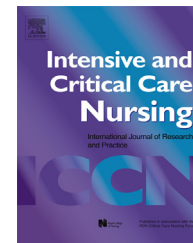




Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/iccn



ORIGINAL ARTICLE

The Bedside Oral Exam and the Barrow Oral Care Protocol: Translating evidence-based oral care into practice

Virginia Prendergast^{a,*}, Cindy Kleiman^b, Mary King^a

^a Division of Advanced Practice Nursing, Barrow Neurological Institute, St. Joseph's Hospital and Medical Center, Phoenix, AZ, United States

^b Oral Care Consultant, Phoenix, AZ, United States

Accepted 5 April 2013

KEYWORDS

Nursing care;
Oral hygiene;
Tooth brushing;
VAP;
Evidence-based care

Summary

Aim: To introduce the Bedside Oral Exam (BOE) and the Barrow Oral Care Protocol (BOCP) to guide oral care for intensive care unit patients. Secondary aim: To explore quality improvement data for incidence of ventilator associated pneumonia (VAP), cost effectiveness of oral hygiene supplies and staff response to change in practice.

Methods: Descriptive case design for implementation and evaluation of oral assessments and oral hygiene. Incidence of VAP and the cost of oral care supplies before and after implementation was compared. Staff responses were elicited both pre- and post-implementation.

Results: Incidence of VAP fell significantly from 4.21 to 2.1 per 1000 ventilator days ($p = .04$). A cost savings of 65% was noted on a monthly basis for oral hygiene supplies. Staff reported increased satisfaction in providing oral hygiene with a combination of oral care products.

Conclusions: A significant reduction in VAP was noted using the BOCP. The BOE guided individualised oral care with contemporary supplies, including a tongue scraper, electric toothbrush, non-foaming toothpaste and oral moisturisers. Cost-effective, comprehensive oral care appears to be effective in reducing VAP. Further studies are needed to assess impact of oral hygiene on oral health and patient comfort.

© 2013 Elsevier Ltd. All rights reserved.

* Corresponding author at: c/o Neuroscience Publications, Barrow Neurological Institute, St. Joseph's Hospital and Medical Center, 350 W. Thomas Road, Phoenix, AZ 85013, United States. Tel.: +1 602 406 3593; fax: +1 602 406 4104.

E-mail address: Neuropub@dignityhealth.org (V. Prendergast).

Implications for Clinical Practice

- Poor oral hygiene contributes to deterioration of oral health and increases incidence of VAP.
- A simple bedside oral exam provides a surrogate marker for oral health and can be used to guide oral care in critical care settings.
- The Barrow Oral Care Protocol is a cost-effective method of providing oral hygiene and reducing VAP among ICU patients.
- A tongue scraper, electric tooth brush, non-foaming toothpaste and oral moisturiser are key components in providing oral hygiene for hospitalised patients.

Introduction

Hospitalisation negatively impacts patients' overall oral health as evidenced by an increased accumulation of biofilms and dental plaque, deterioration in mucous membranes and colonisation with potential respiratory pathogens (Needleman et al., 2012; Terezakis et al., 2011). Prehospitalisation neglect or trauma, ineffective oral care during hospitalisation or both worsen the oral environment of patients who are already critically ill, further emphasising the need for effective oral care. Despite a significant relationship to systemic health, oral assessments and optimal oral care practices in the critically ill are lacking (Ames, 2011). Although intensive care unit (ICU) nurses understand the importance of oral care, providing such care to ICU patients may often be neglected (Fitch et al., 1999; Furr et al., 2004). Well-documented changes in oral health among intubated patients may have an adverse effect on patient outcomes (Dennesen et al., 2003; Munro et al., 2006; Terezakis et al., 2011). Cost-effective oral hygiene may result in improved oral health and comfort in the critically ill.

Literature review

A complex integration exists to maintain oral health and wellness. In a healthy mouth, saliva is produced and secreted by the salivary glands at a rate of 500 mL to 1.5 L per day, with production noted to be highest when standing and lowest when recumbent (Dawes, 1996; Stonecypher, 2010). When saliva is normal in quantity and composition, it cleanses the mouth, moisturises mucous membranes, lubricates food during mastication and acts as a removal mechanism for microorganisms, thereby maintaining integrity of the teeth and soft tissues (Dennesen et al., 2003; Fitch et al., 1999). The tooth surface is uniquely defined by its non-shedding characteristics of oral bacteria compared to the natural shedding surface of oral mucosa (Mager et al., 2005). Consequently, when teeth are not cleaned, the tooth surface may harbour pathogenic organisms leading to the development of thick biofilms and an increased microbial burden of pathogens (Marsh and Devine, 2011).

Despite the growing consensus that oral care is a component of critical care, measures of oral health status for ICU patients are underreported in the critical care literature (Abidia, 2007; Berry and Davidson, 2006). Oral health assessments conducted during hospitalisation can be viewed as





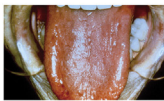
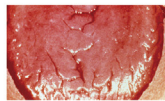
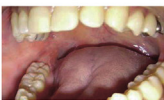
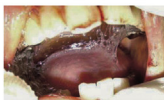



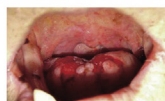






indicators of overall oral health on a continuum scale ranging from poor health to excellent health. The Oral Assessment Guide (OAG) (Eilers et al., 1988), based upon eight items with each item rated on a three-point scale, was originally developed to assess the oral health of patients who received stomatotoxic treatments. It has since been modified for use in several healthcare settings (Chalmers et al., 2005; Hallberg and Andersson, 2011; Talbot et al., 2005).

