

REDUCTION OF MICROBIAL COLONIZATION IN THE OROPHARYNX AND DENTAL PLAQUE REDUCES VENTILATOR-ASSOCIATED PNEUMONIA.

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ABSTRACT

BACKGROUND: An estimated 150,000 to 300,000 cases of nosocomial pneumonia occur each year in US hospitals. The primary risk factor for nosocomial bacterial pneumonia is mechanical ventilation using an endotracheal tube. Ventilator-associated pneumonia (VAP) outcomes can be severe with mortality reaching 87%. VAP also extends length of stay by an average of 6 days and can cost >\$40,000 per event. The scientific literature provides strong evidence of an association between oropharyngeal and dental plaque colonization and respiratory infection.

OBJECTIVES: To determine the effectiveness of a comprehensive program of oral and dental health assessment and intervention to reduce the rates of VAP.

METHODS: All adult patients placed on mechanical ventilation using an endotracheal tube in the medical intensive care unit (MICU) during Jan 2002–Dec 2003 were included in the study. Patients intubated between Jan-Dec 2002 (pre-intervention) received standard oral care. For the period of Jan-Dec 2003 (post-intervention), nurses were required to assess the daily condition of the lips, oral tissues, tongue, teeth, and saliva. Review of practices revealed a need for improved interventions. A new oral-dental care kit with universal adaptor was introduced that provided [1] a closed oral/tracheal suction

system; [2] covered Yankauer to reduce environmental contamination; [3] catheters for suctioning secretions that pool in the mouth and oropharynx prior to accumulating above the endotracheal cuff (q6h); [4] suction toothbrush with hydrogen peroxide solution to reduce dental plaque (2x day); [5] suction oral swab with moisturizer to promote mucosal integrity (q4h). No other interventions were introduced during the study period.

RESULTS: Patient ages, sex, and diagnoses were similar in the pre-intervention group and the study group. The number of patients and ventilator days were 377 and 2,641 (avg. 7.0 days) for the pre-intervention group and 360 and 2,490 (avg. 6.9 days) for the patients using the new intervention. Risk for pneumonia in both years was high: ventilator utilization ratio (VUR) for the MICU in 2002 was 0.63 and 0.55 for 2003 or approximately 75th-90th percentile of NNIS data. Rate of VAP per 1000 ventilator days in the MICU was 7.6 in 2002 and 4.4 in 2003, a 42.1% reduction in the overall rate. NNIS benchmark data indicates median MICU VAP rates at 6.0 per 1000 ventilator days.

CONCLUSION: Careful assessment and improved oral care interventions to reduce bacterial colonization of the oropharynx and teeth reduces contaminated aspirates and subsequent VAP.

BACKGROUND

The efficacy and cost effectiveness of various intervention strategies for the prevention and control of nosocomial pneumonia, particularly for patients on mechanical ventilation, have been extensively reviewed. (1-4) In 2002, the Healthcare Infection Control Practices Advisory Committee (HICPAC) of the US Centers for Disease Control and Prevention (CDC) issued a preliminary evidence-based guideline (5) that listed graded recommendations addressing a wide-range of issues including the need to educate healthcare workers on risk-reduction practices, the safe handling and cleaning of respiratory care devices such as mechanical ventilators and humidifiers, the duration of use of disposable ventilator circuits and closed suction catheters, the suctioning of subglottic secretions, placement of patients in semirecumbent positions, the use of stress ulcer medications, and selective decontamination of the digestive tract. Following a comment and review period, the CDC issued the final version of the guideline in 2004. (6)

Two interventions that have emerged in the scientific literature as contributory to the prevention of pneumonia in hospitalized patients, and are currently not fully addressed in either the CDC pneumonia prevention guideline or other published sets of recommendations, are the performance and frequency of oropharyngeal care and the elimination of dental plaque to reduce bacterial colonization. This abstract describes and summarizes the results of a study that incorporated oral assessment protocols, oral and dental

interventions to reduce bacterial colonization, and staff education to reduce the occurrence of VAP in medical intensive-care patients.

