation vacation, DVT prophylaxis, and peptic ulcer prophylaxis (Crunden et al. 2005; Hampton et al. 2005; Resar et al. 2005; Youngquist et al. 2007). Although VAPB directly relates to VAP reduction, only the HOB elevation and sedation vacations in ventilator care bundles have been shown to have an effect on outcomes for VAP (Resar et al. 2005). Although DVT prophylaxis and peptic ulcer prophylaxis improve the outcomes of mechanically ventilated patients, they do not directly affect the VAP outcomes of patients in the ICU (IHI 2006).

**Interventions Contained in Reviewed VAPBs and Ventilator Care Bundles**

Across all six studies were inconsistencies in the various interventions included in the bundles implemented. All six studies implemented HOB elevation of 30°-45°. The benefit of HOB elevation is well documented. Supine positioning in the first 24 hours of intubation, as compared with elevation of the HOB to 30°-45° (a semirecumbent position), has been shown to increase the incidence of VAP (Grap & Munro 1997). The semirecumbent position is preferred not only because of better diaphragmatic descent, ensuring better ventilation and reducing risk of atelectasis (IHI 2006), but also because of the reduced risk of gastric aspiration (Vincent 2004).

Five out of the six studies (the exception being Abbott et al. 2006) included DVT prophylaxis and stress ulcer prophylaxis. DVT prophylaxis has been widely accepted in practice in the critical care area. Patients’ recovery while ventilated is sedentary in nature and it is assumed that patients benefit from an anticoagulant therapy and the application of antithrombotic stockings or sequential compression devices while on complete bed rest. Stress ulcer prophylaxis is implemented because researchers have verified that...
patients with respiratory failure are at an increased risk of developing stress ulcers and gastric bleeding (IHI 2006; see Table 2.)

Sedation vacations can help establish a patient’s readiness for weaning and target early extubation. The use of chemical sedation for extended periods or prolonged use of paralytics or neuromuscular blocking agents (NMBA) might contribute to VAP (Kunis & Puntillo 2003). Sedation and NMBA impede the patient’s ability to swallow effectively, which prevents effective clearance of saliva from the oral cavity and can migrate via microaspiration into the lungs.

During the removal of sedation, a practitioner can perform a spontaneous breathing trial to see if a patient is ready to be weaned from the ventilator. Kress et al. (2000) conducted a randomized controlled trial (RCT) and found that daily interruption in sedation significantly reduces the time on the ventilator from 7.3 to 4.9 days. Along with reducing the amount of time on a ventilator, one should promote care that enables the intubated patient to better control coughing and have the ability to manage oral secretions when extubated.

Researchers have reported that continuous aspiration of subglottic secretions via the Hi-Lo Evac endotracheal tube (Mallinckrodt Laboratories, Athlone, Ireland) decreased VAP rates by 52% (Valles et al. 1995). A recent meta-analysis conducted by Dezfulian et al. (2005) showed that subglottic secretion drainage reduced the incidence of VAP by nearly 50%.

As early as 2003, the Centers for Disease Control and Prevention provided guidelines for preventing VAP. Included in these were hand washing, wearing gloves, and developing an oral hygiene and oral decontamination program (Cason et al. 2007). Reducing bacterial colonization is essential in preventing VAP. Meticulous attention to hand washing is the minimum standard of care, along with adherence to universal precautions by wearing clean gloves with a closed suction system and sterile gloves with an open suction system which requires the circuit to be opened to suction secretions (O’Keefe-McCarthy 2006).