The Bedside Oral Exam (BOE) (Fig. 1), modified from the OAG with permission, has been used as a measure of oral health for neuroscience ICU patients (Prendergast et al., 2012). Total BOE scores range from 8 (excellent oral health) to 24 (poor oral health). The item "voice", included in the original OAG (Eilers et al., 1988), was replaced with the category "odour". Foul odour, formed from bacteria most commonly found over the dorsal surface of the tongue, serves as an indicator of oral health (Outhouse et al., 2006). The oral health of hospitalised patients is vulnerable to exogenous threats, endogenous threats or both (Fig. 2). External threats include artificial airways, ambient air and effects of medications (Abidia, 2007; Fitch et al., 1999). Airway devices, which are necessary to maintain a patent airway, mandate that the mouth be exposed to air constantly, which dries oral mucosal surfaces and the tongue while increasing dental plaque (Munro and Grap, 2004). Dried mucosal areas under the endotracheal tube have been reported to tear upon extubation (Schweiger and Lang, 1981). Commonly administered medications such as narcotics, antihypertensives, benzodiazepines and diuretics may result in, or worsen, a xerostomic state (Munro and Grap, 2004). Sodium lauryl sulfate, a common detergent agent, is an ingredient in many toothpastes and results in a foaming action. If the toothpaste is not adequately rinsed from the mouth, residual amounts dry and harden on the mucosal surface, thereby blunting future efforts to clean the mouth and associated structures (Herlofson and Barkvoll, 1996).

Endogenous threats, such as haemodynamic instability, fever and stress during critical illness, can also compromise oral health. Patients who have experienced volume loss from trauma or operative procedures have decreased tissue perfusion which results in xerostomia (Labeau and Blot, 2011). Complications such as fever and diarrhoea, combined with an inadequate fluid intake, can result in a decreased production of saliva, thereby worsening xerostomia (Dennesen et al., 2003). Such threats, together with improper or poor oral hygiene, foster growth of bacterial deposits along gingival crevices and cause inflammation. If left untreated, these areas may serve as a portal for infection and further result in

Bedside Oral Exam (BOE)

Perform each Shift

Category	Methods of Measurement	Numerical and Descriptive Ratings		
		1 Normal	2 Moderate Dysfunction	3 Severe Dysfunction
Swallow	Observe while patient swallows, check gag reflex	Normal swallow	Pain or difficulty with swallow	Unable to swallow (intubated, absent gag)
Lips	Observe	 Smooth, pink	 Dry or cracked	 Ulcerated or bleeding
Tongue	Observe appearance of tissue	 Pink, moist, papillae present	 Coated or loss of papillae with shiny appearance, with or w/o redness	 Blistered, cracked, or bleeding
Saliva	Observe Use tongue blade, touching the center of tongue and floor of mouth (optional)	 Watery	 Thick or ropy	 Absent
Mucous Membranes	Observe appearance of tissue	 Pink, moist	 Red or coated, no ulcers	 Ulcers with or w/o bleeding
Gingiva	Observe Use tongue blade, may gently press tissue with tip of blade (optional)	 Pink, firm	 Edema, with or w/o redness; with or w/o bleeding	 Bleeds easily
Teeth or dentures	Observe appearance of teeth or denture	 Clean or no teeth	 Local debris (between teeth)	 General debris, decay
Odor	Smell	Normal	Slightly to moderately foul	Strong foul odor

Modified from: Eilers, et al. (1988) "Development, testing, and application of the oral assessment guide." *Oncol Nurs Forum* 15(3): 325-30.

Figure 1 The Bedside Oral Exam.

Oral assessment guide text from Eilers Oral Assessment Guide and Oral Care Protocol, *The Japanese Journal of Nursing Arts*, 58(1):12–16, 2012. Modified with permission from University of Nebraska. Some of the photographs from Masumi Muramatsu: Eilers Oral Assessment Guide and Oral Care Protocol. *Kango Gijyutsu*. January 2012: 12–16. Modified with permission from Kango Gijyutsu.

subgingival inflammation and destruction of the bone (periodontitis) (Labeau and Blot, 2011). Periodontitis has been implicated as a contributing factor in the worsening of a number of systemic diseases, including (but not limited to) cardiovascular disease, bacterial pneumonia and premature babies with low birthweight (Fowler et al., 2001; Labeau and Blot, 2011; Li et al., 2000).

For optimal oral care, oral hygiene should include a combination of debridement and moisturisers. Given the host of threats to oral health for hospitalised patients, tooth brushing twice daily to reduce oral debris, biofilms and dental plaque remains the mainstay of oral health. Tooth brushing has been described as the single most important oral hygiene activity (Sweeney, 2005). During the past decade, electric toothbrushes have been reported as superior to manual toothbrushes in plaque reduction and improved gingival health (Haffajee et al., 2001; Heanue et al., 2003). Debridement of the tongue via scraping is also advocated in the outpatient setting as a means to reduce halitosis due to bacterial load along the dorsal surface of the tongue (Rosenberg, 1996).

