



EFFECTS OF SYSTEMATIC ORAL CARE IN CRITICALLY ILL PATIENTS: A MULTICENTER STUDY

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CE 1.0 Hour

Notice to CE enrollees:

A closed-book, multiple-choice examination following this article tests your understanding of the following objectives:

1. Describe the purpose of this study and the measurements used to determine the results.
2. Identify the limitations of evidence-based guidelines for specific oral care procedures and their impact on various outcome measures.
3. Discuss the nursing considerations associated with assessment of oral health in critically-ill patients and the related implications for provision of appropriate oral care for these patients.

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Background No standard oral assessment tools are available for determining frequency of oral care in critical care patients, and the method of providing oral care is controversial.

Objectives To examine the effects of a systematic program of oral care on oral assessment scores in critically ill intubated and nonintubated, patients.

Methods Clinical data were collected 3 times during critical care admissions before and after institution of a systematic program of oral care in 3 different medical centers. The oral care education program consisted of instruction from a dentist or dental hygienist and a clear procedure outlining systematic oral care. The Beck Oral Assessment Scale and the mucosal-plaque score were used to assess the oral cavity. Data were analyzed by using linear mixed modeling with controls for severity of illness.

Results Scores on the Beck Scale differed significantly ($F=4.79$, $P=.01$) in the pattern of scores across the 3 days and between the control group (before oral education) and the systematic oral care group. Unlike the control group, the treatment group had decreasing scores on the Beck Scale from day 1 to day 5. The mucosal-plaque score and the Beck Scale scores had strong correlations throughout the study; the highest correlation was on day 5 ($r=0.798$, $P<.001$, $n=43$).

Conclusions Oral assessment scores improved after nurses implemented a protocol for systematic oral care. Use of the Beck Scale and the mucosal-plaque score could standardize oral assessment and guide nurses in providing oral interventions. (*American Journal of Critical Care*. 2011;20:e103-e114)

Oral care is a basic nursing care activity that provides relief and comfort to patients who are seriously ill and cannot perform this simple activity themselves. In a critical care unit, providing oral care to patients who are uncooperative, have a high risk for aspiration, or are intubated can be a challenge and, at times, an impossible task. However, if the benefit of oral care outweighs the risk, clear, precise oral care procedures and adequate evidence to support these processes are needed. If providing systematic oral care can decrease the incidence of pneumonia and other outcome measures, the care should be considered an important and critical component of critical care nursing. Except for investigations¹⁻³ in cardiac surgery patients, few studies^{4,5} have demonstrated these benefits from oral care. Studies of specific oral care practices, such as oral decontamination and toothbrushing, including use of powered toothbrushes, have not resulted in improvements in duration of mechanical ventilation, length of hospital stay, or mortality.^{6,7} A recent randomized clinical trial⁸ in critical care patients receiving mechanical ventilation indicated that powered toothbrushes reduced plaque burden, but other outcome measures, such as ventilator-associated pneumonia (VAP), were not included in the trial.

In addition to the lack of outcome data to support oral care, no standard oral assessment tools for determining the frequency and procedure for oral care are available. Treloar and Stechmiller⁹ developed an oral assessment tool and tested it on 16 intubated patients. However, no information on psychometric testing was provided, and the oral assessment lacked quantitative metrics or scales. Fitch et al¹⁰ used a 100-mm visual analog scale to assess the different structures in the oral cavity. In this 3-phase, longitudinal study,¹⁰ 30 patients were treated according to a specific oral care protocol that included brushing with a child's toothbrush. Although the oral care was performed by the nursing staff in less than 5 minutes, no specific information was provided on the time required to perform the oral assessment. The results indicated a significant difference in the mean inflammation score between the oral care group and the

comparison group, but no other variable differed between the 2 groups. Finally, Fourrier et al¹¹ used a plaque index score¹² and a dental assessment by an odontologist to assess 228 intubated patients in a double-blind, placebo-controlled trial of chlorhexidine gel for prevention of respiratory infections. Although the number of plaque cultures positive for pathogens was decreased in the intervention group by day 10, the rate of VAP, days of mechanical ventilation, and other outcome measures did not differ between the 2 groups. In a recent single-center study, Munro et al¹³ examined the effect of toothbrushing alone, chlorhexidine alone, and toothbrushing plus chlorhexidine in reducing the rate of VAP. The decayed, missing, and filled teeth index was used as a baseline assessment of general oral health. In a subgroup analysis of patients who did not have elevated pneumonia scores at baseline and received chlorhexidine, pneumonia rates on day 3 were reduced.

Another area of research is health care practitioners' oral care practices, in particular the practices of nurses and respiratory therapists. Although nurses think oral care is important, many use inadequate instruments such as foam sponges to perform oral care.¹⁴ In addition, nurses acknowledge that oral care procedures are not evidence based.¹⁵⁻¹⁷

Many performance improvement studies of VAP and oral care have been published. Some of the investigators^{18,19} found significant decreases in VAP rates after instituting numerous interventions including oral care. However, in these studies, oral care frequency

No standard oral assessment tools to determine oral care frequency and procedure are available.