Current research indicates that microbial colonization in the mouth causes VAP. A patient’s previous oral health is a significant risk factor affecting intubated patients, predisposing them to VAP. Any disturbance in a patient’s oral health can contribute to the development of VAP (Grap et al. 2004). There is evidence to support instituting standardized oral care protocols for ventilated patients. RNs need to be aware of patient outcomes resulting from omitting oral health, the benefit of delivering timely oral care, and prorating healthy oral immunity to mechanically ventilated patients (O’Keefe-McCarthy 2006). Implementing oral care protocols reduces the amount of dental plaque and the microbes contained in the oral flora and maintains a patient’s oral immunity. Oral care has not yet been officially included in standardized bundled practices for VAP and standardized oral care protocols need to be considered as a foundational component in the VAPB. We suggest that oral care with chlorhexidine gluconate twice daily should become the minimum standard in oral care for VAP. This added component is proactive, preventive, and cost effective, and could decrease the incidence of VAP. Of interest in this review, the studies conducted by Abbott et al. (2006) and Hatler et al. (2006) included oral care as a component of the VAPB.

### TABLE 2

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<td>S-VAC + ETT-WEAN</td>
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<td>TUBING-ETT</td>
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<td>TURNING</td>
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<td>6</td>
<td>4</td>
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HOBE = Head of Bed Elevation; DVTP = Deep Vein Thrombosis Prophylaxis; S-VAC + ETT-WEAN = Sedation vacation and Ventilator Weaning Trial; ULCER-P = Ulcer Prophylaxis; TUBING-ETT = Daily Endotracheal Tubing Change.

**Implementing Bundles into Practice**

The goal-oriented nature and the bundling of care practices indicate having an organized team approach to ensure successful implementation of the bundled strategies. Resar et al. (2005) and Youngquist et al. (2007) emphasized...
Structural support is important to ensure that implementation is uniform and compliance is universal and consistent. Structured activities include daily rounds and a “tick list” to identify barriers and compliance and normalize expected behaviors and activities of bundled care (Crunden et al. 2005; Hatler et al. 2006). Systematic structural change includes preprinted order sets for ventilator management, sedation, and oral care (Youngquist et al. 2007), head-of-bed order (Hampton et al. 2005), daily patient goals, and multidisciplinary rounds (Resar et al. 2005; Hatler et al. 2006).

Context is important for enhancing the success of delivering evidence-based interventions and increasing acceptance by the health care team. Crunden et al. (2005), Abbott et al. (2006) and Hatler et al. (2006) identified the benefit of best practices and clinical practice guidelines to establish acceptance and a team approach to implementing bundled care. The PDCA strategy (Hampton et al. 2005) is similar to rapid cycle testing (Hatler et al. 2006) whereby the activities are group-processed, preplanned, short-acting, goal-oriented, and evaluated to improve the next step. Each has a team approach and staff involvement, and increases staff acceptance and ownership. Youngquist et al. (2007) aptly identified the all-or-none nature of the bundle theory that helped multidisciplinary staff to carry out systematic structural and cultural changes (e.g., multidisciplinary collaboration and daily rounds on bundle care checklists). Systematic structural changes and team approach are supported by the traditional strategies of staff education, in-service programs, bulletin board, and e-mail notification, which are passive types of strategies (Hampton et al. 2005).

**Appraisal of Studies**

**Study design.** All studies included in this review are observational; the investigators did not control the intervention but compared nonrandomized sequential groups (Sheldon 2001). Specifically, five studies are retrospective and prospective cohort studies, where samples were defined before and after the observation time. Investigators of the observational studies followed up patients in real time from when they were identified as cohorts and evaluated the effect of VAPBs on reduction of VAP rates and the number of ventilator days (Crunden et al. 2005; Hampton et al. 2005; Resar et al. 2005; Abbott et al. 2006; Youngquist et al. 2007). One study was a theory-guided project implementation with self-reports and prospective observations (Hatler et al. 2006; see Table 4).

Because all studies used historical controls in a nonrandomized design, selection bias became a threat to internal validity (Burns & Grove 2001). The groups being compared were nonequivalent. Crunden and
colleagues (2005) acknowledge that the main limitation of their study was the lack of a control group against which outcomes of the ventilator care bundle could be compared.