With varying degrees of success, saliva substitutes, oral moisturizing agents and various rinses have all been promoted as methods to maintain oral hydration for the ill or intubated patient (DeKeyser et al., 2009; Hsu et al., 2011). A moisturising gel substitute, Oral Balance® (GlaxoSmithKline, Philadelphia, PA) has been recommended for mucous membranes as it contains two antimicrobial enzymes normally found in saliva, lactoperoxidase and glucose oxidase (Jones, 2005). Oral Balance Gel® studied in conjunction with Biotene® dry mouth toothpaste has been found to be effective (Warde et al., 2000). During a two-year randomised controlled trial, the Barrow Oral Care Protocol (BOCP) was found to be superior in maintaining oral health during intubation compared to standard oral care using the BOE (Prendergast et al., 2012).

Aim

The aim of this study was to translate the evidence-based BOE and the stratified BOCP into practice for adult

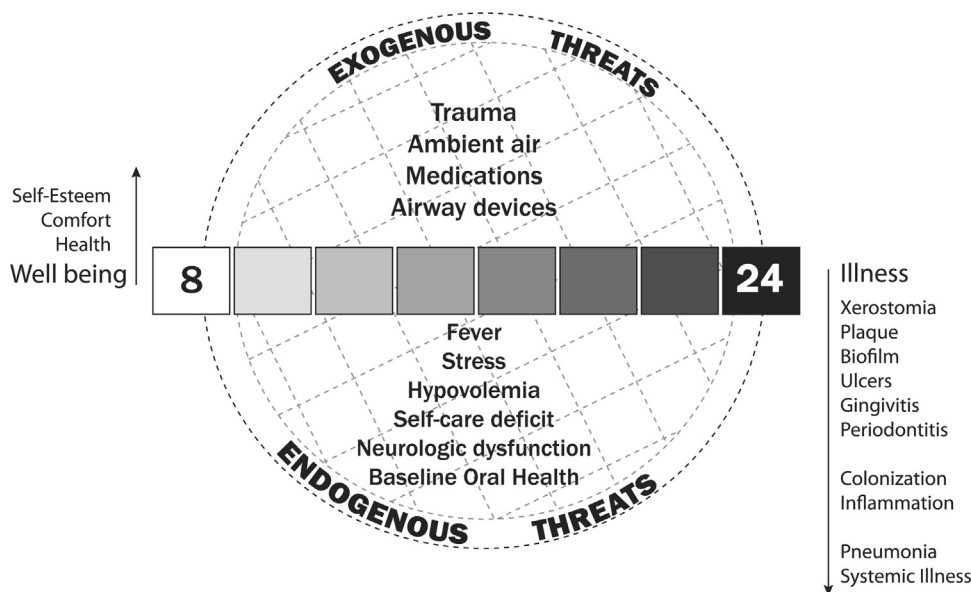


Figure 2 Threats to oral health during hospitalization and intubation. Numerical scale represents the BOE scale for oral health assessments; “8” indicates good oral health. Used with permission from Barrow Neurological Institute.

ICU patients. Additionally, researchers sought to monitor quality improvement data for ventilator associated pneumonia (VAP) rates, cost of supplies and nursing staff response.

Methods

Setting

The study included 32 beds in mixed adult intensive care units in a large, urban tertiary referral hospital in the Southwestern United States. The nurse-to-patient ratio was 1:2 and patient care technicians were available to assist with bedside care.

Study design

A quality improvement, descriptive case design was used to direct the implementation and evaluation of the BOE and BOC. The first phase was pre-implementation and guided by the formation and subsequent recommendations of an Oral Health Initiative Committee. Volunteer members of this group included: a nurse researcher, members of the hospital Infection Control Department, physicians from Infectious Disease and Pulmonary Critical Care, VAP committee chair, Clinical Nurse Specialists (CNS) and the Director of Materials Management. The second phase was the implementation of the BOE and the BOC. Analysis was performed in several different areas, including: routine comparative data to assess VAP rates before and after implementation, cost comparisons of previously used oral care supplies versus new oral hygiene supplies and quality of oral hygiene as reported through nurse interviews to a dental hygienist.

Phase I – preparation

Using the Institute for Health Care Improvement problem solving methodology of “plan-do-study-act” (Berwick, 1996), experts representing clinical and management excellence formed an Oral Health Initiative Committee. Members of this multidisciplinary committee agreed to review the applicability of oral assessments and protocols, evaluate potential changes in practice and participate in periodic evaluations. The committee agreed to present the BOE and stratified BOC to hospital-wide medical and nursing committees. The critical care, internal medicine, trauma and VAP prevention committees together with nursing shared governance, nursing practice and education, and nursing leadership unanimously approved the proposed changes in bedside assessments and care. Members of the Oral Health Initiative Committee were divided into three subgroups to accomplish the following: purchasing new oral care products, developing educational strategies and monitoring quality improvement data.

