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# Reducing Ventilator-Associated Pneumonia Through Advanced Oral-Dental Care: A 48-Month Study

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**Objective** To determine the effect of implementing a comprehensive oral and dental care system and protocol on the rate of ventilator-associated pneumonia.

**Methods** Patients more than 18 years old receiving mechanical ventilation for more than 48 hours in a medical intensive care unit at a university-affiliated medical center were studied in 2 consecutive 24-month periods. Patients in the group studied before the intervention (n = 779) had no oral assessments, no suctioning of the subglottic space, no toothbrushing, and suctioning of secretions in the oral cavity as needed. The group studied during the intervention (n = 759) included patients treated under a protocol whereby the oral cavity was assessed, deep suctioning was done every 6 hours, oral tissue cleansing was done every 4 hours or as needed, and toothbrushing was done twice daily.

**Results** Compliance with protocol components exceeded 80%. The groups did not differ significantly in age, sex, or severity of illness. The rate of ventilator-associated pneumonia was 12.0 per 1000 ventilator days before the intervention and decreased to 8.0 per 1000 ventilator days during the intervention ($P = .06$). Duration of mechanical ventilation and length of stay in the intensive care unit differed significantly between groups, as did mortality.

**Conclusion** Our findings suggest that use of advanced tools, a comprehensive oral care protocol, and staff compliance with the protocol can significantly reduce rates of ventilator-associated pneumonia and associated costs.


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Prevention and control of ventilator-associated pneumonia (VAP) remains a primary concern in intensive care units (ICUs). VAP is the most commonly reported health care–acquired infection in patients receiving mechanical ventilation, with the most recent National Healthcare Safety Network report[1] indicating an incidence rate ranging from 2.1 to 10.7. A separate study[2] showed VAP incidence in patients intubated less than 72 hours to be around 20%. Prevalence rates are consistently in the 10% to 20% range.[3] Mortality rates in the ICU are 2 to 3 times as great in patients with VAP as in patients without VAP.[4] Despite variability in study design and severity of illness among the populations, reported mortality rates have ranged from 24% in general adult ICUs to greater than 85% when the infection is caused by a multidrug-resistant gram-negative pathogen.[5,6] Length of stay (LOS) in the hospital is greater (median increase, 6 days) in patients with VAP.[7] Estimates of the economic impact of an individual case of VAP range from $11 897 to $150 841.[8-11]

The Healthcare Infection Control Practices Advisory Committee of the Centers for Disease Control and Prevention has developed guidelines for the prevention of pneumonia, with a focus on care of patients receiving mechanical ventilation.[12] These guidelines provide recommendations that have been incorporated, in part, in several national initiatives, such as the Institute for Healthcare Improvement's how-to guide for preventing VAP.[13] Although many pharmacological and nonpharmacological interventions have been well studied,[14] controversies persist about the effectiveness of each intervention for VAP reduction. These measures can be categorized as strategies for managing ventilator circuits (eg, replacement of ventilator circuits, use of closed vs open suction, and use of heat moisture exchange vs heated circuit technology), strategies aimed at preventing aspiration of contaminated oral secretions or stomach content (eg, elevation of the head of the bed and drainage of subglottic secretions), and interventions that directly or indirectly alter bacterial colonization of the stomach (eg, stress ulcer prophylaxis and selective digestive decontamination).

Information drawn from extensive research during the past 20 years indicates that bacterial colonization of the oropharyngeal tract plays a more significant role in outcomes of respiratory infection than previously thought.[15] The evolution in knowledge of pathogenesis and epidemiology of VAP has led to the understanding that "the major route for acquiring endemic VAP is oropharyngeal colonization by endogenous flora or by pathogens acquired exogenously from the intensive care unit environment…."[16] We designed a study to evaluate the effectiveness of implementing an integrated oral care system designed to reduce bacterial colonization in the oropharynx and on the teeth and to evaluate the subsequent impact of such a system on the occurrence of VAP.

Secondary outcomes assessed were length of ICU stay, duration of mechanical ventilation, and ICU mortality.