In addition, the heterogeneity in the components of bundles studied prevented detecting a true relationship between intervention and outcome (Burns & Grove 2001), and the asynchronous groups made ascertaining VAP outcomes difficult. For instance, Abbott et al. (2006) found erratic changes in VAP rates between sites and attributed this finding to inconsistencies in adherence to treatment protocols, variability of bundle implementation, inherent differences in organizational culture, and mixed levels of staff competency.

### TABLE 4
Critical appraisal of studies on VAP bundles

<table>
<thead>
<tr>
<th>Author/year</th>
<th>Design</th>
<th>Sample</th>
<th>Measures, reliability, and validity</th>
<th>Interventions/program components</th>
<th>Outcome measures</th>
<th>Results</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Youngquist et al. (2007)</td>
<td>Retrospective and prospective observational study (June 2003–May 2004)</td>
<td>Year 2003 – 205 samples; year 2004–224 samples; Mercy &amp; Unity Hospitals Minnesota, US.</td>
<td>Retrospective CR (January 2003–July 2003) using CDC-NNIS VAP definition. Prospective CR since July 2003 Interrater reliability test conducted on random basis for patients with +CXR</td>
<td>IHI ventilator bundle 1. HOB elevation 30° 2. Daily sedation vacation + readiness to wean assessment 3. Peptic ulcer prophylaxis 4. DVT prophylaxis 5. Hand hygiene and oral care protocol</td>
<td>1. Rates/frequency of VAP 2. ICU average LOS 3. Total number of ventilation days 4. ICU mortality 5. Compliance rate</td>
<td>1. VAP rate: Mercy ↓ from 6.1 to 2.7 per 1,000 ventilation days. Unity ↓ from 2.66 to 0 per 1,000 ventilation days (p = 0.02). 2. ICU LOS: Unity (p = 0.02) Mercy—not statistically significant but already low. 3 and 4 results not reported. 5. Compliance rate: 100%</td>
<td>1. Two of the four bundles, that is, DVT and ulcer prophylaxes are not correlated directly to VAP reduction. 2. Susceptible to bias d/t nonrandomization.</td>
</tr>
</tbody>
</table>
| Resar et al. (2005) | Multicenter before and after observation (July 2002–January 2004) | 61 ICUs participating in collaborative campaign across US and Canada 21 teaching and 40 community hospitals. | 1. CDC definition of VAP 2. Web-based extranet posting of monthly data collected by participating ICUs and posting of narrative descriptions re-changes tested and strategies implemented—standard template. | IHI ventilator bundle 1. HOB elevation 30° 2. Daily sedation vacation + readiness to wean assessment 3. Peptic ulcer prophylaxis 4. DVT prophylaxis | 1. VAP rates 2. ICU LOS 3. Total number of ventilation days 4. ICU mortality 5. Compliance rate | 1. In 21 ICUs with ≥95% compliance, VAP ↓ from 6.6 to 2.7 per 1,000 ventilation days. 2. In the 35 ICUs, VAP ↓ by 44.5% and ↑20% bundle adherence improvement. Other results not reported. | (Continued)
### TABLE 4 (Continued)

