Oral Care Intervention to Reduce Incidence of Ventilator-Associated Pneumonia in the Neurologic Intensive Care Unit

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Abstract and Introduction

Abstract

Ventilator-associated pneumonia (VAP) is a preventable secondary consequence of intubation and mechanical ventilation. VAP is pneumonia that develops in an intubated patient after 48 hours or more of mechanical ventilator support. Mechanically ventilated patients in neurologic and other intensive care units (ICUs) are at an increased risk of VAP due to factors such as decreased level of consciousness; dry, open mouth; and microaspiration of secretions. VAP can be prevented by initiating interventions from the Institute of Healthcare Improvement's VAP bundle, including (a) elevating the head of the bed of ventilated patients to 30˚, (b) preventing venous thromboembolism through use of sequential compression devices or anticoagulation, (c) administering gastric acid histamine$_2$ blockers, (d) practicing good hand hygiene, (e) initiating early mobilization, and (f) performing daily sedation interruption at 10 am to evaluate neurologic status. The one intervention not included in the IHI bundle is oral hygiene. The purpose of this project is to support the premise that oral care, including timed toothbrushing, combined with the VAP bundle can mitigate and prevent the occurrence of VAP. Our project specifically addressed timed oral care of mechanically ventilated patients on a 24-bed stroke, neurologic, and medical ICU. Patients were randomized into a control group that performed usual oral care or an intervention group that brushed teeth every 8 hours. The results were immediate and startling, as the VAP rate dropped to zero within a week of beginning the every-8-hours toothbrushing regimen in the intervention group. The study was so successful that the control group was dropped after 6 months, and all intubated patients' teeth were brushed every 8 hours, maintaining the zero rate until the end of the study.

Introduction

Ventilator-associated pneumonia (VAP) is a preventable secondary consequence of intubation and mechanical ventilation and is the most common nosocomial infection in mechanically ventilated patients (Barclay & Vega, 2005; National Nosocomial Infections Surveillance System, 2000). Summa Health System, a 925-bed, level I trauma center in Akron, OH, embarked on a performance improvement (PI) project to decrease the incidence of VAP as part of The Institute of Healthcare Improvement's (IHI's) Protecting 5 Million Lives campaign. The campaign consists of evidence-based interventions including best practices in several disease processes such as VAP. The groups of interventions are called *bundles*. The goals of the IHI bundles are to improve treatment of specific disease processes and improve patient outcomes. Summa Health System embraced several of these bundles, the most successful of which was the VAP bundle, which decreased the VAP rate from 4.265% to 0% within 6 months.

Literature Search

VAP is defined as pneumonia that develops in an intubated patient after 48 hours or more of mechanical ventilator support. VAP significantly increases the morbidity and mortality of patients (Dodek et al., 2004) and can cost an additional $29,000–$40,000 per patient (Rello et al., 2002; Schleder, Stott, & Lloyd, 2002). In addition, VAP carries a mortality rate of 40%–80% and a twofold increase in the length of hospital stay (Fagon et al., 1993; Porzecanski & Bowton, 2006). VAP and other nosocomial pneumonias account for 15% of all hospital-associated infections in the intensive care unit (ICU) and represent the second most common hospital-associated infection after urinary tract infection (Richards, Edwards, Culver, & Gaynes,

1999). Patients with traumatic brain injury tend to be on mechanical ventilation longer than medically intubated patients (14 days versus 10 days) and VAP in the neurologic ICU can further increase the stay (21 days versus 15.5 days; Ortiz & Lee, 2006; Rincón-Ferrari et al., 2004). Hilker and colleagues (2003) found that patients who developed VAP after a stroke, especially after a vertebrobasilar stroke or multiple strokes, were at an increased risk of death (26.9% versus 8.2%).

To make a diagnosis of pneumonia, at least one finding, such as a new or persistent infiltrate on a chest X ray, an organism isolated from sputum or pleural fluid, or a positive culture from a bronchoalveolar lavage, must be present (Mayhall, 2001). A diagnosis of VAP also could be made if two further symptoms, such as fever higher than 38.3 ˚C, leukocytosis (25% increase and value greater than 10,000 mm^3), leukopenia (25% decrease and value less than 5,000 mm^3), or purulent tracheal secretions, are present (Eggimann et al., 2003; Mayhall, 2001).