## Methods

The study was performed at Brookdale University Hospital and Medical Center, a 427-bed university-affiliated teaching hospital. Patients at least 18 years old who were admitted between January 1, 2001, and December 31, 2004, to a 10-bed medical intensive care unit (MICU) were eligible for study inclusion if they had been intubated for more than 48 hours. Patients enrolled in the study were prospectively followed up for VAP occurrence until they were weaned off of mechanical ventilation in the MICU, for 48 hours after their transfer from the

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MICU if still receiving mechanical ventilation, or until they died. The standards of care for all patients during the 48-month study period included changes in the ventilator circuit every 7 days, replacement of the heat moisture exchange filter every 24 hours, closed suction catheter changes every 24 hours (suctioning performed every 2 hours or as needed), use of a 30° semirecumbent positioning protocol when medically feasible, administration of stress ulcer prophylaxis, and use of an active weaning protocol. Compliance with these interventions for the full study period ranged from 90% to 100%. Neither continuous drainage of subglottic secretions nor selective digestive decontamination was used for any patient. Decisions on the use and mode of enteral feeding were made by the MICU's attending physician. Oral chlorhexidine was not used in this study.

### Control Group (Before the Intervention)

The 24-month period from January 1, 2001, to December 31, 2002, was defined as the preintervention period. During this period, 2 experienced infection control professionals used staff interviews and observations of practice to identify barriers to best practice in VAP prevention. Respiratory therapists, nurses, and physicians were included in the review. No pervasive breaks in aseptic technique or procedure protocols were identified. However, several practices relating to mouth and dental care were infection control concerns: the lack of a daily assessment of oral tissues and teeth, disconnection of the closed suction tubing to suction secretions in the mouth, placement of uncovered Yankauer suctioning devices after use on environmental surfaces, inadequate suctioning of secretions accumulating in the oral cavity, inadequate dental care, poor practices relating to care of oral tissues and gums, no standardization of oral care solutions, and lack of policy addressing intervals between suctioning and dental care.

The most common reason for admission to the ICU was acute respiratory failure.

During the preintervention period, MICU protocols required "standard" oral care, which included suctioning of the oral cavity with suction catheters or Yankauer suctioning devices and glycerin swabs for tissue and lip care. No specific time frames for using these items was established. Sections of tubing used for suctioning through the endotracheal tube via a closed suction device were disconnected before oropharyngeal suctioning. Dental care products were not used for patients receiving mechanical ventilation.

The infection control department organized a series of meetings with key representatives, including the nursing and physician staffs of the MICU, nurse educators, anesthesiologists, and staff from the emergency, materials management, and performance improvement departments. Information gathered during the interview and observation sessions was shared with the members of the VAP Prevention Task Force. This information, coupled with a review of policies and products available for patient care, led to the formulation of a list of needs for oral and dental care: the need for staff to understand the nature and severity of the problem; a uniform education program for nurses, physicians, and respiratory therapy staff; an assessment tool for newly intubated patients; reduction of environmental exposure after the use of Yankauer catheters; the need to maintain a true closed suction system; the need for frequent and adequate removal of oropharyngeal secretions; the provision of effective removal of dental plaque; the provision of solutions that maintain the integrity of oral tissues; and the establishment of protocols for documentation of interventions on each nursing shift. A master plan was developed by the infection control department and was subsequently approved by the infection control and performance improvement committees of the institution.

The education portion of the plan was conducted by infection control professionals during November and December 2002. These initial learning sessions targeted medical residents (94% trained), surgical residents (98%), anesthesiologists (100%), respiratory therapists (98%), and all nurses involved in oral care procedures (93%). Topics included morbidity, mortality, and costs associated with VAP; MICU rates vs national benchmarks; procedure and timing of hand washing; intubation procedures; review of protocols for ventilator circuits, closed suction devices, and changes of heat moisture exchange filters; medication administration; care of equipment; review of weaning protocols; and review of policies addressing elevating the head of the bed. The questions addressed in the principal education handout are outlined in Table 1.