Adoption of the BOC required three new oral care products: a tongue scraper, an electric toothbrush and an oral moisturiser. The selected tongue scraper had a low-angled, slim profile to provide a nontraumatic means of removing soft debris and bacteria from the surface of the tongue. The Oral B Vitality® toothbrush, a battery-powered electric toothbrush with a 2-minute timer, was chosen for all intubated patients (Procter and Gamble, Cincinnati, OH). Paediatric toothbrushes remained in stock for non-intubated patients. Oral Balance® was selected because its gel-like consistency effectively moisturizes the tongue and oral mucosa. Biotene® toothpaste (GlaxoSmithKline, Philadelphia, PA) is a commercially available, non-foaming toothpaste for xerostomia and was used exclusively for all patients.

All CNSs attended three sessions to learn components of oral health, the BOE and the BOCP. Strategies to educate staff were mutually decided by the CNSs together with a registered dental hygienist (RDH). Educational plans included preparation of inservices, construction of colour-coded handouts, pictures showing oral health, creation of a 'Frequently Asked Questions' series to follow initial education and a competency module. The BOE was incorporated to the electronic medical record as an automatic addition to every patient's vital sign record. The cumulative BOE score guided subsequent oral care therapy during the shift.

Phase II – implementation

Based on the work completed in Phase I, the director of Materials Management coordinated the purchase of new oral care supplies. After six months of negotiation, the manufacturer agreed to allow and establish distribution channels to the hospital. Previously, electric toothbrush manufacturers had established distribution exclusively to retailers and dental offices. All staff underwent an initial competency evaluation. Laminated, double-sided handouts that illustrated the BOE, the BOCP and "how-to" information detailing the cleaning and storage of supplies were provided to all staff. Periodic oral hygiene rounds were conducted by the CNSs in assigned units to clarify BOE findings. Additional instructions regarding new oral hygiene products were provided.

The stratified BOCP (Fig. 3) consisted of increasingly comprehensive measures based on the total BOE score. Non-intubated patients with good oral health scores (BOE 8–10) received the basic oral care protocol consisting of tongue scraping, brushing with a paediatric toothbrush and a thin layer of petroleum jelly applied to lips twice daily. If a patient had moderately impaired oral health (BOE 11–14), mucosal care was performed every 4 hours in addition to the basic oral care protocol. All intubated patients, or those with significant deterioration (BOE 15–24), received an electric toothbrush. Staff was instructed to tilt the toothbrush towards the gums at a 45° angle to allow the head of the toothbrush to clean the tooth surface and gumline effectively. One hour after brushing, a chlorhexidine-soaked swab was used to paint the entire oral cavity. Mucosal care was provided every 2 hours for these patients. Regardless of the type of toothbrush that was used, staff were instructed to clean the toothbrush and scraper by rinsing them under warm water and placing them in a clean, dry emesis basin. The emesis basin was covered with a dry washcloth to prevent contamination from ambient air particles and was placed in the patient's bedside cabinet to further protect and isolate its contents. Pictures depicting proper and improper storage of oral care supplies were included in the oral care protocol for reference and reinforcement.

During several oral care inservices, an RDH offered bedside strategies to assist in the education of the BOE and oral care. Nurses were instructed to use the thumb and index finger in the mucobuccal fold to raise or lower the lip for visualisation of the oral tissue. The RDH remained available to staff on a periodic basis to assist with additional questions and serve as a consultant on problematic patients.

Following the introduction of the BOE and individualised oral hygiene protocols, periodic oral hygiene rounds were conducted by the CNSs in assigned units. Ongoing clarification of BOE findings and additional instructions on the oral hygiene products were provided.

Analysis

VAP rates were calculated by members of the hospital's Infection Control Committee using the National Healthcare Safety Network report structure. Summary statistics of VAP rates from 2011 to 2012 were compared. The Z test was used to compare proportions; a *p*-value of .05 or less considered statistically significant. A cost analysis was performed by materials management to compare the cost of products used for the BOCP to those previously used for oral care. Feedback from bedside staff was elicited over a six month period during staff meetings and during one-on-one clinical rounds conducted by CNS staff and the RDH. The staff responses were reviewed, and additional educational strategies developed to facilitate oral care were adopted accordingly.

Results

VAP

Significant differences were noted in VAP rates after the BOE and the BOCP were implemented. The proportion of VAP rates was reduced from 4.21 per 1000 ventilator days in 2011 to 2.1 per 1000 ventilator days in 2012 (*p* = .04). Year-to-date cumulative VAP occurrences were 18 in 2011, compared to 10 in 2012.


Cost

Cost comparisons yielded significant savings using the BOCP. Average monthly costs for the Sage Oral Suction Q-Care Product® in 2011 protocol were \$4000.00. Following introduction of the new supplies, the average monthly cost in 2012 was \$1453.00, a savings of 65%. The greatest cost savings was the result of replacing the Sage Oral Suction Q-Care products (prepackaged, disposable supplies consisting of foam swabs, a paediatric suction toothbrush and various rinses) with an electric toothbrush complete with a 2 minute timer. The cost of the tooth brush was a one-time charge of \$8.54. The cost of a tongue scraper at \$0.74 was an additional expense in the armamentarium of oral hygiene supplies. However, its effectiveness in promotion of tongue health and reduction of odour justified the expense and together with the non-foaming toothpaste, resulted in improved cleanliness of teeth and gingival margins upon inspection by the RDH.