Pathophysiology

In ventilated patients, the normal defense system of the body, including the cilia in the nose and protective mucus, are circumvented, allowing the patient's mouth to be colonized with pathogenic bacteria such as *Pseudomonas, Acinetobacter,* and Methicillin-resistant *Staphylococcus aureus* (MRSA) within 24 hours of admission to an ICU (El-Solh et al., 2004; Rello, 2005). Mechanically ventilated neurointensive care patients are at an increased risk for VAP due to factors such as decreased level of consciousness and inability to protect the airway (Cohn & Fulton, 2006; Kollef et al., 2006). Neurologic patients with decreased level of consciousness or low Glasgow Coma Scale scores are prone to aspiration due to an unprotected airway and inability to swallow properly. Interventions for lowering intracranial pressure (ICP), such as raising the head of the bed, are a positive influence on prevention of VAP, whereas limited mobility because of ICP monitors, ventriculostomies, and disease processes such as spinal cord injury, can negatively affect VAP-prevention techniques (Cocanour et al., 2005). In addition, because it is difficult to temporarily stop sedation in neurologic patients who have increased ICP, the cessation of daily sedation cannot be used to prevent VAP in these patients. Other risk factors include gastric distension, presence of gastric or duodenal tubes, and trauma or chronic obstructive pulmonary disease (Harris & Miller, 2000).

Meticulous mouth care is crucial for preventing VAP. Rincón-Ferrari and colleagues (2004) found that in head-injured patients, 40%–60% of the gram-negative bacilli found were due to endogenous lung colonization after aspiration of oropharyngeal secretions. Twenty percent to forty percent of these bacteria were *Staphylococcus aureus,* and more than half of the *Staphylococcus aureus* were methicillin-resistant. This type of staphylococcus is exogenous, usually originating from the hands (Mori et al., 2006).

Studies have shown that patients can become colonized with pathogenic bacteria within 24 hours of admission to a critical care unit (Garcia, Jendresky, & Colbert, 2004; Sole, Poalillo, Byers, & Ludy, 2002). The oral cavity and its components—especially dental plaque—are the perfect media in which bacteria can colonize (Garcia et al.).

The American Association of Critical-Care Nurses published an evidence-based practice alert in 2006 that offered guidelines for oral care of the mechanically ventilated patient. In addition, Grap and Munro (2004) and Collard and Saint (2004) recommended raising the head of the bed to an elevation of 30˚ to 40˚, using endotracheal tubes that have a dorsal lumen above the endotracheal cuff, and sporadically changing ventilator circuits.

Grap and Munro (2004) presented supporting evidence indicating that critically ill patients who are intubated for more than 24 hours are at higher risk for VAP, and therefore, mouth care and oral health should be an important part of nursing care. Current literature identified a problem with adequate oral care in the intubated patient that included the definition and quantification of oral care (Fourrier et al., 2000). Bergmans and colleagues (2001) provided evidence that prevention of bacterial colonization of the oropharynx is the key to preventing VAP. The Centers for Disease Control and Prevention guidelines (Tablan, Anderson, Besser, Bridges, & Hajjeh, 2004) determined that the primary route of bacterial entry into the lungs is through the oropharynx during episodes of microaspiration.

Several studies (El-Solh et al., 2004; Schleder et al., 2002; Shinn, 2004) have verified that removing bacteria from the oropharynx requires the removal of dental plaque, and the only way to remove the plaque is with toothbrushing. Pearson and Hutton (2002) and others found that the majority of nurses use a soft Toothette® instead of toothbrushing and that the Toothettes do not remove plaque as effectively as toothbrushes; consequently, oral bacteria can proliferate (Baker, 2007; Binkley, Furr, Carrico, & McCurren, 2004).