### Study Group (During the Intervention)

The 24-month period from January 1, 2003, through December 31, 2004, was defined as the intervention period. The infection control committee and the products evaluation and standardization committee approved for use a comprehensive oral and dental care system (Q-Care Suction Oral System, Sage Products, Inc, Cary, Illinois) that incorporated several novel advances directed at reducing secretions that accumulate in the oral cavity after the

introduction of an endotracheal tube and reducing plaque on the surface of the teeth. The principal system components include a Y-connector that when placed on a suction cannister port provides the capability to attach 2 suctioning tubings, one for oral care and the other for the closed suction device; a universal handle that accommodates a variety of suctioning and cleansing devices; a covered Yankauer catheter to reduce the risk of contaminating the patient's environment; a suctioning dental brush with the antiseptic agent 0.05% cetylpyridinium chloride[17] designed for mechanical reduction of the quantity of dental plaque; a suction oral swab with 1.5% hydrogen peroxide[18] for cleansing the oral cavity and surrounding tissues; an applicator swab with moisturizers to promote mucosal integrity; and a suctioning catheter for removal of secretions that form in the oral cavity. The protocol for use of the system components included oropharyngeal suctioning every 6 hours, oral cleaning of the tissues and gums every 4 hours or as needed, and toothbrushing twice per day. Nursing knowledge of the protocol details was tested twice per year as part of the nursing education competency requirements.

**Table 1**
**Questions addressed in the primary education handout on the prevention of ventilator-associated pneumonia**

1. Why is prevention of ventilator-associated pneumonia important?
2. What is the hospital's current rate of infection (by unit)?
3. How does this rate compare with national benchmarks?
4. What major interventions to prevent ventilator-associated pneumonia have been implemented to this point?
5. How does bacterial colonization of the mouth, oropharynx, and teeth affect the occurrence of respiratory infection in patients receiving mechanical ventilation?
6. Is there evidence in the scientific literature that oral and dental colonization may lead to respiratory infection?
7. What interventions are available that limit the accumulation of bacteria-laden secretions in the mouth and oropharynx and reduce the incidence of dental plaque?
8. How do you set up the new oral and dental care system?
9. What is the institution's protocol regarding the frequency of using each component in the oral and dental care system?
10. How shall the nurse document the use of the new oral and dental care practices?

### Confirmatory Period

The 12-month period from January 1, 2005, through December 31, 2005, is considered the confirmatory period. This additional period was included to test the ability of MICU personnel to implement the established protocol consistently over time and ensure that lower VAP rates were sustainable for long periods. The sole outcome measured during this period was VAP. Statistical analysis was not conducted for data from the confirmatory period.

### Primary Outcome Measure

The rate of VAP was the primary outcome measure. Secondary outcomes assessed were LOS in the ICU, duration of mechanical ventilation, and ICU mortality.

### Data Collection

Demographic patient data were recorded at the time of admission to the MICU and included sex, age, Acute Physiology and Chronic Health Evaluation (APACHE) II score, and reason for ICU admission. Information for calculating LOS data was recorded in an MICU log. Surveillance for VAP was conducted by an experienced infection control professional. Surveillance information was recorded on a form and included intubation date; extubation date; date of MICU admission, transfer, or death; chest radiographic results; temperature; leukocytosis; and results of sputum culture. Determination of ventilator days was based on information provided by the respiratory therapy department. Three tiers of review on all patients receiving mechanical ventilation were held: initial review by the surveillance infection control professional, review by the assistant director of infection control, and, finally, review by 4 pulmonary specialists, each an MICU attending physician (2 specialists were physician authors of the study). The profiles reviewed by the physicians did not contain information about whether the patient was in the control group or the study group, nor did the profiles contain data from the confirmatory period. Graphs depicting monthly VAP rates were distributed to the staff and posted in the MICU.

During the intervention period, VAP rates decreased significantly.

### Definition

A VAP case was defined according to definitions published by the Centers for Disease Control and Prevention.[19] VAP was defined as occurring when the patient had a chest radiograph showing new or progressive infiltrate, consolidation, cavitation, or pleural effusion in conjunction with either new onset of purulent sputum or change in character of sputum, an organism isolated from blood, or the isolation of an etiologic agent from a specimen obtained via suction aspiration through the endotracheal or