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Table 1
Beck Oral Assessment Scale (BOAS), modified^a

Area	Score			
	1	2	3	4
Lips	Smooth, pink, moist, and intact	Slightly dry, red	Dry, swollen isolated blisters	Edematous, inflamed blisters
Gingiva and oral mucosa	Smooth, pink, moist, and intact	Pale, dry, isolated lesions	Swollen red	Very dry and edematous, inflamed
Tongue	Smooth, pink, moist, and intact	Dry, prominent papillae	Dry, swollen, tip and papillae are red with lesions	Very dry, edematous, engorged coating
Teeth	Clean, no debris	Minimal debris	Moderate debris	Covered with debris
Saliva	Thin, watery plentiful	Increase in amount	Scanty and somewhat thicker	Thick and ropy, viscid or mucid
Total score ^b	5 No dysfunction	6-10 Mild dysfunction	11-15 Moderate dysfunction	16-20 Severe dysfunction
Note: Provide moisture more often than oral care.	Minimum care every 12 h	Minimum care every 8-12 h	Minimum care every 8 h	Minimum care every 4 h

^a Modified from Beck.²³

^b Interpretation of total score:

BOAS 0-5: Perform an oral assessment once a day. Follow oral care as outlined in the systematic oral care procedure twice per day.

BOAS 6-10: Perform oral assessments twice a day. Moisten mouth/lips every 4 hours. Follow oral care as outlined in the systematic oral care procedure twice per day.

BOAS 11-15: Perform an oral assessment every shift (every 8-12 h). Follow oral care as outlined in the systematic oral care every shift. Use an ultra-soft toothbrush. Moisten lips and mouth every 2 h.

BOAS 16-20: Perform an oral assessment every 4 hours. Follow oral care as outlined. If brushing not possible, use soft gauze-wrapped finger. Moisten lips and mouth every 1-2 h.

and type were not clearly defined or consisted solely of chlorhexidine rinses.^{18,20} None of the studies included any oral assessment measure to determine the effects of oral care.

Recently, having critical care nurses provide oral care has received increased emphasis. National organizations^{21,22} have listed oral care in a number of prevention interventions. Providing evidence-based oral care requires data to support the intervention. Reliable and valid measures for oral assessment are essential to measure progress and guide intervention. In our study, we used a modified Beck Oral Assessment Scale (BOAS)²³ and the mucosal-plaque score (MPS)^{24,25} to assess the oral cavity (Table 1 and Figure 1).

The purpose of our study was to examine the effects of a systematic oral care program in improving oral assessment scores in critically ill patients in 3 intensive care units.

Methods

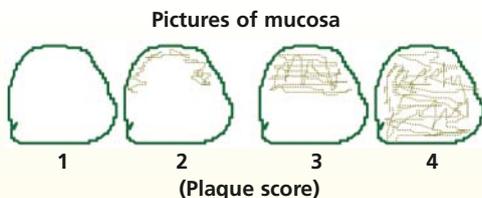
This multicenter study was conducted between November 2004 and January 2007. The study was initially approved through the intramural institutional review board of the National Institute of Dental and Craniofacial Research, and then approval was obtained from the institutional review boards

of the other participating institutions. Patients were recruited from 4 different critical care units in Virginia, the District of Columbia, and Maryland. Informed consent was obtained from each patient or the patient's legally authorized representative before collection of data or specimens. All eligible patients were asked to provide consent.

A convenience sample and a pre-post study design with an educational intervention were used. Each critical care unit served as its own control when patients received standard unit-based oral care before the educational intervention. After the intervention, each critical care unit instituted systematic oral care. From November 2004 until October 2005, patients received standard care, and then the educational intervention was implemented. The systematic oral care period began in December 2005 and continued until the end of the study in January 2007.

All patients were assessed, and specimens of plaque and saliva were collected. Microbiological analysis is not reported here. Data were collected within 48 hours of admission to a critical care unit (day 1), 48 hours from initial specimen (day 3), and 96 hours after initial specimen (day 5).

Patients were excluded if their expected length of critical care stay was less than 48 hours; they



Criteria	Score	
Mucosa		
Normal appearance of gingiva and oral mucosa	1	
Mild inflammation = slight redness and or hypertrophy/hyperplasia	2	
Slight redness in some areas of the palatal mucosa; red spots indicating inflamed salivary duct orifices	3	
Moderate inflammation = marked redness and hypertrophy/hyperplasia of the gingiva, which bleeds easily when pressure is applied and/or any of the following: Marked redness in large areas ($\geq 2/3$) of palate Marked inflammatory redness of the oral mucosa in sites other than the palate Presence of ulcerations Red and inflamed fibroepithelial hyperplasia		
Severe inflammation = severe redness and hypertrophy/hyperplasia of the gingiva Spontaneous gingival bleeding Marked palatal granulations Inflamed oral mucosal areas that "break" easily and bleed under pressure		4
Plaque		
No easily visible plaque	1	
Small amounts of hardly visible plaque	2	
Moderate amounts of plaque	3	
Abundant amounts of confluent plaque	4	

Figure 1 Mucosal-Plaque Score (MPS).^a

^a Based on data in Henriksen et al²⁴ and Silness and L e.²⁵

were less than 18 years old; they had significant oral, facial trauma; or they were edentulous. Patients were also excluded if they could provide their own oral care. In addition, patients were excluded if they had a clinical diagnosis of pneumonia at the time of admission and/or a modified Clinical Pulmonary Infection Score (CPIS)²⁶ of 6 or greater. Patients were excluded if their length of stay was less than 48 hours because these patients' oral environments would not be affected by the systematic oral care. Children were excluded because of a lack of this population in the critical care units that were recruited for the study. Patients with oral or facial trauma and patients who were edentulous were excluded because of the risk of oral care in the former and the significantly different oral environment in the latter. If patients could provide their own oral care, the type of oral care they would receive was different. Patients with pneumonia or a CPIS of 6 or greater were excluded because of the lack of benefit and possible risk of the systematic oral care provided. If a patient was transferred from the critical care unit, no further data were collected, and study participation ended on transfer out of the unit.