Pearson and Hutton (2002) completed a controlled trial that compared the ability of foam swabs and toothbrushes to remove dental plaque and to quantify any differences. They concluded that toothbrushing skills must be taught to nurses and clinical support staff. Schleder (2003) reviewed the pathogenesis of bacteria; identified risk factors, including colonization of the oropharynx; and recommended the following approaches:

1. Use good oral hygiene, including toothbrushing, on all patients.

2. Implement oral-hygiene assessments and intervention strategies for all patients at risk for developing VAP.
3. Decontaminate devices that come into contact with the respiratory tract.
4. Implement the hand-hygiene guidelines released by the CDC in 2003. The guidelines include decontaminating hands by washing them with antimicrobial soap and water or by using an alcohol-based, waterless antiseptic agent if hands are not visibly contaminated. In addition, gloves should be worn when handling respiratory secretions or objects contaminated with the respiratory secretions of any patient (Schleder, 2003; Tablan et al., 2004).

Grap, Munro, Ashtiani, and Bryant (2003) have substantiated the need to standardize oral care for a variety of reasons, the most compelling of which is to prevent or lower VAP rates in mechanically ventilated patients. Oral care is not only part of a standard of care that lowers infection rates by removing plaque-harboring organisms, but is also a comfort care issue (Fourrier et al., 2000; Munro & Grap, 2004). Using evidence-based outcomes and research, the CDC and its Hospital Infection Control Practices Advisory Committee have developed a set of guidelines for VAP prevention that are beneficial for any institution. The guidelines include preferential use of orotracheal tubes over nasotracheal tubes, use of endotracheal tubes with a dorsal lumen to allow drainage, elevating the head of the bed to 30° or 40°, routinely verifying placement of feeding tubes, and preventing or modulating oropharyngeal colonization with implementation of a comprehensive oral hygiene program (Dodek et al., 2004; Tablan et al., 2004).

Implementation of the VAP Bundle

The VAP bundle was implemented over a period of 2 years and included (a) elevating the head of the bed of ventilated patients to 30°, (b) preventing venous thromboembolism with the use of sequential compression devices or anticoagulation, (c) administering gastric acid histamine$_2$ (H_2) blockers, (d) practicing good hand hygiene, (e) initiating early mobilization, and (f) performing daily sedation interruption at 10 am for evaluating neurologic status. Other precautions also were initiated and include the following: (a) the practice of universal gloving was observed (i.e., as staff in all hard-wire units enter a patient's room [after having meticulously washed their hands], they put on gloves. At the bedside, they used hand sanitizer.), (b) in-services regarding VAP and its consequences were held on all shifts and weekends, and (c) dual lumen endotracheal tubes were implemented.

The first intervention in the bundle was to keep the head of the bed above 30° in intubated patients (Shorr & Kollef, 2005). When the head of the bed is flat, more secretions can pool in the back of the airway, become colonized, and then aspirate into the lungs (Safdar, Crnich, & Maki, 2006). In conjunction with in-services about VAP, posters with a picture of a 30° angle showing what the height of the head of the bed should be were put up at patients' bedsides.

The next pieces of the bundle that were put into place were hand washing and gloving. Universal gloving requires any staff member walking into a patient's room to put on gloves as they enter. Sinks are available in the front of every room in critical care, so in-services were held on all shifts to encourage universal gloving, as well as frequent hand washing before and after putting on gloves, before and after suctioning, and before and after touching ventilator equipment or coming into contact with patients' respiratory secretions. In addition, alcohol-based hand sanitizer dispensers were placed outside all rooms and around the units.

The third intervention was to increase mobility. Rehabilitation services staff were intimately involved with nursing and respiratory personnel to develop an activity flow sheet and protocols for progressive ambulation. Every patient admitted to critical care received a physical and occupational therapy screen within 24 hours and then received appropriate rehabilitation services, even if those included only range of motion services. Even intubated patients without contraindications such as back injury were encouraged to sit on the edge of the bed or to try to ambulate a few steps with the assistance of ceiling lifts.