**Table 2**
**Demographic characteristics and baseline measurements**

| Characteristic | Before intervention (n = 779) | During intervention (n = 759) | *P* |
|---|---|---|---|
| Age, mean (SD), y | 60 (11) | 61 (8) | |
| Sex, No. of patients | | | .74 |
| Male | 477 | 471 | |
| Female | 302 | 288 | |
| APACHE II score | 28 (7) | 29 (5) | |
| Reason for ICU admission, No. (%) | | | |
| Acute respiratory failure | 428 (55) | 412 (54) | .79 |
| Cardiovascular disease | 135 (17) | 126 (17) | .70 |
| Gastrointestinal disease | 70 (9) | 74 (10) | .76 |
| Renal disease | 62 (8) | 66 (9) | .60 |
| Sepsis | 53 (7) | 47 (6) | .63 |
| Trauma | 15 (2) | 19 (3) | .44 |
| Neurological disease | 8 (1) | 7 (1) | .83 |
| Other | 8 (1) | 8 (1) | .96 |

Abbreviations: APACHE, Acute Physiologic and Chronic Health Evaluation; ICU, intensive care unit.

tracheostomy tube. Specimens in this study were not obtained by bronchoscopy or biopsy. An infiltrate was considered to be a new occurrence if it occurred more than 48 hours after the start of mechanical ventilation or within 48 hours of extubation.

### Statistical Analysis

Given the fact that one of the primary focuses of the study was measuring the effectiveness of an oral-dental care protocol over a sustained period, the length of the study period was used in the study design rather than the specific number of patients needed to detect a 15% difference in the rate of VAP occurrence between the 2 groups. Approximately 250 patients in each group would have been sufficient to provide 80% power; a considerably higher number of patients was required to be observed for a 4-year period.

Comparisons used in the study were unpaired, and all tests of significance were 2-tailed. All variables with normal Gaussian distribution were evaluated with the Student *t* test, and variables with non-Gaussian distribution were analyzed by using Mann-Whitney analysis. Mann-Whitney analysis was used on the categorical variable of age. The APACHE scores and the remaining variables were evaluated with the Student *t* test. Mortality analysis was done by using a 2 x 2 contingency table to compare deaths in patients who had VAP with all deaths. A commercial statistical analysis package (SAS/STAT, SAS Institute Inc, Cary, North Carolina) was used to compare VAP incidence between patients receiving standard oral care and patients receiving comprehensive oral-dental interventions, with patients' characteristics controlled for. Potential confounding variables were deemed acceptable or unacceptable at .05. All results of logistic regression analysis are stated as adjusted odds ratios with 95% confidence intervals. Reported *P* values of .05 or less were considered statistically significant.

Patients had shorter ICU stays and decreased mortality rates after the intervention.

## Results

### Inclusion of Patients

Of 1616 eligible patients, 32 patients (3.9%) in the control group and 46 (5.7%) from the study group were eliminated because they had not been receiving mechanical ventilation for 48 hours. A total of 1538 patients were included in the study (779 in the control group and 759 in the study group).

### Demographic and Baseline Physiological Characteristics

No statistically significant differences were found between the 2 treatment groups with respect to age, sex, mean APACHE II scores, or admission diagnosis (Table 2). The most common reasons for admission to the ICU were acute respiratory failure and cardiovascular disease.

### Staff Compliance With Intervention Protocol

The infection control professionals reviewed the MICU's critical care flow sheets 55 times during the 24-month intervention period to determine nurses' compliance with 4 protocol components: (1) daily oral assessment, (2) deep suctioning, (3) toothbrushing, and (4) oral cleansing of tissues and lips. Compliance with the established protocol