Demographic data, diagnosis, medications, and results of oral assessment measures, including the

MPS value and the BOAS score, were recorded. The BOAS used for this study was simplified from the original developed by Susan Beck.²³ Table 1 includes the interpretation of the timing of oral care based on the score. This interpretation was not part of the original assessment score and was developed for this study.

The Acute Physiology and Chronic Health Evaluation (APACHE) II was used to compare severity of illness between hospitals and patients. The APACHE II was developed by Knaus et al²⁷ as a modified version of the APACHE scoring system. For the APACHE II, physiological parameters are measured at the time of admission to a critical care unit. APACHE II scores have also been used to prognostically stratify acutely ill patients by predicted risk of hospital mortality.²⁸ Results of other studies^{29,30} support the use of the APACHE II score in defined groups of patients as a measure of disease severity and as a predictor of mortality, but findings suggest that measuring these outcomes in individual patients is neither possible nor justified.

A modified CPIS (Table 2), which did not include microbiological results, was obtained each day of data collection.²⁶ The CPIS was also used to exclude patients who had pneumonia at the time of admission to the critical care unit.

Table 2
Clinical Pulmonary Infection Score^a

Variable	Value	Score
Body temperature, °C	36.5 - 38.4	0
	38.5 - 39.0	1
	>39.0	2
White blood cell count, x1000/ μ L	4 - 11	0
	11 - 17	1
	>17	2
Secretions	-	0
	+	1
	++	2
Pao ₂ /fraction of inspired oxygen	>200	0
	<200	2
Infiltrates on chest radiograph	Clear	0
	Patchy	1
	Localized	2

Score ≥ 6 = pneumonia.

^a Data from Fartoukh et al.²⁶

An evidence-based oral care procedure for critically ill patients must include reliable and valid measures to assess oral health. No single oral assessment scale has been identified that is appropriate in all clinical settings. The original BOAS,²³ developed to assess the oral cavity of oncology patients with stomatitis, has 7 subscales that include voice quality and ability to swallow. The modified BOAS consists of 5 subscales: assessment of lips, mucosa and gingiva, tongue, teeth, and saliva. A higher score reflects dysfunction or tissue injury. BOAS scores range from 5 (no oral dysfunction) to

20 (severe dysfunction). A score greater than 5 is abnormal. The MPS includes only 2 scores that reflect an assessment of mucosal surfaces and plaque.²⁵ MPS values range from 2 to 8; any score greater than 5 reflects marked lack of oral integrity. This MPS has been used in studies of elderly persons in nursing homes to assess oral hygiene but has not

been used in critical care patients.²⁴ Neither oral assessment scale has published reliability studies.

The study was designed with a baseline or control period in which each nurse in the critical care units provided standard, unit-based oral care. No common or standard oral care across the 3 units was used. Rather, standard oral care was the oral care that each unit delivered before the educational intervention. No attempts were made to vary the oral care provided in each critical care unit during the control period. After the educational intervention,

a systematic oral care procedure (Figure 2) was introduced in all critical care units. Briefly, patients were assessed at the time of admission to the critical care unit and whenever a change in caregiver occurred. The frequency of oral care was determined by the BOAS score but was at least every 12 hours. Nurses were instructed to assess the level of consciousness and use suctioning before providing oral care. An oral examination was performed, and the data required in the BOAS and MPS were obtained. After assessment for bleeding, toothbrushing was performed in a systematic way to prevent missing any areas. If an endotracheal tube was present, the tube was included in the oral care. Nurses were instructed to brush it gently with the toothbrush or use gauze to remove any debris. After oral care, alcohol-free 0.12% chlorhexidine (supplied by Clinical Center Pharmacy Department, National Institutes of Health), delivered as a spray, was applied to teeth and mucosa. Excess chlorhexidine and secretions were suctioned. Between toothbrushings, the oral cavity was moistened with mouthwash (Biotene; GlaxoSmithKline Inc, Research Triangle Park, North Carolina) or water.

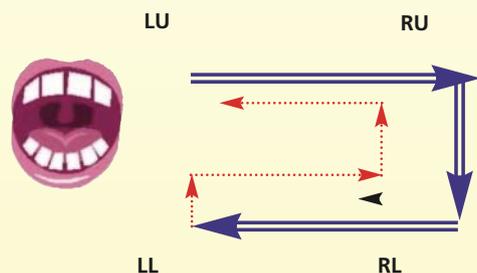
The study had no restriction on using tap water either to moisten and rinse the toothbrushes or to moisten the toothettes. In 2 reviews^{37,38} and a recent study,³⁹ it has been noted that potentially pathogenic bacteria are present in the water supply of health care facilities. Berry et al⁴⁰ recognized that tap water can be a source of nosocomial infections and stated that tap water should not be used as a mouth rinse for critically ill patients but left unresolved the use of sterile water as a substitute. Tap water is used in many critical care units when providing oral care.

Frequency of oral care was based on the results of the oral assessment. An index card was provided in the oral care kit delivered during the treatment phase for each patient. Nurses providing oral care were instructed to record the frequency of oral care and their initials on the card. The card was collected by the research nurse.