Daily sedation interruption (i.e., a "sedation vacation") was the fourth part of the bundle incorporated into our policy. A multidisciplinary group including pharmacists, intensivists, and nurses met over several months to develop a system to ensure a daily sedation reprieve for mechanically ventilated patients (Simmons-Trau, Cenek, Counterman, Hockenbury, & Litwiller, 2004). If a patient was on a sedative drip, it was turned off at 10 am every morning to allow the patient to wake up to a level whereby he or she could be assessed neurologically. The Richmond Agitation Sedation Scale (RASS) was used to measure the level of sedation. After the patient reached the predetermined score on the RASS, the drip was then restarted at 75% of the rate. This decreased side effects of the drugs, prevented oversedation, allowed the patient to wake up sooner, and allowed the doctors to assess the patient's neurologic status more accurately.

In addition to the other bundle recommendations, a dual lumen endotracheal tube (ETT) was introduced. Dual lumen ETTs are much more expensive than ordinary endotracheal tubes ($14 versus $1), but some studies have shown that the dual lumen ETT's extra subglottic port decreases VAP by as much as 20%–40%, thereby decreasing the overall costs associated

with VAP (Shorr & O'Malley, 2001; Smulders, van der Hoeven, Weers-Pothoff, & Vandenbroucke-Grauls, 2002). Although the dual lumen ETTs have an extra port for subglottic secretions, and some hospitals use continuous suction, our hospital did not have any of the low-volume, low-pressure suction the manufacturer suggested (Hijazi & Al-Ansari, 2004). Nurses and respiratory therapists devised a plan to have only respiratory suction from the port with a 10-ml syringe every 2 hours with ventilator checks. These endotracheal tubes were enthusiastically accepted by the staff and placed on all emergency carts.

The final portion of the bundle was the use of H_2 blockers or sucralfate to prevent ulcers, as well as preventive measures against deep vein thrombosis (Berriel-Cass, Adkins, Jones, & Fakih, 2006; Collard, Saint, & Matthay, 2003). Fortunately, our institution had been following current guidelines, so it was not necessary to take further action with ulcer and DVT prevention.

Performance Improvement Project

The purpose of this PI project was to (a) define oral care policies at Summa Health System and (b) compare rates of VAP in patients on ventilators whose teeth were brushed three times a day (i.e., every 8 hours) with those of patients who received daily toothbrushing and oral care with Toothettes as needed.

Research on oral care and VAP is abundant, but conclusions about the role of toothbrushing are scant, so our project specifically addressed timed oral care of mechanically ventilated patients on a 24-bed stroke, neurologic, and medical intensive care unit.

Design

A randomized controlled trial (RCT) was initiated on a 24-bed ICU with stroke patients. This study originally was designed as an RCT, with patients assigned to the intervention group whose teeth were brushed with a suction toothbrush every 8 hours, or to the control group in which they received "usual care," which could include daily toothbrushing along with Toothette mouth care as needed. The desired sample size was 200 ventilator-dependent patients or 2,000 ventilator days. Ventilator days were already being counted by the respiratory department; counting patients to include in the project was difficult, because one patient could be on the ventilator for 1 day or for 13 days, so it was decided to use whichever number came first, ventilator days or patients. The setting for this study was a critical care unit in a large teaching hospital. Enrollment and data collection began in October 2005. After an expedited review determined this study posed no threat to patient care and was simply a part of routine nursing care, the hospital's institutional review board (IRB) granted permission to proceed.

Nurses were instructed about the importance of oral care; each was given laminated cards with basic instructions. They were told to brush the patient's teeth, tongue, and hard palate with a toothbrush and toothpaste for at least 1 minute at 22:00, 06:00, and 14:00. They were then to use a Toothette to swab the patient's teeth, tongue, and hard palate for at least 1 minute and to apply a moisturizing ointment to the patient's lips every 4 hours. The mouth and pharynx of the patient were suctioned as needed with an enclosed Yankauer suction catheter, which was disposed of every 24 hours. Oral assessment of the patient was to be performed every 12 hours and included a full inspection of the oral cavity, gums, lips, and teeth. A commercially prepared oral-care kit with two toothbrushes, one disposable Yankauer catheter, a toothpaste/plaque remover, and a 24-hour supply of Toothettes was chosen. A third toothbrush was attached to the intervention group's kit.