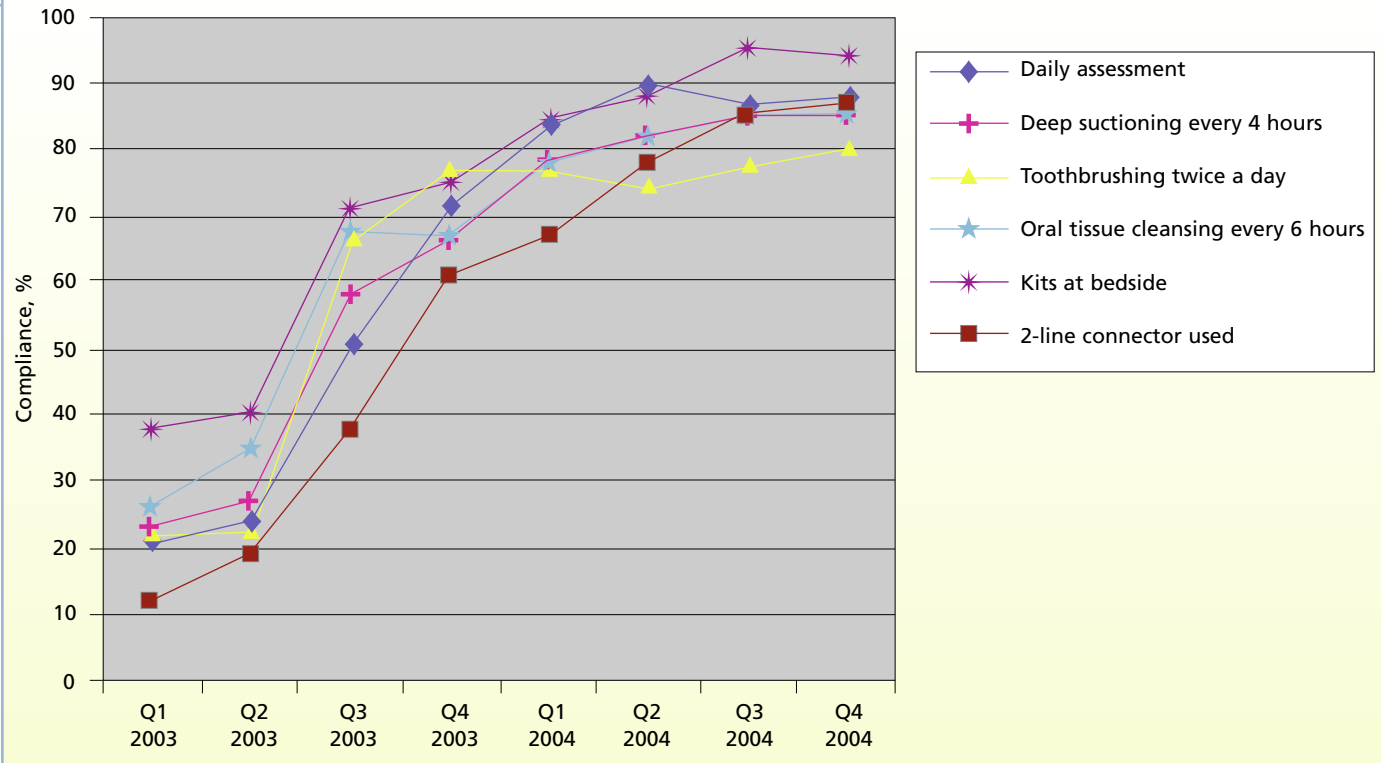


**Figure 1** Compliance with components of the oral-dental protocol, by quarter (Q).

increased during the intervention period and reached at least 80% for all 6 monitored standards (Figure 1), which included requirements for bedside setup of the oral care kit and use of a Y-connector to create a 2-line system.

## Outcome Measures

VAP occurred in 8.6% (67/779) of patients in the control group and 4.1% (31/759) of patients in the study group (Table 3). During the intervention period, VAP rates decreased by 33.3%, although the result was only marginally significant (12 vs 8 cases per 1000 ventilator days, $P = .06$). After review of these results, the critical care committee approved continuing the intervention as an integral part of MICU care. VAP rates in the MICU for 2005 (defined as the confirmatory period) were 0 cases per 1000 ventilator days for the first and fourth quarters, 5.7 cases per 1000 ventilator days in the second quarter, and 3.5 cases per 1000 days in the third quarter (Figure 2). During the confirmatory period, no cases of VAP were seen in 8 of 12 months. Both duration of mechanical ventilation and length of MICU stay decreased significantly after implementation of the intervention (Table 3). The mean time to VAP was 2.9 days before the intervention and 4.7 days during the intervention ($P < .001$). Mortality was reduced significantly in the intervention period from 19.4% to 14.6% ($P = .01$).