Staff response

The introduction of the BOE and the BOCP was initially met with mixed responses from bedside nursing staff. While the scientific rationale of performing an assessment was understood, staff verbalised feelings of frustration with being asked to perform an additional assessment. Furthermore,

Barrow Oral Care Protocol

		Protocol 1: Score 8 - 10 Normal	Protocol 2: Score 11-14 Moderate Dysfunction	Protocol 3: Score 15-24 Severe Dysfunction
Oral Care	Brush teeth q 12 hours	✓	✓	✓
	Oral mucosal care	prn	q 4 hours	q 2 hours
	CHG	—	—	1 hour after toothbrushing swab CHG along gum line and surface of tongue
Methods	Brush teeth Rinse mouth or swab with damp sponge. Scrape tongue from back to front. Use Biotene®, brush back to front, inside/outside for 2 minutes. Conclude with mucosal care for comatose patients. Apply thin layer of petroleum jelly to lips*.		Oral mucosal care Rinse mouth or swab with damp sponge. Use new, dampened sponge and apply OralBalance® to tongue, oral mucosa. Apply thin layer of petroleum jelly to lips*. If hardened debris present: Saturate sponge with OralBalance® and swab areas of debris. Wait 1 minute and swab or scrape to remove. Rinse. Apply fresh application of OralBalance®.	
	*Per PCCM – thin layer of petroleum ok for patients on O2 and ventilator approved.			
Supplies and Storage	Tongue scraper, Biotene toothpaste, petroleum jelly	Store supplies in covered emesis basin. Emesis basin placed in drawer or cabinet. NO ORAL CARE SUPPLIES in bath basin.		
	Pediatric toothbrush, electric toothbrush (if ETT/trached), swabs Oral Balance - Protocol 2, 3 CHG - If intubated, and/or Protocol 3			
Denture Care	Brush dentures every 24 hours. Keep in covered container (in water).			

© 2012, BNI

Figure 3 The Barrow Oral Care Protocol. Stratified oral care protocols 1–3 based on BOE score. CHG, chlorhexidine. Used with permission from Barrow Neurological Institute.

staff reported never having received formal education in providing oral hygiene. The RDH developed the following strategies to improve the techniques of oral care including: (1) lubricate patients’ lips before oral care is provided. (2) Dampen an oral swab with Oral Balance® to loosen and remove dried secretions. For hardened debris, apply lubricant and leave undisturbed for two to three minutes to soften the debris. Remove secretions with a dry oral swab brought from the back forward to the lips. (3) Apply lubricant to the dorsal surface of tongue (as needed) and clean the tongue with soft strokes from the back to the front. The scraper may need to be wiped off intermittently if secretions are copious. (4) Regardless of whether an electric toothbrush or a manual toothbrush is used, two minutes of brushing are necessary for proper debridement of teeth and stimulation of gingival tissues. If possible, the lingual aspects of the teeth are brushed first, starting with the back teeth, then occlusal. Progressing from the back to the front, facial surfaces in the front are the last to be brushed as this is the easiest area of the mouth to brush. Patients cannot bite the care provider during oral care if the fingers remain in the inner cheek fold when retracting the lip. Oral bite blocks may be inserted horizontally and turned vertically

once between the teeth to minimise biting on the endotracheal tube or toothbrush during oral hygiene. The nursing staff reported significant increase in satisfaction in performing oral care armed with products deemed superior. While the use of a tongue scraper was novel in the hospital, many staff reported using one at home for their own oral hygiene needs. The Biotene® toothpaste was acknowledged as being easy to rinse from the teeth and mucous membranes. Additionally, staff was not confronted with the increased volume of suds as seen with standard toothpaste or hydrogen peroxide in previously supplied pre-packaged kits. There were no reports of mechanical issues with the electric toothbrushes. Staff reported them being easy to use and felt that patients’ mouths were cleaner overall. Furthermore, staff reported that the use of the electric toothbrush allayed concerns about the degree of pressure required in providing oral care.

Discussion

A descriptive approach was used to introduce the BOE and the BOCPP and evaluate the merits based on VAP rates, cost

savings and nursing feedback. Representation by knowledgeable stakeholders on the Oral Health Initiative Committee was crucial to the evaluation of strengths and weaknesses of the proposed oral hygiene project and to define expectations for success (Grol et al., 2004). Results obtained during this study underscore the difficulty required in translating evidence-based guidelines into practice. The dedication of practitioners and leadership within the organization was critical to success, especially when confronted with barriers of reportedly unobtainable products (Melnyk and Fineout-Overhold, 2010).