<table>
<thead>
<tr>
<th>Author/year</th>
<th>Design</th>
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<th>Results</th>
<th>Limitations</th>
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<tbody>
<tr>
<td>Crunden et al. (2005)</td>
<td>Retrospective and prospective observational study</td>
<td>286 patients (group A), 2002; 372 patients (group B) (2003, Surrey Hospital, United Kingdom)</td>
<td>1. Two audits to assess ICU team’s compliance with delivery of each intervention, chart review, and observations 2. Wardwatcher database used for data collection</td>
<td>IHI ventilator bundle 1. HOB elevation 30° 2. Daily sedation cessation 3. Peptic ulcer prophylaxis 4. DVT prophylaxis</td>
<td>1. Number of ventilator days 2. Mean ICU LOS 3. Mortality 4. ICU patient through put 5. Compliance rate</td>
<td>1. Mean ventilation days ↓ from 10.8 to 6.1 days 2. ICU LOS ↓ from 13.75 to 8.36 days 3. Mortality rate unchanged 4. Unit patient throughput ↑ by 30.1%, and number of ventilated patients ↑ by 39.5% 5. Compliance 70.2–79.1%</td>
<td>1. No control group against which the outcomes of bundle could be compared. 2. Temporal bias—concurrent treatments and imperceptible organizational changes.</td>
</tr>
<tr>
<td>Hatler et al. (2006)</td>
<td>Theory-guided project implementation, self-report, and observed behavior used for data collection</td>
<td>8-bed ICU, 15-month study; sample size not reported (Arizona, US)</td>
<td>1. Self-report 2. Rapid cycle testing (feedback process) of short trials of interventions provides measured outcomes in 2–4 weeks and identifies ineffective processes</td>
<td>Hot spud 1. HOB E 2. Oral care Q2H 3. Turing Q2H 4. Sedation vacation 5. Peptic ulcer prophylaxis 6. DVT prophylaxis</td>
<td>1. VAP rate 2. CRBI rate 3. Mean ICU LOS</td>
<td>1. 54% reduction in VAP rate. 2. 78% reduction in CRBI rate. 3. 18% reduction in mean LOS 4. Estimated cost saving of 1.0–2.3 million dollars</td>
<td>1. Self-report, from open comment, is subjective. 2. Biases associated to observations, for example, prejudice of observer, may result in erroneous conclusions.</td>
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Furthermore, the chance of temporal bias and the confounding factors were discussed in the studies. Crunden et al. (2005) acknowledged that because the study was conducted at two places over a 2-year period, the authors cannot exclude the imperceptible changes in practice or organization that could have influenced the results that were observed. Abbott et al. (2006) claim that despite their efforts to adjust for risks, some confounding variables could not be controlled, such as the differences in mechanical ventilation and respiratory equipment across units and sites.

**Sample.** Altman et al. (2001) suggest that careful descriptions of study participants, setting, sample selection, and size should be reported. The authors state that descriptions of study participants’ characteristics and setting in which they were studied are necessary so that readers can...
assess generalizability of the results of the study. The authors also explain that description of sample selection and size helps the readers to detect internal validity associated with ascertaining statistically significant and clinically important differences of a given size if such differences exist. Investigators for four of the six studies (see Table 4) reported participants, setting, sample size, and before and after observational groupings. In the studies of Hampton et al. (2005) and Hatler et al. (2006), the participants, settings, sample selection, and size were not reported to be contributing to the difficulty in appraising the evidence of clinical significance of the studies. None of the studies included power analysis to determine high probability (power) of detecting statistical significance and clinically important difference of a given size. Two of the studies, however, indicated statistically significant results (see Table 4; Abbott et al. 2006; Youngquist et al. 2007).

**Data collection.** Relevant data for these observational studies were collected from databases. Data about other demographics, VAP, chest X-ray, and laboratory results were tracked and analyzed using linkages between the core data set and laboratory database. Because the studies were reliant on databases, where one depended on data collected routinely, information about other potentially confounding variables was not adequate (Sheldon 2001). Furthermore, it was not clear in the studies how much data collected from charts were entered in the database—the implication being that chart reviews could indicate subjective reporting of different values by different people.

To improve the rigor of data collection, investigators used interrater reliability (Crunden et al. 2005; Hampton et al. 2005; Youngquist et al. 2007; see Table 4). To determine severity of illness, the studies of Crunden et al. and Abbott et al. used the Acute Physiology and Chronic Health Evaluation (APACHE II) scores. The APACHE II scores are standard psychometric measurements used in ICUs to assess the acuity of illness among critically ill patients (Knaus et al. 1985). Sheldon (2001) claims that the APACHE II score improved the validity of comparing severity of illness because it allowed users to measure risk-adjusted mortality rates.