**Table 3**
**Outcome measures**

| Measure | Before intervention (n = 779) | During intervention (n = 759) | *P* |
|---|---|---|---|
| Ventilator days (VD) | 5581 | 3856 | |
| VAP, No. (%) of patients | 67 (8.6) | 31 (4.1) | <.001 |
| VAP rate (per 1000 VD) | 12.0 | 8.0 | .06 |
| MICU patient days (PD, all patients) | 7222 | 7087 | .54 |
| Utilization ratio (VD/PD) | 0.77 | 0.54 | <.001 |
| Duration of ventilation, mean, days | 7.2 | 5.1 | <.05 |
| Days in MICU (ventilator patients), mean | 8.7 | 6.4 | <.05 |
| Time to VAP, mean, days | 2.9 | 4.7 | <.001 |
| Mortality (ventilator patients), No. (%) | 151 (19.4) | 111 (14.6) | .01 |

Abbreviations: MICU, medical intensive care unit; VAP, ventilator-associated pneumonia.

This study did not address oral bacterial burden or colonization; however, implementation of an oral care regimen in addition to the ventilator bundle did reduce VAP rates. The patient population had a reduced ICU LOS, but no decrease in mortality,

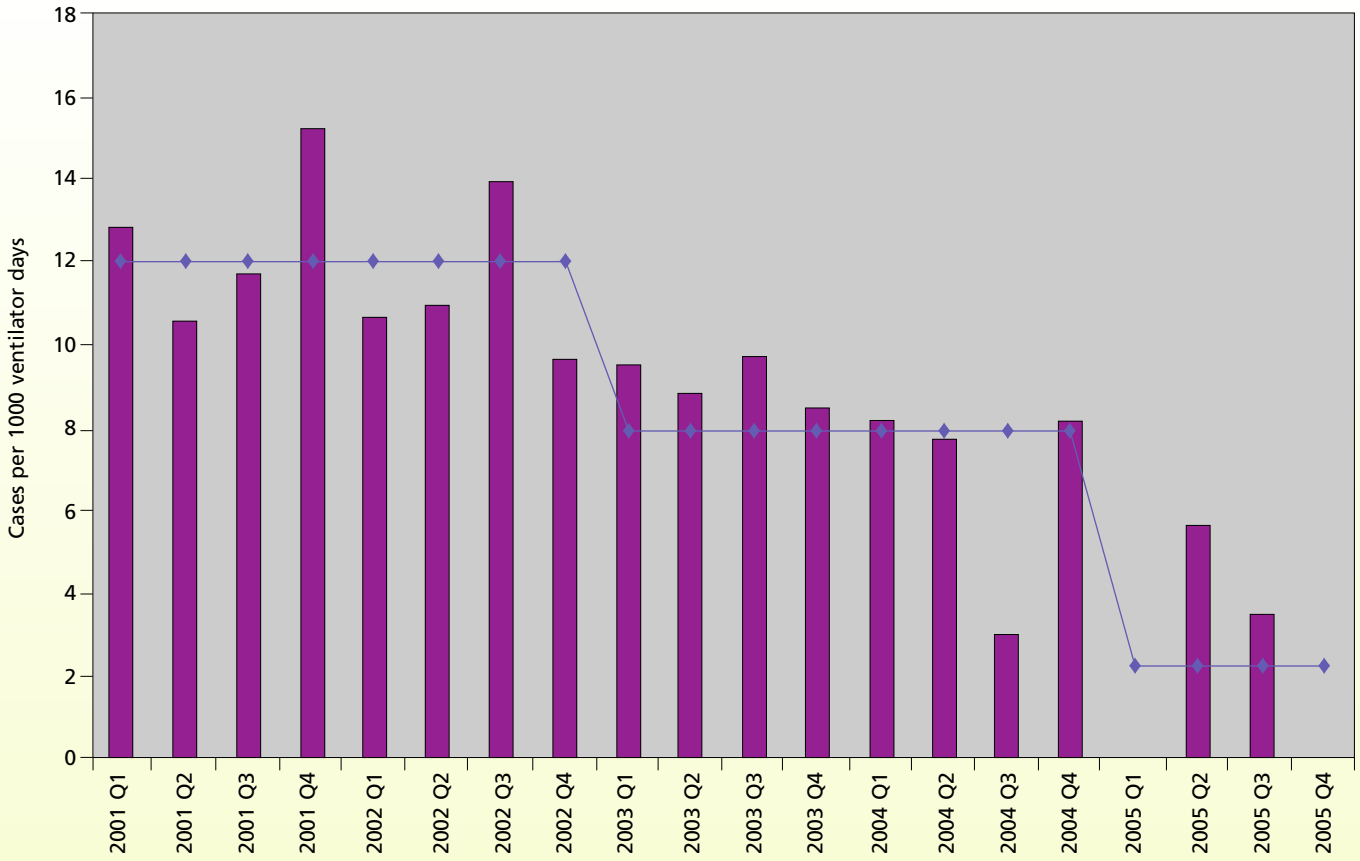


**Figure 2** Ventilator-associated pneumonia rates in the medical intensive care unit, 2001-2005, by quarter (Q). Blue line connects data points (diamonds) indicating mean annual rate of ventilator-associated pneumonia during preintervention period, intervention period, and confirmatory period.

possibly because of an overall low mortality rate in the study population.

## Discussion

This 48-month study of adult ICU patients yielded 4 important findings: (1) risk and incidence of VAP are significantly reduced by implementation of a multifaceted protocol that includes daily oral assessment combined with procedures and tools specifically designated for bacterial reduction in the oral cavity, subglottic space, and on teeth, and conducted on an established daily schedule; (2) infection avoidance can be sustained for considerable periods, in this case for 36 months (24-month intervention period plus 12-month confirmatory period); (3) despite the establishment of other evidence-based interventions such as elevation of the head of the bed and prophylaxis of stress ulcers, VAP rates of zero did not occur until the new protocol was instituted; (4) a comprehensive oral-dental care program has profound effects on reducing the duration of mechanical ventilation (from 7.2 days to 5.1 days) and ICU LOS (from 8.7 days to 6.4 days). This study is also the first published trial we know of that shows these improvements in adult ICU patients with similar demographic characteristics and at similar risk for VAP.