Daily oral assessments have been previously recommended to guide oral hygiene in critical care settings (Fitch et al., 1999; Treloar and Stechmiller, 1995). The BOE provided a narrative and visual reference for bedside staff. The inclusion of odour as part of oral health assessments has been reported as a valid indicator of poor oral health (Outhouse et al., 2006; Sjogren and Nordstrom, 2000). The combination of the colour-coded assessment scale and corresponding pictures of the BOE provided the necessary framework to reinforce and sustain the practice of oral health assessments. While the BOE is rapid, easy to perform and appears reliable (Prendergast, 2012), additional investigations of reliability and validity aspects should be conducted as difficulties in assessments may be accentuated by presence of the endotracheal tube.

The conversion to evidence-based oral care products was supported by literature from outpatient settings, microbiology and dental sciences (Haffajee et al., 2001; Jones, 2005; Marsh and Devine, 2011). Brushing the teeth with toothpaste has long been promoted as the mainstay for promotion of tooth and gingival health for hospitalised patients (American Association of Critical-Care Nurses, 2008; Howarth, 1977; Schweiger and Lang, 1981). The teeth, being the only non-shedding surfaces of bacteria in the body, require debridement of biofilm in order to prevent build-up of plaque which lends itself to retention of pathogenic respiratory pathogens. While few randomised controlled trials have been conducted specifically to address electric toothbrushes among critically ill patients (Needleman et al., 2011; Prendergast et al., 2012), electric toothbrushes have demonstrated their superiority in plaque removal and are able to better clean gingival crevices when compared to manual toothbrushes (Terezhalmy et al., 2005). In addition, evidence indicates the effectiveness of a tongue scraper in reducing bacterial concentrations (Outhouse et al., 2006).

Scientific literature has investigated practices of oral hygiene in response to the association between poor oral health and VAP (Fourrier et al., 1998; Scannapieco et al., 2003). When oral hygiene is ineffective or neglected, complications may be manifested locally and systemically (Scannapieco and Mylotte, 1996; Treloar and Stechmiller, 1995). Nosocomial bacterial species have been found to be genetically indistinguishable from tracheal aspirates underscoring the fact that the teeth, gingival margins and tongue may be reservoirs of bacteria responsible for nosocomial pneumonia (Heo et al., 2008). Therefore, it follows that a comprehensive oral care protocol directed towards promotion of oral health is a critical component to reducing the burden of nosocomial organisms. Improved oral hygiene may result in decreased risk of VAP, thereby improving patient outcomes and decreasing hospital healthcare costs. The

BOCP demonstrated significant cost savings. The projected cost of VAP in billed charges per patient averages \$40,000 USD more compared to ventilated patients without VAP, thereby underscoring the significant cost savings with the BOCP (Rello et al., 2002; Restrepo et al., 2010). As a result, the BOE and the BOCP have been implemented across every department in the 550 bed hospital.

Proper oral hygiene is a critical task provided by nurses; it is those nurses' responsibility to maintain this aspect of the patients' health when the patients are unable to do it themselves (McCloskey et al., 2003). Patients who cannot adequately perform oral care bear the burden of oral health deterioration and pain if their hygiene needs are unattended. To meet basic hygiene needs, nurses need to perform oral assessments and provide oral hygiene with products proven to provide superior care. However, ICU nurses continue to use foam swabs as the main tool for cleaning teeth, gingiva and mucous membranes (Cutler and Davis, 2005; Grap et al., 2003). This practice persists in the United States and Europe despite ICU nurses' acknowledgement of the superiority of a toothbrush over a swab (Binkley et al., 2004; Rello et al., 2007).

To provide cost effective, improved oral hygiene, health-care workers must use a combination of products to achieve necessary debridement of biofilms and plaque together with use of non-drying toothpaste and oral moisturisers to maximise oral health. Studies which investigate only one component of oral hygiene (e.g., tooth brushing) as a measure of success in combating VAP, fail to address the complexity of meeting oral health needs of the hospitalised patient. We have demonstrated the ability to provide improved oral hygiene, at a lower cost, to achieve a significant reduction in the incidence of VAP.

Conclusion

Oral assessments can serve as a surrogate marker of oral health upon which oral care may be individually tailored. This initiative was associated with a 50% reduction in VAP, decreased oral care supply costs by 65%, improved staff satisfaction and reported compliance with oral hygiene. The use of a tongue scraper, previously unreported in critical care oral hygiene protocols and electric toothbrush provided a non-traumatic means of removing debris from tongue and teeth surfaces.

Critically ill patients are unable to independently perform self-care activities such as oral care, making the oral hygiene by nursing staff essential. Staff education raised awareness of patients' vulnerability in maintenance of oral health against the backdrop of exogenous and endogenous threats. This further supported the incorporation of the BOE and the stratified BOCP into daily practice.

Promoting and maintaining the oral health of critically ill patients can be accomplished through a comprehensive oral care protocol using a bedside assessment tool (Chan et al., 2011). Oral hygiene interventions have been reported to reduce the incidence of VAP (Scannapieco et al., 2003). However, the primary endpoint of VAP should not be the sole indicator of oral hygiene efficacy. Too little attention has been focused on efficacy of oral hygiene practices, patient comfort and prevention of oral tissue degradation

and should be further explored for patients in a variety of ICUs and hospital wards. When applicable, focus should also include preoperative oral hygiene protocols for patients who are expected to require intubation during the postoperative time period.

Conflict of interest statement

The authors have no conflicts of interest to report.