The structured educational program was multifaceted. After initial introduction by the researcher, a dentist or dental hygienist provided each patient care unit with instructions on the oral care procedure. The educational program was repeated several times according to each unit's needs and the current staff. After the initial instruction, the oral care procedure was available as a recorded educational program on a DVD player provided to each critical care unit for the nursing staff. A colored pocket flip chart-booklet developed by the principal investigator (J.Y.) contained information and pictures describing the oral cavity and the BOAS. A copy of the

Nurses gently brushed the endotracheal tube with the toothbrush or used gauze to remove debris.

1. The patient's level of consciousness may be a factor. If patients are unconscious or disoriented, they may reflexively bite when something is introduced into their mouth. You may need to use a "prop" (the end of a toothbrush works well) to keep the mouth open.³¹
2. Be sure to use suctioning before giving oral care because the process of oral care stimulates secretions.^{32,33}
3. Begin by placing a gloved finger in the side of the mouth between teeth and cheek. This step lets the patient know the examination and care will not hurt, relaxes the patient, and generates trust. If lips are dry and cracked, lubricate them before placing your gloved finger in the side of mouth.^{34(p50)}
4. Assess oropharyngeal cavity by using the order suggested in Beck's oral assessment tool.²³ Additional notes to Beck's score:
 - a. Examine lips—if dry, cracked, or caked, expect the same condition in mouth.
 - b. Always palpate with glove-covered index finger first.
 - c. Have penlight handy for better visualization of oral structures.
 - d. Move gloved finger on gingival surfaces around the mouth—upper right, upper left, lower left, and then lower right. This visual examination determines redness, swelling, injury, and bleeding of any oral structure.
 - e. Examine secretions for amount, viscosity, and color. If secretions are copious, suction.
5. Moisten a single layer of soft gauze or a washcloth; wrap around your index finger. Gently move the finger from right upper to left upper gingiva (gumline), then from lower left to right lower gingiva.^{34(p50)}
6. Next, repeat examination in the same direction for the inside of the mouth (lingual). Use the suggested direction, because going here and there misses areas.
7. Examine the gauze for blood—if bleeding occurs and is copious, do not brush teeth. Use a gauze-wrapped finger instead to clean teeth.
8. Insert index finger of left hand as guide or prop and brush with right hand.
9. Use following types of toothbrush^{8,21}:
 - a. Use soft pediatric toothbrush for nonintubated patients or soft tapered toothbrush if patient is intubated.
 - b. Use ultrasoft toothbrush if patient's mouth is very sore or inflamed.
10. Brush in a continuous line: upper right to upper left to lower left to lower right outside, then lower right to lower left to upper left and finally to upper right gingival to lingual.



Brush in one continuous line starting at the left upper (LU) gingival surface of the teeth, then move to right upper (RU), then to right lower (RL), then to left lower (LL) gingival area. Begin with the lingual surface of the teeth at LL and move along path shown here.

11. Use water to moisten toothbrush. Use of toothpaste depends on the condition of the patient and oral mucosa. If an individual is particularly sensitive or the mucosal surfaces are inflamed, then consider use Biotene (dry mouth fluoride) toothpaste or simply dipping the toothbrush into the alcohol-free chlorhexidine. Toothbrushing should be done no more than every 8 hours unless plaque is particularly heavy.
12. Always suction excess fluid and remove debris to prevent aspiration.³²
13. If patient has an endotracheal tube, plaque and bacterial biofilm can form on the surface of the tube, so mouth care includes this appliance. Note if mucus or debris is present.³⁵
14. After mechanically cleaning the teeth, spray teeth and oral mucosa with 0.12% chlorhexidine. The chlorhexidine is supplied and is alcohol-free. Suction excess chlorhexidine to prevent aspiration.^{4,7,13,36}
15. In between brushing, moisten oropharyngeal cavity (can be water or Biotene).

Figure 2 Protocol for systematic oral care in the intensive care unit.

booklet was placed in each patient's oral care kit. The oral care kit contained the chlorhexidine spray, a child's toothbrush, an instruction booklet, and an oral care documentation card.

Sample Size and Statistical Analysis

The sample size for the study was based on a pilot study⁴¹ of 22 patients conducted at the Clinical

Center of the National Institutes of Health in 2001. The change in the BOAS score was the main clinical outcome for both the pilot study and the study reported here. It was estimated that to detect a change in the BOAS score between the control group and the treatment group (mean score change of 2.05; SD, 2.26), a sample size of approximately 340 patients would be required based on 80% power and a

Table 3
Characteristics of sample by site (n = 116)