Targeting of bacterial organisms that colonize the oropharynx is not typical but is emerging as a practical intervention.[20-23] The results of our study add further weight to the theory that oropharyngeal colonization is central in the etiology of VAP. Prevention of bacterial colonization of these anatomic sites as a means of reducing the occurrence of respiratory infection in adult patients is based on extensive and varied research conducted in the past 20 years. Efforts to prevent bacterial colonization are particularly important, given that oral care is often considered difficult and does not always include toothbrushing for patients in the ICU.[24]

### Oropharyngeal and Stomach Colonization

Early research into the principal link between bacterial colonization and eventual respiratory infection indicated that the stomach was the key source in this pathway.[25-28] Further studies[29-31] using advanced diagnostic techniques, however, strongly

supported the contention that colonization of the oropharyngeal tissues is primarily responsible for colonization of the stomach or gut. Extensive research has been conducted on procedures that directly or indirectly attempt to control bacterial colonization of gastric fluid[32-34]; however, none of these interventions have been proven definitively to reduce VAP incidence. Elevating the head of the bed also has been advocated as a means of decreasing aspiration in patients receiving mechanical ventilation. In a recent randomized trial, however, elevation of the head of the bed as a singular intervention did not reduce the incidence of pneumonia.[35]

Researchers in the United States and Europe have taken a more direct approach in controlling colonization by studying the effects of oral decontamination on pulmonary infection. These methods involved the administration of antibiotic pastes or solutions into the oropharynx or trachea of patients receiving mechanical ventilation.[36-38]

Antiseptic solutions such as chlorhexidine gluconate also have been used as decolonizing agents. Results from a prospective, randomized, double-blind, placebo-controlled clinical trial of 353 patients undergoing open heart surgical procedures in which 0.12% chlorhexidine gluconate oral rinse was applied to the oropharyngeal region did not show reduced rates of wound, blood, or urinary tract infections.[39] However, treatment of bacterial colonization in the oral tract resulted in a 69% reduction in respiratory infections. More recent studies achieved decreased rates of colonization and infection with the use of either 2% chlorhexidine gluconate/colistin[40] or povidone iodine.[41]

### Colonization of Dental Plaque

Dental plaque is a highly complex mass that grows by the continuous layering of aerobic, anaerobic, and filamentous bacteria on the surface of teeth and the surrounding soft tissues.[42] Several published studies[42-46] strongly suggest that colonized dental plaque serves as a contributory factor in developing respiratory infections and VAP.