References

- Abidia RF. Oral care in the intensive care unit: a review. *J Contemp Dent Pract* 2007;8:76–82.
- American Association of Critical-Care Nurses. Oral Care in the Critically Ill: Practice Alerts. American Association of Critical-Care Nurses 2008 January [cited 2008 March 7]; Available from: <http://www.aacn.org/wd/practice/content/vap-practice-alert.pcms?menu=practice>
- Ames NJ. Evidence to support tooth brushing in critically ill patients. *Am J Crit Care* 2011;20:242–50.
- Berry AM, Davidson PM. Beyond comfort: oral hygiene as a critical nursing activity in the intensive care unit. *Intensive Crit Care Nurs* 2006;22:318–28.
- Berwick DM. A primer on leading the improvement of systems. *BMJ* 1996;312:619–22.
- Binkley C, Furr LA, Carrico R, McCurren C. Survey of oral care practices in US intensive care units. *Am J Infect Control* 2004;32:161–9.
- Chalmers JM, King PL, Spencer AJ, Wright FA, Carter KD. The oral health assessment tool – validity and reliability. *Aust Dent J* 2005;50:191–9.
- Chan EY, Lee YK, Poh TH, Ng IH, Prabhakaran L. Translating evidence into nursing practice: oral hygiene for care dependent adults. *Int J Evid Based Healthcare* 2011;9:172–83.
- Cutler CJ, Davis N. Improving oral care in patients receiving mechanical ventilation. *Am J Crit Care* 2005;14:389–94.
- Dawes C. Factors influencing salivary flow rate and composition. In: Edgar WM, O’Mullane DM, editors. *Saliva and oral health*. 2nd ed. London: British Dental Association; 1996. p. 27–41.
- DeKeyser GF, Fink NF, Raanan O, Asher M, Bruttin M, Nun MB, et al. ICU nurses’ oral-care practices and the current best evidence. *J Nurs Scholarship* 2009;41:132–8.
- Dennesen P, van der Ven A, Vlasveld M, Lokker L, Ramsay G, Kessels A, et al. Inadequate salivary flow and poor oral mucosal status in intubated intensive care unit patients. *Crit Care Med* 2003;31:781–6.
- Eilers J, Berger AM, Petersen MC. Development, testing, and application of the oral assessment guide. *Oncol Nurs Forum* 1988;15:325–30.
- Fitch JA, Munro CL, Glass CA, Pellegrini JM. Oral care in the adult intensive care unit. *Am J Crit Care* 1999;8:314–8.
- Fourrier F, Duvivier B, Boutigny H, Roussel-Delvallez M, Chopin C. Colonization of dental plaque: a source of nosocomial infections in intensive care unit patients. *Crit Care Med* 1998;26:301–8.
- Fowler EB, Breault LG, Cuenin MF. Periodontal disease and its association with systemic disease. *Mil Med* 2001;166:85–9.
- Furr AL, Binkley CJ, McCurren C, Carrico R. Factors affecting quality of oral care in intensive care units. *J Adv Nurs* 2004;48:454–62.
- Grap MJ, Munro CL, Ashtiani B, Bryant S. Oral care interventions in critical care: frequency and documentation. *Am J Crit Care* 2003;12:113–8.
- Grol R, Baker R, Moss F. *Quality improvement research: understanding the science of change in health care*. London: BMJ Books; 2004.
- Haffajee AD, Thompson M, Torresyap G, Guerrero D, Socransky SS. Efficacy of manual and powered toothbrushes (I). Effect on clinical parameters. *J Clin Periodontol* 2001;28:937–46.
- Hallberg IR, Andersson P. Oral health and oral assessment. In: Reuschenbach B, Mahler C, editors. *International handbook of assessment tools for nursing and health care research (Internationales Handbuch für Pflegeforschung und – praxis)*. Bern: Verlag Hans Huber; 2011. p. 253–70.
- Heanue M, Deacon SA, Deery C, Robinson PG, Walmsley AD, Worthington HV, et al. Manual versus powered toothbrushing for oral health. *Cochrane Database Syst Rev* 2003;CD002281.
- Heo SM, Haase EM, Lesse AJ, Gill SR, Scannapieco FA. Genetic relationships between respiratory pathogens isolated from dental plaque and bronchoalveolar lavage fluid from patients in the intensive care unit undergoing mechanical ventilation. *Clin Infect Dis* 2008;47:1562–70.
- Herlufson BB, Barkvoll P. Oral mucosal desquamation caused by two toothpaste detergents in an experimental model. *Eur J Oral Sci* 1996;104:21–6.
- Howarth H. Mouth care procedures for the very ill. *Nurs Times* 1977;73:354–5.
- Hsu SP, Liao CS, Li CY, Chiou AF. The effects of different oral care protocols on mucosal change in orally intubated patients from an intensive care unit. *J Clin Nurs* 2011;20:1044–53.
- Jones H. Oral care in intensive care units: a literature review. *Spec Care Dentist* 2005;25:6–11.
- Labeau S, Blot S. Research priorities in oral care for endotracheally-intubated patients. In: Vincent JL, editor. *Annual update in intensive care and emergency medicine 2011*. New York: Springer; 2011.
- Li X, Kolltveit KM, Tronstad L, Olsen I. Systemic diseases caused by oral infection. *Clin Microbiol Rev* 2000;13:547–58.
- Mager DL, Haffajee AD, Devlin PM, Norris CM, Posner MR, Goodson JM. The salivary microbiota as a diagnostic indicator of oral cancer: a descriptive, non-randomized study of cancer-free and oral squamous cell carcinoma subjects. *J Trans Med* 2005;3:27.
- Marsh PD, Devine DA. How is the development of dental biofilms influenced by the host? *J Clin Periodontol* 2011;38(Suppl. 11):28–35.
- McCloskey, Dochterman J, Bulechek GM. *Nursing interventions classification (NIC)*. 4th ed. St. Louis: Mosby; 2003.
- Melnyk B, Fineout-Overhold E. *Evidence-based practice in nursing and healthcare: a guide to best practice*. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2010.
- Munro CL, Grap MJ. Oral health and care in the intensive care unit: state of the science. *Am J Crit Care* 2004;13:25–33.
- Munro CL, Grap MJ, Elswick RK Jr, McKinney J, Sessler CN, Hummel RS III. Oral health status and development of ventilator-associated pneumonia: a descriptive study. *Am J Crit Care* 2006;15:453–60.
- Needleman I, Hyun-Ryu J, Brealey D, Sachdev M, Moskal-Fitzpatrick D, Bercades G, et al. The impact of hospitalization on dental plaque accumulation: an observational study. *J Clin Periodontol* 2012;39:1011–6.
- Needleman IG, Hirsch NP, Leemans M, Moles DR, Wilson M, Ready DR, et al. Randomized controlled trial of toothbrushing to reduce ventilator-associated pneumonia pathogens and dental plaque in a critical care unit. *J Clin Periodontol* 2011;38:246–52.
- Outhouse TL, Al-Alawi R, Fedorowicz Z, Keenan JV. Tongue scraping for treating halitosis. *Cochrane Database Syst Rev* 2006;CD005519.
- Prendergast V. Safety and efficacy of oral care for intubated neuroscience intensive care unit patients, Doctoral dissertation. Lund, Sweden: Lund University; 2012.
- Prendergast V, Jakobsson U, Renvert S, Hallberg IR. Effects of a standard versus comprehensive oral care protocol among