The impetus for implementing such interventions evolved from a response to patient safety and quality improvement initiatives as addressed by national organizations:

- The Agency for Healthcare Research and Quality (AHRQ) has developed evidence-based safety practices that are applicable to a wide range of healthcare facilities. Their review of 73 such practices has concluded that measures taken to prevent VAP are well supported in the scientific literature and are generally of low cost impact to the facility. (7)
- The National Quality Forum, in their national voluntary consensus standards for measuring the quality of healthcare, has endorsed the implementation of specific safe practices as related to the prevention of VAP. (8)
- The Joint Commission on Accreditation of Healthcare Organizations has emphasized the requirements for reducing the risks of healthcare-acquired infections by issuing revised 2004-2005 standards which include new patient safety goals. In addition, this organization is field testing new standards specifically addressing the surveillance of VAP occurrences. (9)

OBJECTIVES

To determine the effectiveness of implementing an integrated oral care system designed to reduce the levels of bacterial colonization in the oropharynx and on the teeth, and the subsequent impact on

the occurrence of VAP. Focused interventions to be taken were based on information in the medical literature and as contained in the guidelines on the prevention of VAP as published by the CDC.

METHODS

The study was conducted in a 450-bed university-affiliated teaching hospital. Two infection control professionals (ICPs) were assigned to conduct surveillance for VAP on all adult medical intensive care unit patients intubated during the study periods. A VAP case was defined according to published CDC definitions (10) and included all adult patients who developed such infection after 48 hours of intubation. The 12-month period from January-December 2002 is defined as the pre-intervention period. Principles of interventional epidemiology were used to identify barriers to best practice in the prevention of VAP. Assessment tools used by ICPs during the pre-intervention period included staff interviews and observations of practice. Respiratory therapists, nurses, and physicians were included. Review of policies, coupled with observations to confirm practice, did not reveal any pervasive breaks in aseptic technique (included handwashing compliance; 7-day ventilator circuit changes; replacement of closed suction catheter devices; use of HMEs; handling of humidifiers; use of semirecumbent positioning where medically indicated; use of stress ulcer drugs; and weaning protocol).

However, several practices relating to mouth and dental care among this population were noted to be infection control concerns: the lack of a daily assessment of oral tissues and teeth; disconnection of the closed suction tubing in order to conduct mouth suction; placement of uncovered Yankauer device 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 suction-dental care intervals.

Infection Control organized a series of meetings with key representatives, including nursing and physician staff of the MICU, nursing educators, anesthesiology, the emergency room, materials management, and performance improvement. Information gathered during the interview and observation sessions was shared with the members of this VAP Prevention Task Force. This information, coupled with a review of policies and available patient care products led to a formulation of a list of needs in the area of 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 use of Yankauer catheters; need to maintain a true closed suction system; need for frequent and adequate removal of oropharyngeal secretions; provision of effective dental plaque removal; provision of solutions that maintain the integrity of oral tissues and establishment of protocol for documentation of interventions on each nursing shift. A master plan was developed by the Infection Control Department (ICD) and subsequently approved by the Infection Control Committee (ICC) and Performance Improvement. At the core of the plan were the following key strategies:

1. **Education.** Targeted medical residents (94% captured), surgical residents (98%), anesthesiologists (100%), and all nurses involved in oral care procedures (93%). Topics covered included the morbidity, mortality, and costs associated with

the occurrence of VAP; MICU rates vs. national benchmarks; procedure and timing of handwashing; intubation procedures; review of protocols for ventilator circuit, closed suction device, and HME filter changes; medication administration; care of equipment; review of weaning protocol; review of policy addressing elevating the head of the bed. Questions to address as part of the principle education handout are outlined in Table 1. [Conducted: Nov-Dec 2002]

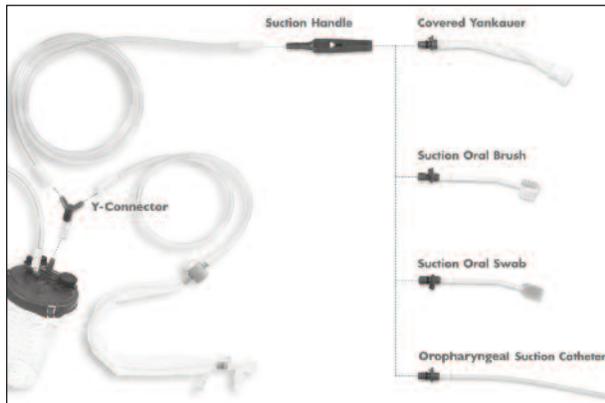
TABLE 1.