**Outcome measures.** Investigators in all studies identified and defined their outcome measures. None made a dichotomy between primary or secondary outcome measures. Two sets of outcomes are identified: clinical and process outcomes. VAP rate, frequency, number of ventilator days, ICU length of stay (LOS), and mortality rate were the clinical outcomes measured. The process outcomes included compliance rate and ICU throughput.

Under clinical outcomes, all six studies included ICU LOS, four included VAP rate, four included integrated number of ventilator days, and four included mortality as outcome measures (Table 4). Under process outcomes, five studies indicated compliance rate, whereas only one included ICU throughput.

**Results.** There is a wide variability of data reported in the six studies. Resar et al. (2005) and Youngquist et al. (2007) used the Central Disease Centre (CDC) definition of VAP, that is, (number of VAP/number of ventilator days x 1,000). Youngquist and colleagues reported that VAP rate decreased to 0.0–2.7 per 1,000 ventilator days in their two program sites. Resar and colleagues found a strong relationship of VAP rate and compliance rate; in the 21 ICUs that have a 95% compliance, VAP decreased from 6.6 to 2.7 per 1,000 ventilator days. Although not statistically significant, Abbott et al. reported that 88% of their sample did not develop VAP, whereas 12% developed VAP. Similarly, Hatler et al. reported a 54% reduction in VAP rate.

A general trend was a decrease in the number of ventilator days in the studies that indicated this outcome measure. Hampton et al. (2005) reported a decrease in the average number of ventilator days from 6.1 to 3.5 days in their study groups. The mean number of ventilator days was also reduced from 10.8 to 6.1 days in comparison groups analyzed by Crunden and colleagues.

The report on ICU LOS was also variable; most researchers claimed a significant reduction such as 15% (Hampton et al. 2005) and 18% (Hatler et al. 2006), others provided vague descriptors such as reports of “low” or “decreased,” and some did not report the effect on ICU LOS, despite identifying that it was one of their outcome measures. Although investigators in four studies specified mortality rate as an outcome measure, only two studies had an actual report, that is, Hampton et al. (2005) reported a 50% reduction in mortality rate, and Crunden et al. claimed no change in mortality rate.

For the process outcomes, Youngquist and colleagues reported a 100% compliance, Resar et al. (2005) claimed an increase of 20% in compliance, Hampton et al. suggested a compliance rate of nearly 100%, and Crunden et al. reported a compliance rate of 70.2–79.1% as well as an increased ICU throughput of 30.1%, enabling more patients access to ICU when needed.

**Implications for Research**

The limitations in their respective studies and the possible sources were acknowledged by some of the authors. The overall limitations identified across the studies include: (1) inconclusive evidence provided, (2) inadequate and unclear documentation of the studies’ methodology, (3) inadequate reporting of data collection, (4) inconsistency of proposed treatment protocols, and (5) incomplete reporting of study results. These factors threaten internal and
external validity of the study results and should preclude uncritical adoption of VAPBs into clinical practice. Nevertheless, although some of the findings and results of the included studies may not be statistically significant, adoption of VAPBs has merit within clinical practice (Burns & Grove 2001). All studies indicate that the VAP bundled interventions have strong clinical significance and a potential to improve outcomes of critically ill patients with VAP.

Intervention studies that meet the criteria of an RCT design are needed. The studies should comprise the essential elements of (1) randomization, (2) researcher-controlled manipulation of the independent variable (i.e., VAPB), and (3) researcher control of the experimental situation, including a control group (Burns & Grove, 2001). RCTs are necessary to indicate the efficacy of VAPBs versus usual ventilator care practices currently employed in critical care settings. The use of RCTs can establish causality between the independent variable (VAPBs) and dependent variables (clinical outcomes, such as VAP rate, number of ventilator days, mortality rates, ICU or hospital LOS, and so on). RCTs can also indicate whether adherence to a VAPB is followed by a reduction of VAP rates. Furthermore, RCTs can help indicate if the addition of standardized interventions that directly affect VAP, such as oral care protocols using chlorhexidine gluconate twice daily, or subglottic removal of secretions, in combination with existing bundled practice components, can further improve clinical outcomes targeted by VAPBs.