Variable ^a	Site			Statistics ^b
	Hospital 1	Hospital 3	Hospital 4	
Group				$\chi^2 = 19.5, P < .001$
Treatment	7 (24)	35 (76)	23 (56)	
Control	22 (76)	11 (24)	18 (44)	
Ethnicity				$\chi^2 = 45.0, P < .001$
White	19 (66)	13 (28)	34 (83)	
African American	5 (17)	28 (61)	1 (2)	
Other	5 (17)	5 (11)	6 (15)	
Sex				$\chi^2 = 2.4, P < .30$
Male	13 (45)	26 (57)	26 (63)	
Female	16 (55)	20 (43)	15 (37)	
Antibiotic use ^c				$\chi^2 = 5.1, P = .08$
No	4 (14)	10 (22)	15 (37)	
Yes	25 (86)	36 (78)	26 (63)	
Mechanical ventilation ^d				$\chi^2 = 21.4, P < .001$
No	6 (21)	8 (17)	25 (61)	
Yes	23 (79)	38 (83)	16 (39)	
Age, mean (SD), y	62.5 (15.03)	62.7 (20.79)	72.6 (17.56)	$F_{2,113} = 3.86, P < .02$
APACHE II score, mean (SD)	15.6 (7.13)	19.5 (7.24)	16.0 (4.96)	$F_{2,113} = 4.30, P < .02$
CPIS on day 1, mean (SD)	2.8 (1.48)	2.9 (1.66)	2.4 (1.80)	$F_{2,113} = 1.29, P < .28$
BOAS score on day 1, mean (SD)	10.9 (3.24)	9.6 (2.37)	10.3 (2.99)	$F_{2,113} = 1.90, P < .15$
MPS value on day 1, mean (SD)	4.1 (1.27)	3.8 (1.4)	4.1 (1.29)	$F_{2,113} = 0.70, P < .50$

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; BOAS, Beck Oral Assessment Scale; CPIS, Clinical Pulmonary Infection Score; MPS, mucosal-plaque score.

^a Values for the 3 hospitals are number (%) of patients unless otherwise indicated. Because of rounding, not all percentages total 100.

^b *F* statistics are from a 1-way analysis of variance.

^c Patient received some antibiotics during hospital stay.

^d Patient was intubated and required mechanical ventilation at time of initial data collection.

0.05 level of significance. Descriptive statistics were used to characterize the BOAS scores and the MPS values. A χ^2 test and 1-way analysis of variance were used to determine differences among sites and between the treatment and control groups. Both a general linear model and linear mixed modeling were used to determine the effects of the program of systematic oral care on the BOAS scores and the MPS values.

Results

A total of 4 critical care units in 4 hospitals in the Washington, DC, area participated in the study. All 4 hospitals were trauma centers with more than 200 beds. A total of 152 patients provided informed consent for the protocol; 116 patients were included in the data analysis (Table 3). Of the 36 patients excluded from the analysis, 12 at hospital 1 received only toothbrushing without the chlorhexidine treatment; 15 were from hospital 2, which withdrew from the study with no treatment group obtained; and 12 at hospital 3 could not be reached to provide consent again after a delay in protocol renewal for that site.

Patients enrolled at the 3 sites differed significantly by hospital setting in age, ethnicity, treatment with mechanical ventilation, and APACHE II scores (Table 3). We found no difference by hospital setting when sex or administration of antibiotics was considered. In addition, the percentage of treatment and control group patients differed by site. Scores on day 1 (BOAS, MPS, and CPIS) did not differ significantly among hospitals, as indicated by analysis of variance.

When patients were compared by treatment group (Table 4), differences were not significant for sex ($\chi^2 = 1.7; P = .20$), use of antibiotics ($\chi^2 = 0.6; P = .45$), requiring mechanical ventilation ($\chi^2 = 0.1; P = .73$), or age ($t = 1.08; P = .28$). Treatment and control groups, however, did differ significantly for APACHE II scores ($t = 2.19; P = .03$), and the BOAS score on day 1 ($t = 2.53; P = .01$). The treatment group had a higher mean APACHE II score than the control group (18.5 vs 15.8) and a lower mean BOAS score on day 1 (9.6 vs 10.9). On day 1, the mean BOAS score for all patients was 10.2 (SD, 2.99),

and the MPS value for all patients was 3.9 (SD, 1.37); the differences between the groups were not significant. The MPS values and the BOAS scores had strong correlations; the highest correlation was on day 5 ($r = 0.798$; $P < .001$; $n = 43$). Correlations on day 1 ($r = 0.727$; $P < .001$; $n = 116$) and day 3 ($r = 0.663$; $P < .001$; $n = 101$) were also significant.

Analysis with a general linear model was performed with the BOAS score as the primary outcome. Sample size was reduced to 45 (26 control and 19 treatment) because of the requirement that all patients have data for all 3 days of data collection. Results indicated a significant difference among the 3 times ($F = 4.80$; $P = .01$) with no difference in the pattern of scores between treatment and control groups and time (interaction $F = 1.57$; $P = .21$). Means for the treatment group on days 1, 3, and 5 were 9.7 (SD, 3.68), 9.8 (SD, 2.48), and 8.1 (SD, 2.80), respectively. Means for the control group were 11.5 (SD, 2.44), 12.6 (SD, 3.50), and 11.5 (SD, 31.4). In addition, the 2 groups differed overall ($F = 12.75$; $P = .001$); the control group had a higher mean than the treatment group did.

Mixed linear modeling was used to analyze the BOAS scores and MPS values across time. In mixed linear modeling, patterns are used to predict or model missing data.⁴² In this method, in contrast to general linear modeling, no assumption is made that all time points must have data present. The pattern of BOAS scores differed significantly across the 5 days depending on the group (interaction $F = 4.19$; $P = .02$). The difference in BOAS scores was also significant over time, day 1, 3, or 5 ($F = 5.1$; $P = .009$), and between groups, treatment or control, ($F = 29.05$; $P < .001$). In the control group, the estimated marginal means of the BOAS scores increased slightly from day 1 to day 3 (10.9 to 11.9) and then decreased slightly from day 3 to day 5 (11.9 to 11.0). In contrast, the treatment group had a slight decrease from day 1 to day 3 (9.5 to 9.2) and then a more pronounced decrease from day 3 to day 5 (9.2 to 7.7). BOAS scores differed overall between the 2 groups; the control group had a higher mean score (Table 5). The MPS values followed a similar pattern with a significant difference in the patterns of scores across the 5 days depending on the group (interaction $F = 4.56$; $P = .01$). The MPS values were also significantly different across time, day 1, 3, or 5, ($F = 7.33$; $P < .001$) and by group, treatment or control ($F = 16.83$; $P < .001$).