QUESTIONS TO ADDRESS IN AN EDUCATION HANDOUT ON THE PREVENTION OF VAP.

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 to national benchmarks?
4. What major interventions to prevent VAP have been implemented to this point?
5. How does bacterial colonization of the mouth, oropharynx, and teeth effect the occurrence of respiratory infection in ventilated patients?
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?

2. **Introduction of a Comprehensive Oral and Dental Care System.** During the pre-intervention period, MICU protocols required "standard" oral care which included suction of the oral cavity as needed using suction catheters or Yankauer, and glycerine swabs for tissue and lip care. Tubings used for suctioning through the endotracheal tube via a closed suction device were disconnected prior to performing oropharyngeal suctioning. Dental care products were not used for patients on mechanical ventilation. The ICC and the Products Evaluation Committee approved for use a comprehensive oral and dental care system [Q•Care™ Oral Cleansing and Suctioning System, Sage Products, Inc., Cary, IL.] which incorporated several novel advances directed at reducing secretions that accumulate in the oral cavity after the introduction of an endotracheal tube and plaque which forms on the surface of teeth [Figure 1].

FIGURE 1.



The principal system components include a y-connector, that when placed on a suction canister port provides the capability to attach two suction tubings, one for oral care and the second 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 environment; a suction dental brush designed for mechanical reduction in the quantity of dental plaque; a suction oral swab for the cleansing of the oral cavity and the surrounding tissues; a suction catheter for removal of secretions that form in the oral cavity.* Protocol for the use of the system components as used in the facility's education program is outlined in Figure 2. [Post-intervention period: Jan-Dec, 2003]

* The device manufacturer does not market or approve of its use below the vocal cords.

FIGURE 2.

Procedure	Component	Frequency of Use
Oral Cleansing	Suction Oral Swab	Q4 or as necessary
Brush Care	Suction Oral Brush	2 times per day
Oropharyngeal Suctioning	Suction Catheter	Q4

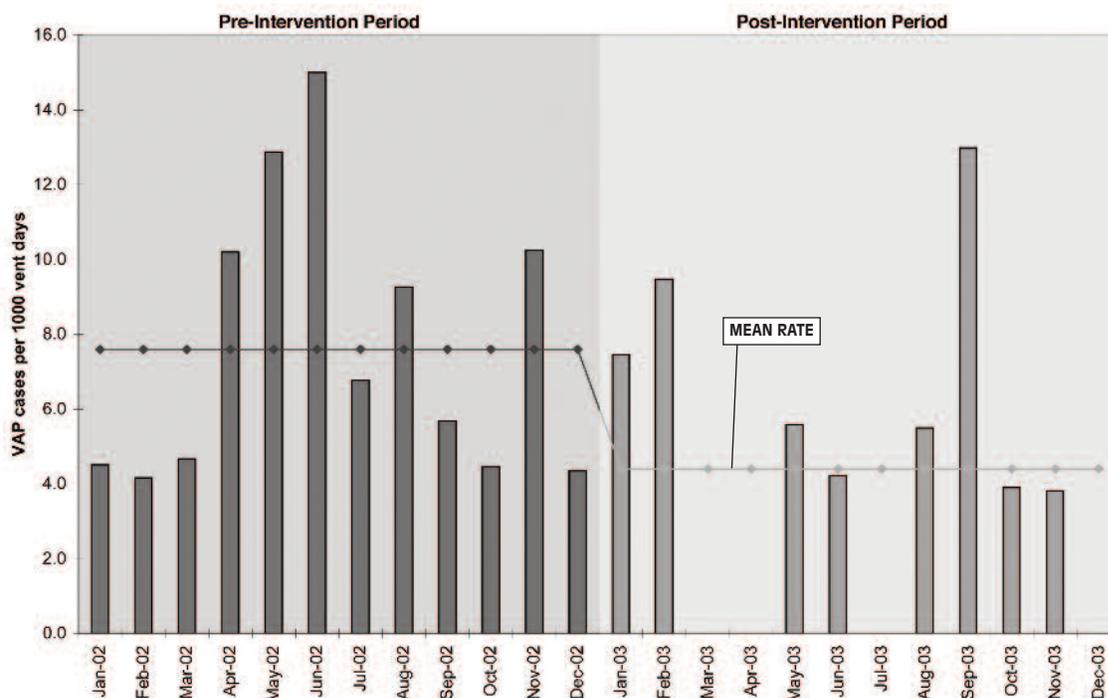
After implementation of the oral and dental care system, ICPs expanded the daily infection surveillance process to include monitoring of product availability and documentation of its use by nursing personnel. Kits containing sufficient system components for a 24-hour period were made available by the manufacturer. One kit was hung from a bedside bracket by a nurse technician at the start of each day shift. The ICP, in turn, verified the placement and the dual line setup during monitoring rounds. Revisions to policy required that nurses document the use of each component by entering a code letter in a designated section of the daily patient assessment sheet in the medical record. These logs are checked for compliance by the ICP