A plastic bin labeled "1 to 350" was placed at the nurses' station. Envelopes were put in the bins; they contained randomized worksheets labeled at the top with "1" or "2" and a statement of research to be given to families. Randomization was accomplished with the assistance of the Clinical Nursing Research Program of Summa Health Systems and the Biostatistics Department at Northeastern Ohio Universities Colleges of Medicine and Pharmacy. After a patient was intubated, the nurses had to take the next envelope, not knowing which group was listed inside.

Nursing worksheets were developed for both the control and the intervention groups and were designed to appear similar to each other. The control group's worksheet was labeled "1" at the top and the intervention group's worksheet was labeled "2." The control group followed "usual practice," which was unspecified and could include up to two toothbrushings a day. The intervention group was assigned specified times for performing oral care, including brushing the teeth with a suction toothbrush every 8 hours (Fig 1).

Medscape

Worksheet 1: Control Group Worksheet—Number 1 (5 on a page with signature area)

Intervention	0600	1000	1400	1800	2200	0200
Q 24 hours—Change Yankauer suction						
Q 12 hours—Oral assessment						
PRN—Toothbrush/Toothette swab teeth, tongue, palate						
PRN—Moisturizer to lips						
PRN—Mouth and pharynx suction						

Worksheet 2: Intervention Group Worksheet—Number 2 (5 on a page with signature area)

Intervention	0600	1000	1400	1800	2200	0200
Q 24 hours—Change Yankauer suction						
Q 12 hours—Oral assessment						
Q 8 hours—Toothbrush teeth, tongue, palate						
Q 8 hours—Toothette swab teeth, tongue, palate						
PRN—Moisturizer to lips						
PRN—Mouth and pharynx suction						

Note. Q = every; PRN = when necessary.

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Figure 1.

Patient Worksheets

The worksheet contained in the envelope that the nurses chose corresponded to two plastic bins in the storeroom. Worksheet 1 required the nurse to take a kit from bin 1, which was the control with two toothbrushes, and worksheet 2 required the nurse to take a kit from bin 2, which was the intervention. The night-shift nurse was required to hang the oral-care kits on the wall every morning at 6 am.

The nurses were shown how and when to document on the worksheets after they had performed oral care on the patient. Documentation included recording their initials in the boxes provided, signing their names on the signature box, and ensuring that a patient label was applied to the worksheet. The nurses then were to place the completed worksheets into a specially marked container at the nurses' station.

A clinical nurse specialist (CNS), who was also the researcher, made daily rounds and provided support and encouragement to the staff and ensured that equipment was available, documentation adequate, and questions answered. The CNS collected the worksheets, transferred the information to a coded Microsoft Excel® worksheet with appropriate demographics, and kept a running total of all ventilator days.

Initially patients were tracked on the worksheets for 10 days and then dropped from the study, but when the VAP rate dropped to 0% per 1,000 ventilator days in the intervention group and was sustained at 0% for 6 months, the medical director asked the researcher to include all intubated patients in the study, and the control group was dropped. Patients were followed from that point until they were extubated, transferred, or had died, and the RCT became a PI project.

Measurement Criteria

VAP episodes were tracked by the infection-control nurse, who used the previously defined criteria (Eggimann et al., 2003; Healthcare Infection Control Practices Advisory Committee, 2004; Mayhall, 2001). After a VAP was identified, it was catalogued and given quarterly to the researcher, after which it was added to the data collected on the worksheets.

The CNS counted ventilator days by maintaining a running total on the Excel audit sheet. In addition, respiratory therapy personnel maintained a separate ventilator-days listing that was to be used at the end of the study to calculate ventilator days between VAP episodes. VAPs are reported as percentages per 1,000 ventilator days (Healthcare Infection Control Practices Advisory Committee, 2004).

Inclusion and Exclusion Criteria

1. As mentioned previously, inclusion and exclusion criteria were used at the beginning of the study but dropped after 6 months of data collection, at which point the study became a PI project.

2. Patients eligible for inclusion in the study included any mechanically ventilated patient on the stroke/medical ICU who had been intubated in the hospital for less than 24 hours and did not have a previous diagnosis of pneumonia.

3. Exclusion criteria included the following

    a. patients with prior tracheotomies
    b. children younger than 18 years of age
    c. patients with AIDS secondary to immunocompromised systems
    d. patients who were edentulous.