### The Oropharynx Colonization–Pneumonia Pathway

We did not address oral bacterial burden or colonization because the evidence reviewed provided strong scientific evidence substantiating a link between oropharyngeal colonization and the development of respiratory infection. Multiple bacteria, including gram-negative bacterial strains, that colonize the tissues and recesses of the mouth, gums, tongue, and teeth are often carried by oral secretions to the subglottic area above the endotracheal cuff in patients receiving mechanical ventilation—the first step of a possible pathway leading to pneumonia.[47] Buildup of subglottic secretions can occur within several hours after initial intubation.[48] Patients often aspirate bacteria-laden fluid continuously through microspaces formed between tracheal tissue and the plastic surface of the inflated endotracheal cuff.[49,50] Inadequate cuff pressures and movement of the endotracheal tube further complicate the need to maintain uniform contact between tissue and cuff.[51] Immunological responses may not be sufficient to penetrate biofilms that have formed at this point on the endotracheal tube and may not be able to counter the high number of organisms present. This scenario increases the risk of colonization of the bronchus and eventual aspiration into the lungs.

> Infection avoidance can be sustained for considerable periods.

### Comparative Studies

In the present study, the VAP rate was initially reduced 33.3% during the intervention period. Several other researchers have reported the results of implementing comprehensive oral-dental care protocols.[52-58] The OSF Saint Francis Medical Center in Peoria, Illinois, conducted a program to determine whether a bundle approach would affect VAP outcomes,[52] and they were able to decrease the VAP rate 67% in the surgical ICU and 48% in the other adult ICUs.

Shay and O'Malley[53] implemented a bundle protocol that included maintaining the head of the bed at 30°, advanced oral care (toothbrushing, subglottic suctioning, and oral cleansing), and checks of endotracheal cuff pressure. That protocol was based on the premise that control of oral colonization, plaque removal, prevention of aspiration, and removal of subglottic secretions may reduce VAP. Multiple regression analyses showed the oral care components and monitoring of endotracheal cuff pressure did not independently affect VAP rates significantly; however, the combined interventions explained 46.28% of the variance in VAP rates. VAP decreased by 68% during the study period of 2 years.

> A comprehensive oral-dental care program has profound effects on reducing the duration of mechanical ventilation and ICU length of stay.

To our knowledge, 2 studies[54,55] have been conducted with a design and methods similar to the study reported here. Schleder et al[54] conducted a

retrospective study in an adult ICU using an evidence-based oral care protocol that measured the effect of reducing oral colonization on VAP outcomes, and reported a nearly 61% decrease in VAP rates (5.6 vs 2.2 infections per 1000 ventilator days). Rhodes et al[55] repeated enforcement of guidelines for VAP prevention and introduced oral care kits with new protocols for each component. In an 8-month period, VAP rates were reduced by 62% (13.2 to 5.0 infections per 1000 catheter days).

The Institute for Healthcare Improvement indicated that 14 hospitals have achieved a zero infection rate in their report of outcomes stemming from a national initiative on VAP prevention.[55] Of these, 8 institutions had added advanced oral and dental care tools as an integral part of the bundle components. Other multihospital efforts have reported continued compliance with elevation of the head of the bed, sedation vacation, and advanced oral care standards, with a resultant reduction to a VAP rate of zero for 12 months.[57,58]

Multiple bacteria are often carried by oral secretions to the subglottic area above the endotracheal cuff.

### Limitations

Our study was limited by the nonrandomized design, in that it is possible that because the treatment groups were not concurrent, other events might have affected the outcomes. For example, the types of patients admitted to an intensive care unit can vary by season and this could affect outcomes of observation periods done sequentially in time.

## Summary

This large study indicates that direct and consistent intervention in reducing bacterial colonization of the oral cavity, including the teeth and subglottic areas above the endotracheal cuff, results in reduced rates of VAP, reduced duration of mechanical ventilation, and a shorter mean ICU LOS. VAP reduction was sustainable for a considerable period. The impact of such a protocol on the prevention of VAP and other respiratory infections on a national scale could be considerable. Further studies are needed to verify the effectiveness of comprehensive oral care protocols and their role as a major strategy for preventing VAP.

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FINANCIAL DISCLOSURES

None reported.

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