RESULTS

A total of 737 patients with 5,130 ventilator days (average duration of ventilation equaled 7.0 days) were included in this

study. VAP rates by month for the two-year study period are shown in Figure 3.

FIGURE 3. VENTILATOR-ASSOCIATED PNEUMONIA RATES, MICU, BUMC, 2002-2003



During the pre-intervention period (Jan-Dec 2002), the mean rate of CR-BSI was 7.6 cases per 1000 ventilator days (VD). It was identified that 5.3% of all MICU patients ventilated during this period developed VAP. The mean rate for the 12-month period in which oral and dental care interventions were implemented (Jan-Dec 2003) was calculated to be 4.4 cases per 1000 CD, an approx-

imate 42.1% in rate reduction. VAP occurred in 3.1% of patients who received proper oral and dental care. Rates of VAP and number of VAP cases occurring in the two study periods are summarized in Table 2. Implementation of protocols for reducing bacterial colonization in the oropharynx and on the teeth avoided an expected 9 cases of VAP in MICU patients in 2003.

TABLE 2. VENTILATOR-ASSOCIATED PNEUMONIA RATES

Period	# Patients	# VAP cases	Ventilator days	Rate (VAP/1000 VD)	% of Patients Developing VAP
Pre-Intervention: Jan-Dec 2002	377	20	2641	7.6	5.3
Post-Intervention: Jan-Dec 2003	360	11	2490	4.4	3.1

DISCUSSION

This study demonstrates that the implementation of a comprehensive program addressing the reduction of bacteria that accumulates in the niches of the gums, oral tissues, teeth, and pharynx of patients who have endotracheal tubes inserted in order to provide ventilation, can have dramatic effects on rates of VAP. Prevention of colonization of these anatomical sites as a means to reduce the occurrence of respiratory infection in this patient population is based on extensive research conducted over the last twenty years.

STOMACH COLONIZATION

Strong evidence that bacterial colonization of the oropharyngeal cavity is a major precursor to the development of respiratory infection can be found in the literature. However, this was not always the belief. Several early studies examining the pathway of respiratory infection in critical care patients appeared to indicate that gastric colonization was the principle source for bacteria contributing to aspiration pneumonia. (11-13) More recent research findings strongly support the hypothesis that colonization of the oropharynx, and not the stomach or gut, is primarily responsible for subsequent respiratory infection. (14-17) This finding has been confirmed using DNA genomic analysis on pathogens identified from bronchoscopic samples. (16) Modulating gastric colonization by the administration of nonabsorbable antibiotics into the stomach and intestine, (18) by use of sucralfate for stress ulcer prophylaxis (19,20) or by varying enteral feeding, (21) has not proven to definitively reduce the incidence of VAP.