Because APACHE II scores differed between the treatment and control groups (Table 4), APACHE II groups were formed by using a median split. This step resulted in 32 control patients and 28 treatment patients in the low APACHE II group (APACHE II

Table 4
Characteristics of sample by group

Characteristic ^a	Control group (n = 51)	Treatment group (n = 65)	Overall (n = 116)
Ethnicity			
White	29 (57)	37 (57)	66 (56.9)
African American	13 (25)	21 (32)	34 (29.3)
Other	9 (18)	7 (11)	16 (13.8)
Sex			
Male	32 (63)	33 (51)	65 (56.0)
Female	19 (37)	32 (49)	51 (44.0)
Antibiotic use ^b			
No	11 (22)	18 (28)	29 (25.0)
Yes	40 (78)	47 (72)	87 (75.0)
Mechanical ventilation ^c			
No	18 (35)	21 (32)	39 (33.6)
Yes	33 (65)	44 (68)	77 (66.4)
Age, mean (SD), y	64.0 (15.84)	67.8 (20.8)	66.2 (18.82)
APACHE II score, mean (SD)	15.8 (5.83)	18.5 (7.09)	17.3 (6.68)
BOAS score on day 1, mean (SD)	10.9 (2.77)	9.6 (2.79)	10.2 (2.99)
MPS value on day 1, mean (SD)	4.2 (1.25)	3.8 (1.38)	3.9 (1.37)

Abbreviations: APACHE, Acute Physiology and Chronic Health Evaluation; BOAS, Beck Oral Assessment Scale; MPS, mucosal-plaque score.

^a Values are number (%) of patients unless otherwise indicated.

^b Patient received some antibiotics during their stay.

^c Patient was intubated and required mechanical ventilation at time of initial data collection.

Table 5
Estimated marginal means (standard error) for scores on Beck Oral Assessment Scale and scores on mucosal-plaque score for groups across time (n = 116)

Group	Day 1	Day 3	Day 5	Overall
Beck Oral Assessment Scale				
Control	10.9 (0.39)	11.9 (0.38)	11.0 (0.51)	11.3 (0.33)
Treatment	9.5 (0.35)	9.2 (0.36)	7.7 (0.58)	8.8 (0.32)
Overall	10.2 (0.26)	10.5 (0.26)	9.4 (0.38)	
Mucosal-Plaque Score				
Control	4.1 (0.19)	4.3 (0.16)	4.0 (0.25)	4.2 (0.16)
Treatment	3.8 (0.16)	3.3 (0.16)	2.6 (0.28)	3.3 (0.15)
Overall	4.0 (0.12)	3.8 (0.11)	3.2 (0.19)	

scores 2-17) and 19 and 37 patients, respectively, in the high APACHE II group (APACHE II scores ≥ 18). When the APACHE group was included in the mixed modeling as a control factor, results indicated that although scores changed across time, the pattern of scores differed between the treatment and the control groups (interaction $F = 4.79$; $P = .01$; Table 6). BOAS scores differed significantly between the control group and the treatment groups ($F = 34.10$; $P < .001$)

Table 6
Analysis of scores on Beck Oral Assessment Scale across time with APACHE II scores (low/high) controlled for by using linear mixed modeling^a

Source	Degrees of freedom		F	P
	Numerator	Denominator		
APACHE II score Low (2-17) High (>18)	1	105.44	5.44	.02
Group: treatment or control	1	105.44	34.10	<.001
Day: day 1, 3, 5	2	61.79	6.47	.003
APACHE II x Day	2	61.79	1.24	.28
APACHE II x Group	1	105.44	0.10	.75
Day x Group	2	61.79	4.79	.01
APACHE II x Group x Day	2	61.79	1.65	.20

Abbreviation: APACHE, Acute Physiology and Chronic Health Evaluation.

^a Analysis assumed unstructured covariance matrix.

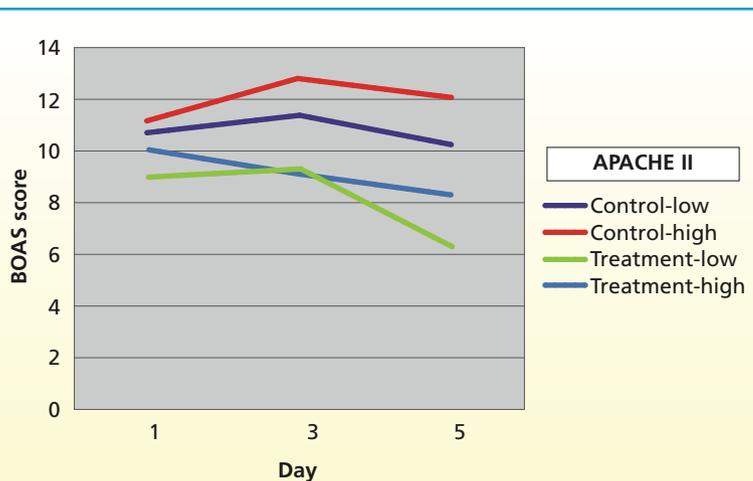


Figure 3 Estimated marginal mean score on Beck Oral Assessment Scale (BOAS) vs scores on the Acute Physiology and Chronic Health Evaluation (APACHE) II by day. Control patients with high and low APACHE II scores have overall higher mean BOAS scores than do treatment patients with high and low APACHE II scores.