Results

After institution of the oral-care project, a VAP rate of 0.62% was found in a total of 1,850 ventilator days (345 patients). The number of patients exceeded the original goal due to incomplete worksheets (only 200 of the 345 patients had complete documentation). An amended explanation was submitted to the IRB about the changes to the design of the project and in the number of patients. The study started as an RCT, but because of the success of the intervention group and the development of VAP in four of the control-group patients over a 6-month period, the control group was dropped and all intubated patients were placed in the intervention group, where they remained for as long as they were intubated. A multidisciplinary team, including the upper-management team, reviewed the success of the study, and the protocol was implemented as policy. Data are now being collected continuously and VAP rates are followed with cause-and-effect scenarios. All VAPs are investigated thoroughly, and audits continue to monitor bundle practices as well as toothbrushing patterns.

As of June 2007, the VAP rate was 0.62%, but by December 2007 it had risen slightly to 1.17%, with an overall hospitalization rate of 1.72% (Fig 2). These rates are in contrast to those of 2005, when at one point the neuro intensive care unit had a VAP rate of 6.49% per 1,000 ventilator days. The increase at the end of 2007 was directly related to the end of the study and the fact that the worksheets did not prompt the nurses to document and perform the oral care.

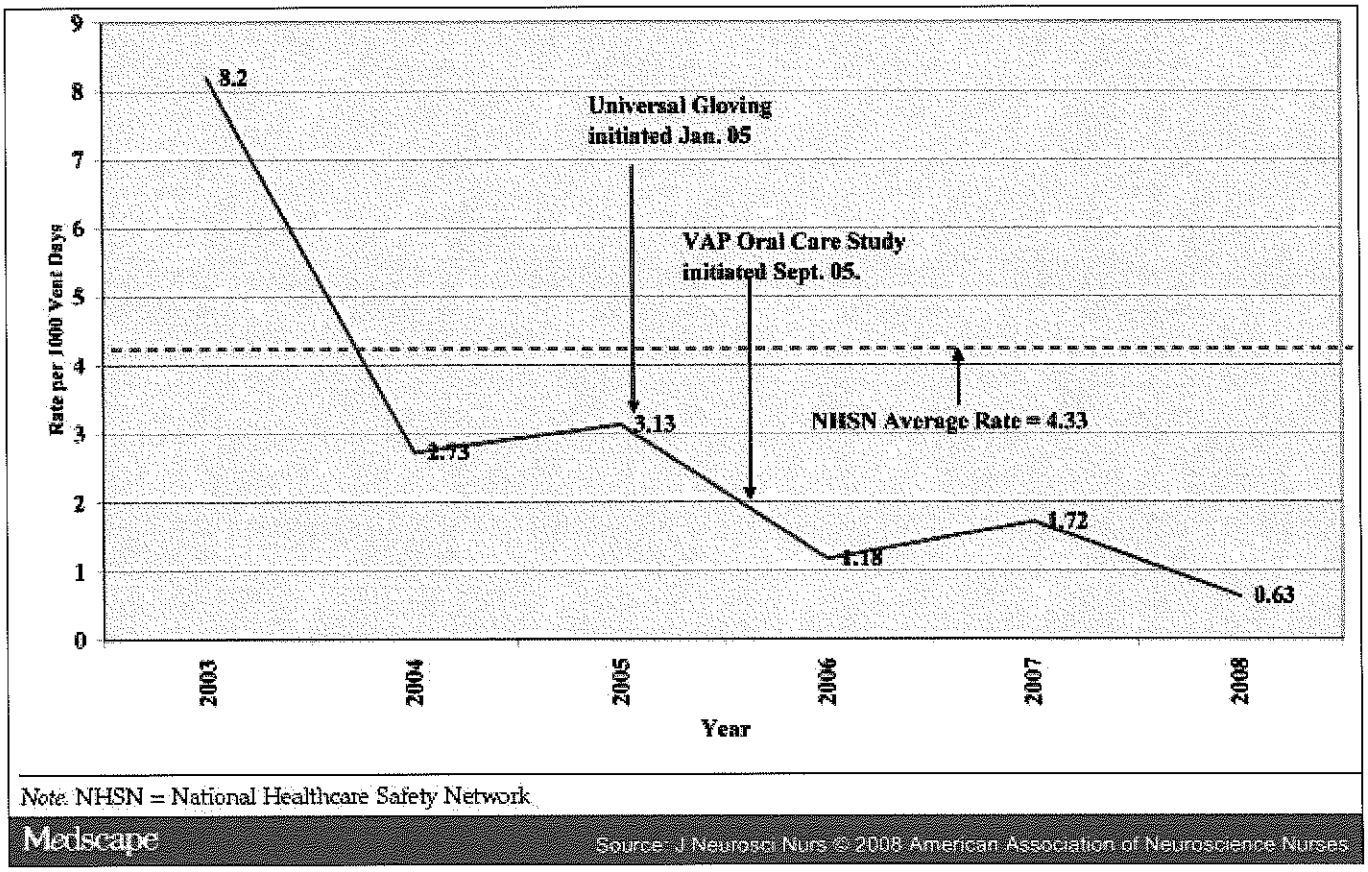

Figure 2.

Summa Health System Ventilator-Associated Pneumonia (VAP) Rates 2003-2008

Discussion

Several studies (e.g., Bonten, Kollef, & Hall, 2004; Healthcare Infection Control Practices Advisory Committee, 2004) have shown that toothbrushing and oral care, along with concurrent nursing interventions such as increasing the patient's mobility, elevating the patient's head, consistently washing one's hands, and performing universal gloving, can mitigate and prevent the occurrence of VAP (Fox, 2006; Heo, Haase, & Scannapieco, 2007). Bacteria reside in plaque in the oropharynx and are transmitted to the lungs via microaspiration (Scannapieco, 2006). Dental plaque can be removed only by toothbrushing, so this study demonstrated that toothbrushing is a more effective way to prevent VAP because it removes the plaque that harbors bacteria. After patients were dropped from the study, 4 of them consequently developed VAP when the nurses no longer followed the every-8-hours schedule of toothbrushing. When questioned, some nurses admitted to not brushing at all, and their documentation supported their statement.