**Implications for Practice**

VAP within the ICU is difficult to manage and even more difficult is incorporating VAPBs into practice. Linking “evidence-based research” with actual practice is an ongoing challenge to RNs. A need exists for the availability of clinically applicable frameworks to enable nurses to understand and overcome barriers in getting research into practice. We propose that combining the PDCA methodology with the PARIHS framework will assist in a strong, consistent implementation of research-based VAPBs into clinical practice. This conceptual framework and methodology targets the process component of the implementation of the bundles into practice.

The PARIHS framework initially developed by Kitson et al. (1998) and further refined by Rycroft-Malone (2004) could enable effective knowledge transfer and translation of bundled strategies into practice. The PARIHS conceptual framework indicates that a successful implementation of research into practice depends on functioning relationships among evidence, context, and facilitation (Rycroft-Malone 2004). A successful incorporation of research into practice depends on simultaneous interaction among the evidence used, the quality of context, and the type of facilitation needed to procure change. The implicit assumption of the PARIHS framework is that effective research utilization can be translated into concrete actions that result in positive patient outcomes.

The PDCA methodology was used by Hampton et al. (2005). PDCA indicates small cycles of change, a process that targets the way in which RNs incorporate new changes in service delivery (Hampton et al. 2005). The multidisciplinary team works together to provide the VAPB, integrating each component in small increments of change. Integral to this process is the use of a nurse champion who would facilitate this component change on one patient, work out the trouble areas by identifying what method of delivering the component works best, and help to re-pilot the revised VAPB component to other staff members. Each new component would be introduced one at a time until the whole VAPB was incorporated. This allows for gradual incremental practice changes, allowing the time needed in the adjustment to and acceptance of new clinical practices. The new clinical practice when worked out becomes the norm rather than the exception. The use of the PDCA method helps with behavior change(s) required in effecting organizational change. It allows users to target and incorporate a multidisciplinary teamwork approach, using ongoing education and visible implementation support, to push the project forward.

**CONCLUSIONS**

Implementing bundled practices decreases VAP (Crunden et al. 2005; Hampton et al. 2005; Resar et al. 2005; Abbott et al. 2006; Hatler et al. 2006; Youngquist et al. 2007). It is not enough to have the required knowledge and education to implement VAPBs. For strategies to be accepted at the clinical level, knowledge translation needs to occur at both individual and organizational levels. Using nurse-led intervention champion leaders to facilitate the desired uptake of VAPB in practice is warranted.

When attempting to create cultures for sustaining change, it is wise to support the position of nurse champion leaders who will “spearhead” the intervention required. To translate research results into practice, RNs need to be aware of the contextual environments that shape their behavior. One should ask, for example: (1) How do unit members perceive important nursing work? (2) Are clinicians encouraged to look up research results, read a journal article, or present papers at national conferences?

Knowledge translation requires behavior change. Knowledge transfer and the active linking of research with practice will not occur if leaders cannot provide and sustain work environments that value research. Organizational preparedness and understanding the complexities
of a unit-specific culture and how the process of change occurs can affect acceptance of new research into the clinical area. Using a conceptual framework such as PARIHS, for targeting the processes used by health care organizations and professionals when implementing change, is fundamental.

These studies are evidence-based perspectives alerting clinicians' and researchers' attention to the imperative to implement VAPBs to reduce VAP rates, the number of ventilator days, mortality rates, ICU LOS, and associated costs. The findings should lead clinicians to question traditional ventilator care management strategies and motivate them to explore ways of improving adherence to bundled strategies. Some of the studies show a strong correlation between compliance and VAP outcomes, that is, the higher the compliance level concerning VAPBs, the lower the VAP rates. For researchers, the findings of this review should indicate the rationale and initiative to design trials to further investigate effective protocols that can be standardized in ICUs to improve clinical outcomes for patients at risk for VAP.

References