In contrast, three published studies (22-24) that administered antibiotic pastes or solutions in the oropharynx or trachea to patients on mechanical ventilation provide strong evidence that oropharyngeal decontamination will effectively decrease VAP rates. Rodriguez-Roldan and colleagues reported no occurrences of VAP in patients being treated with antimicrobial pastes while the control group developed pneumonia in eleven (73%) of 15 patients. (22) Pugin and researchers found a relative risk reduction in VAP of 0.79 when patients were administered a polymyxin B-neomycin-vancomycin solution. (23) Bergmans and researchers concluded that the recent weight of evidence to date "...proves the pivotal role of oropharyngeal colonization in the pathogenesis of this infection." (24)

OROPHARYNGEAL COLONIZATION

The mouth in a normal state is colonized by commensal streptococci, made possible by the body's release of fibronectin which creates binding sites for these specific bacteria. In disease, particularly in conditions where the tissues of the mouth become dry or inflamed, the tissues lose streptococci binding sites, leaving the oropharynx susceptible to pathogenic organisms, particularly gram-negative bacteria. (25,26) Patients in prone positions, especially those with an endotracheal tube, are especially susceptible to aspirating secretions that accumulate in the mouth and pharynx. These secretions are heavily contaminated with the pathogenic organisms. (27)

The relationship between colonization of the oropharynx and nosocomial infection in ICU patients was initially studied in 1987. (28) Cultures taken three times per week revealed that colonization of the oropharynx cavity progressed rapidly, with 60% of all patients colonized after 5 days and 85% by the 10th day. Gram-negative microorganisms predominated during this period. In 66% of the 35 episodes of respiratory infection, the pathogen was the same as that which first colonized the oral cavity. Using more sophisticated specimen collection techniques (bronchoscopy with protected specimen brush), Torres and researchers (29) not only found that mean bacterial counts increased significantly in the oropharynx of patients in ICUs, but occurred more often in patients developing VAP than in those who did not. This was confirmed in a 1999 study that also indicated that post-intubation colonization with gram-negative bacteria (mean time to colonization of 43 hrs.) was a predictor of late-onset pneumonia (i.e., pneumonia occurring >4 days after intubation). (30)

In intensive care unit patients, the oropharynx becomes more susceptible to further colonization due to exposure to endemic antibiotic-resistant organisms, the pressures created by multi-antibiotic regimens, mucosal desiccation and epithelial injuries, decreased IgA salivary content, reduced salivary secretion, and the accumulation of secretions caused by the existence of an endotracheal (ET) and/or nasogastric tube. (31) Within several hours of initial intubation, subglottic secretions develop which pool above the ET cuff, (32) a condition exacerbated by the patient's supine position. Researchers have established that the oral cavity becomes heavily colonized by gram-negative organisms, (33) an event that may occur in as little as 24 hours after intubation. (34) Oral cavity

colonization is often a precursor to the contamination of the secretions formed above the ET cuff. Extensive research indicates that patients aspirate, on a continuous basis, these subglottic bacteria-laden secretions. (35,36) Figure 4 illustrates the secretions that build up in the mouth, above the vocal cords, and eventually in the subglottic space.

DENTITION

Dental plaque has been described as "...a specific and highly variable structural entity resulting from colonization and growth of micro-organisms on the surfaces of teeth, soft tissues, and dental prosthesis...Plaque mass grows by cumulative addition of aerobic, anaerobic, and filamentous microorganisms and without mechanical elimination it can cover the entire tooth surface...Bacteria constitute approximately 70-80% of the solid material and 1 mm³ of plaque contains more than 10⁶ bacteria with 300 different aerobic and anaerobic species...poor oral hygiene and lack of mechanical elimination are the main factors leading to proliferation and accumulation of dental plaque and subsequent colonization." (37)

Colonized dental plaque has been cited as a major contributory factor in respiratory infections and specifically VAP in several

studies. (38,39) Scannapieco and colleagues demonstrated that MICU patients were significantly more prone to be colonized in dental plaque by pathogens than were healthy subjects. (38) Fourrier went on to identify that 40% of all ICU patients had significant levels of dental plaque on admission and was predictive of subsequent respiratory infection. (39)

Current recommendations addressing oral care contained in the 2004 Hospital Infection Control Practices Advisory Committee (HICPAC) guideline on preventing pneumonia are outlined in Table 3.