Limitations

The most difficult part of the study was documentation on the worksheets. Respiratory therapists documented more than 4,000 ventilator days, but adequately documented nursing worksheets reflected only 1,850 ventilator days. Inadequate documentation by the nurses was attributed to reasons such as "lack of time," "too busy," or "I forgot." To obtain 2,000 ventilator days of full documentation, a total of 345 patients were followed. In addition, there must be strong support from administration to reinforce the importance of documentation. The solution to the documentation problem was to add the toothbrushing regimen to the medication administration record, which is computerized and allows easy tracking of caregivers who are tardy with their charting.

Another hurdle was lack of funding. Using the commercially prepared kits and attaching a toothbrush to each of them was time consuming and expensive. Senior management had to be approached and convinced that brushing teeth every 8 hours

actually could save money. The kits cost the floor an additional $12,000 a year, but the cost was offset by the decrease in VAP.

To validate this study and support the relationship between toothbrushing and VAP, this study needs to be replicated using a larger randomized sample over a longer period. In addition, a dedicated person should be available to track documentation daily and ensure that all equipment is readily available and that a third toothbrush is stapled to the intervention kits.

Summary

VAP is a preventable and expensive nosocomial disease. Literature has covered its pathophysiology and the myriad reasons that patients develop VAP, but solid evidence that supports nursing interventions has not been forthcoming. Oral-care interventions have been suggested as a preventive technique, but there are few evidence-based studies that report exactly how and when to perform oral care. A multidisciplinary approach (Salahuddin et al., 2004) is the most efficient and efficacious way to effect change in a system; such an approach was used to implement the timed oral-care and toothbrushing regimen to change nursing practice. This study changed nursing practice, saved lives, and saved more than $724,000 for Summa in 2006, as indicated in the 2007 Summa financial scorecard. The study showed that the simple nursing intervention of brushing the teeth three times a day and using the IHI VAP bundle can be powerful tools for preventing VAP.

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