and by day ($F = 6.47$; $P = .003$). Examination of the estimated marginal means indicated that BOAS scores in the control group increased on day 5 (11.2) and did not return to day 1 (10.9) levels, whereas scores in the treatment group decreased from day 1 (9.5) to day 5 (7.4). This finding was also true for patients in the high APACHE group or patients who had an increased severity of illness score. Among patients who had APACHE II scores greater than 17, indicating the patients were more acutely ill on admission to the critical care unit than the patients with lower scores, the mean BOAS scores were

higher in the control group than in the treatment group. In the control group with high APACHE II scores, the BOAS scores were higher across time when day 1 scores were compared with day 5 scores. In the treatment group, the BOAS scores decreased across time (Figure 3). The control patients with both high and low APACHE II scores had overall higher mean BOAS scores for the day than did the treatment patients with both high and low APACHE II scores.

The index cards on which nurses recorded the times of providing oral care were used to assess the integrity of the intervention. A total of 52% of the treatment group ($n = 65$) had study cards completed. However, some of the cards had only a few notations.

Discussion

In this multicenter study of 116 critically ill patients, the BOAS scores were higher before the educational intervention, reflecting poor oral health for patients who received standard unit-based oral care rather than systematic oral care. Compared with patients who had standard unit-based oral care, patients who had systematic oral care had significantly lower BOAS scores overall. When critically ill patients with APACHE II scores of 18 or greater were compared, this effect of systematic oral care remained. Overall in the study, the APACHE II scores reflected a moderate level of severity of illness; the highest score was 35, in a patient in the treatment group. The majority (66.4%) of the patients in this study were intubated and receiving mechanical ventilation, but many of the patients were not intubated. The presence of nonintubated patients in the critical care unit reflects some other organ dysfunction and places this group at high risk for aspiration.

The modified BOAS provides a realistic and clinically useful assessment of oral integrity in critically ill patients. The 5 subscales, saliva, teeth, tongue, lips, and oral mucosa, encompass the uniqueness of the oral cavity. As reflected in the BOAS scores, the overall results show that systematic oral care can improve oral health in critically ill patients. With the MPS, a much more widely used measure, only the mucosa and the plaque on the teeth are assessed. However, even though BOAS scores are a broader representation of the oral cavity, both the BOAS and the MPS positively correlated across all times. Use of these 2 oral assessment scores can help standardize oral care by providing a mechanism to measure the effects of this important nursing intervention.

In the study by Munro et al,¹³ the oral care interventions, toothbrushing and chlorhexidine treatment, were performed by study personnel. This method is the optimum one to use to ensure the integrity of the

intervention. In our study, the critical care nurses who cared for the patients delivered the oral care. Although it could be assumed that oral care was provided more often than was recorded on the intervention cards, we have no way to know how often. The study by Munro et al¹³ included only patients treated with mechanical ventilation, whereas our study included critically ill patients who were not intubated. Because of the lack of a secure airway, patients who are not intubated might be at greater risk for aspiration than are intubated patients. Another interesting finding of Munro et al is that the toothbrushing group had higher CPIS values than did the other groups in their study because the toothbrushing group received additional days of brushing. Munro et al stated that these high CPIS values could have been related to dislodgement of plaque biofilm organisms by toothbrushing and subsequent entry of the organisms into the lungs. Munro et al question the safety of toothbrushing in critically ill patients and note that the "optimal oral care practices . . . have not been tested."^{13(p436)}

In the study by Fitch et al,¹⁰ a complex assessment of oral care was used that included evaluation of 9 factors in the mouth: inflammation, bleeding, salivary flow, candidiasis, dental plaque, purulent material, calculus, stains, and caries. These factors were assessed by using a 100-point scale. Clearly, a limitation of this scale would be the time required to administer it. This characteristic alone would render this oral assessment measure less than useful in the clinical environment.

The major limitations of our study were the pre-post test design and the differences between the treatment and control groups, including diagnosis, severity of illness, and other factors. Despite these differences between the 2 groups, acuity, sex, and antibiotic use did not differ significantly. The length of time between the 2 parts of the study was also a limitation. A smaller than anticipated sample size, loss of study patients who were transferred from the critical care unit and had to provide informed consent again to be in the study, and loss of patients because 1 site did not wish to continue, were also limitations. Measuring the fidelity of the intervention in terms of the consistency of the nursing staff performing the systematic oral care was difficult. Despite the training and educational reminders, variations occurred in the oral care delivered. If the oral intervention cards were a true reflection of protocol compliance, then only 52% of the oral care procedures were performed. However, the BOAS scores still differed significantly between the systematic oral care group and the control group. In future

studies, a more reliable method for recording systematic oral care should be implemented. For example, the care could be recorded in the patient's medical record.

Tap water is used in many critical care units for providing oral care. Researchers³⁷⁻³⁹ have noted that potentially pathogenic bacteria are present in the water supplies of health care facilities. Berry et al⁴⁰ recognized that tap water can be a source of nosocomial infections and stated that tap water should not be used as a mouth rinse for critically ill patients, but they left unresolved the use of sterile water as a substitute. This issue requires further study.