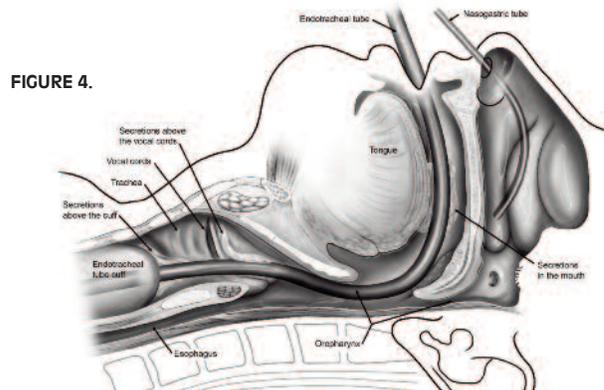


TABLE 3.

2004 HICPAC RECOMMENDATIONS ON ORAL AND DENTAL CARE

Recommendation	Level of Recommendation
IV.B.1.d. Use an endotracheal tube with a dorsal lumen above the endotracheal cuff to allow drainage (by continuous or frequent intermittent suctioning) of tracheal secretions that accumulate in the patient's subglottic area.	Category II
IV.B.1.e. Before deflating the cuff of an endotracheal tube in preparation for tube removal, or before moving the tube, ensure that secretions are cleared from above the tube cuff.	Category II
IV.B.3.a. Oropharyngeal cleaning and decontamination with an antiseptic agent: develop and implement a comprehensive oral-hygiene program (that might include the use of an antiseptic agent) for patients in acute-care settings or residents in long-term-care facilities who are at high risk for health-care-associated pneumonia.	Category II
IV.B.3.b. 1. No recommendation on the routine use of an oral chlorhexidine rinse for the prevention of healthcare-associated pneumonia in all post-operative or critically ill patients and/or other patients at high risk for pneumonia.	Unresolved issue
IV.B.3.b.2. Use an oral chlorhexidine gluconate (0.12%) rinse during the perioperative period on patients who undergo cardiac surgery.	Category II
IV.B.3.c.1. No recommendation can be made for the routine use of topical antimicrobial agents for oral decontamination to prevent VAP.	Unresolved issue

Source: Guidelines for Preventing Healthcare-Associated Pneumonia, 2004, Healthcare Infection Control Practices Advisory Committee, MMWR, Vol. 53(RR03);1-36, March 26, 2004, Centers for Disease Control and Prevention, Atlanta, GA.

CDC CATEGORIES:

Category IA. Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies.

Category IB. Strongly recommended for implementation and supported by certain experimental, clinical, or epidemiologic studies and strong theoretical rationale.

Category IC. Required for implementation as mandated by federal or state regulation or standard.

Category II. Suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale.

No recommendation. Unresolved issue. Practices for which insufficient evidence or no consensus regarding efficacy exists.

COST SAVINGS

It is estimated that 9 cases of VAP were avoided after implementation of interventions in 2003. Reported figures on attributable cost per infection are estimated at \$40,000. (40) The projected total cost for the 9 avoided cases is calculated to be \$360,000. Cost of new product for the 360 patients in the post-intervention period

was estimated to be \$55,775. Costs avoided are therefore calculated to be \$304,225 (cost of infections avoided – product cost). Additional savings due to the elimination of various products used during the pre-intervention period was not calculated.

CONCLUSION

The evolving world of performance improvement in healthcare is today focused on initiation of patient safety initiatives. Given the extent of morbidity and mortality associated with healthcare-acquired infections, their prevention has clearly become a principal goal in the patient safety arena. The study summarized here demonstrates that implementing proper practices to reduce bacterial colonization

in the mouth and on the surface of teeth of intensive care patients, decreases a major healthcare-acquired infection, namely ventilator-associated pneumonia. The impact on reducing hospital costs can also be considerable. Further studies will be needed to confirm these results in various settings and patient populations.

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