- intubated neuroscience ICU patients: results of a randomized controlled trial. *J Neurosci Nurs* 2012;44:134–46.
- Rello J, Koulenti D, Blot S, Sierra R, Diaz E, De Waele JJ, et al. Oral care practices in intensive care units: a survey of 59 European ICUs. *Intensive Care Med* 2007;33:1066–70.
- Rello J, Ollendorf DA, Oster G, Vera-Llonch M, Bellm L, Redman R, et al. Epidemiology and outcomes of ventilator-associated pneumonia in a large US database. *Chest* 2002;122:2115–21.
- Restrepo MI, Anzueto A, Arroliga AC, Afessa B, Atkinson MJ, Ho NJ, et al. Economic burden of ventilator-associated pneumonia based on total resource utilization. *Infect Control Hosp Epidemiol* 2010;31:509–15.
- Rosenberg M. Clinical assessment of bad breath: current concepts. *J Am Dent Assoc* 1996;127:475–82.
- Scannapieco FA, Bush RB, Paju S. Associations between periodontal disease and risk for nosocomial bacterial pneumonia and chronic obstructive pulmonary disease. A systematic review. *Ann Periodontol* 2003;8:54–69.
- Scannapieco FA, Mylotte JM. Relationships between periodontal disease and bacterial pneumonia. *J Periodontol* 1996;67:1114–22.
- Schweiger J, Lang JW. Oral care and assessment in the critical care setting. *Crit Care Update* 1981;8:26–34.
- Sjogren R, Nordstrom G. Oral health status of psychiatric patients. *J Clin Nurs* 2000;9:632–8.
- Stonecipher K. Ventilator-associated pneumonia: the importance of oral care in intubated adults. *Crit Care Nurs Q* 2010;33:339–47.
- Sweeney P. Oral hygiene. In: Davies A, Finlay I, editors. *Oral care in advanced disease*. New York: Oxford University Press; 2005.
- Talbot A, Brady M, Furlanetto DL, Frenkel H, Williams BO. Oral care and stroke units. *Gerodontology* 2005;22:77–83.
- Terezakis E, Needleman I, Kumar N, Moles D, Agudo E. The impact of hospitalization on oral health: a systematic review. *J Clin Periodontol* 2011;38:628–36.
- Terezhalmay GT, Bartizek RD, Biesbrock AR. Relative plaque removal of three toothbrushes in a nine-period crossover study. *J Periodontol* 2005;76:2230–5.
- Treloar DM, Stechmiller JK. Use of a clinical assessment tool for orally intubated patients. *Am J Crit Care* 1995;4:355–60.
- Warde P, Kroll B, O'Sullivan B, Aslanidis J, Tew-George E, Waldron J, et al. A phase II study of Biotene in the treatment of postradiation xerostomia in patients with head and neck cancer. *Support Care Cancer* 2000;8:203–8.