The strength of our study is that we tested, in a clinical setting, 2 oral assessment measures, the BOAS and the MPS. These measures are easy to use and teach to critical care nurses. BOAS scores and MPS values reflect the condition of the oral cavity and can be used to guide oral care in critically ill patients. The BOAS scores and the MPS values improved after nurses implemented an intervention for systematic oral care. This improvement took place despite inconsistent adherence to this oral intervention. Future research should focus on testing the reliability and validity of these oral assessment measures. Oral care interventions must be tested for safety in high-risk critically ill patients before any recommendation can be made to follow the interventions in routine care.

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FINANCIAL DISCLOSURES

None reported.

eLetters

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CE Test Test ID A1120053: Effects of Systematic Oral Care in Critically Ill Patients: A Multicenter Study. *Learning objectives:* 1. Describe the purpose of this study and the measurements used to determine the results. 2. Identify the limitations of evidence-based guidelines for specific oral care procedures and their impact on various outcome measures. 3. Discuss the nursing considerations associated with assessment of oral health in critically ill patients and the related implications for provision of appropriate oral care for these patients.

1. According to this article's authors, a major limitation of recent performance improvement studies about oral care is their lack of which of the following?

- a. Statistically significant outcomes
- b. Valid and reliable oral assessment measures
- c. Restricted use of tap water as a mouth rinse
- d. Adequate sample sizes

2. Higher scores on the modified Beck Oral Assessment Scale (BOAS) are reflective of which of the following?

- a. Increased oral integrity
- b. Multiple decayed, missing, and/or filled teeth
- c. Decreased oral bacterial growth
- d. Oral tissue injury

3. Which of the following was the main clinical outcome measured in this study?

- a. Mucosal-plaque score (MPS) value
- b. BOAS score
- c. Acute Physiology and Chronic Health Evaluation (APACHE) II score
- d. Clinical Pulmonary Infection Score (CPIS) value

4. Which of the following patients would have been eligible for inclusion in this study?

- a. A 20-year-old male patient who sustained a LeFort III fracture in a motorcycle accident
- b. An 18-year-old female with a C-spine fracture and resultant quadriplegia
- c. A 70-year-old male patient with a modified CPIS of 6
- d. A 48-year-old female requiring ventilatory support for pneumonia

5. Which of the following statements regarding the oral care for patients participating in the study is true?

- a. Each patient received oral care at least 4 times daily.
- b. Sterile water was used in place of tap water as a mouth rinse.
- c. Gentle brushing of the endotracheal tube was part of the oral care for intubated patients.
- d. Each patient's oral cavity was moistened with chlorhexidine mouthwash in between toothbrushings.

6. Which of the following explains why suctioning was performed before oral care was provided to patients in the study?

- a. Suctioning allowed for more accurate assessment of the amount of plaque present inside patients' mouths.
- b. Examination of suctioned secretions for amount, viscosity, and color was part of the pre-oral care assessment procedure.
- c. If bleeding occurred during suctioning, nurses rinsed the patient's mouth with dry mouth fluoride rinse instead of proceeding with toothbrushing.
- d. Provision of oral care was expected to increase the patients' oral secretions.

7. Both the modified BOAS and the MPS include assessment of which of the following?

- a. Plaque
- b. Saliva
- c. Oral mucosa
- d. Lips

8. Which of the following was the reason for reduction of the sample size used for the general linear model analysis in this study to a total of 45 patients?

- a. Only patients who had data for all 3 days of data collection were included.
- b. Patients who were receiving antibiotics were eliminated.
- c. One of the hospitals in the study withdrew shortly after data collection began.
- d. Proper informed consent was not obtained from numerous patients prior to their participation.

9. When was data collected during the study?

- a. Within 24 hours of admission, 24 hours after initial specimen, and 48 hours after initial specimen
- b. Within 24 hours of admission, 48 hours after initial specimen, and 72 hours after initial specimen
- c. Within 12 hours of admission, 24 hours after initial specimen, and 72 hours after initial specimen
- d. Within 48 hours of admission, 48 hours after initial specimen, and 96 hours after initial specimen

10. Toothbrushing, as part of the systematic oral care provided during the study, was completed in which of the following patterns?

- a. Outside upper right to upper left; outside lower left to lower right; inside lower right to lower left; inside upper left to upper right
- b. Inside upper left to upper right; inside lower right to lower left; outside lower left to lower right; outside upper right to upper left
- c. Inside lower left to lower right; outside lower right to lower left; outside upper left to upper right; inside upper right to upper left
- d. Outside upper right to upper left; inside upper left to upper right; outside lower right to lower left; inside lower left to lower right

11. The frequency with which oral care was provided to patients in the study was determined by which of the following?

- a. Each unit's standard oral care procedures
- b. The individual patient's BOAS score
- c. The individual patient's APACHE II score
- d. The individual patient's CPIS value

12. Systematic oral care interventions were found to have which of the following overall effects on the oral health assessment scores of patients in this study?

- a. BOAS scores and MPS values improved in all patients who received oral care interventions.
- b. BOAS scores differed only slightly between patients in the control group and those in the treatment group.
- c. There was no difference in the MPS values between patients in the control group and those in the treatment group.
- d. MPS values were significantly higher for patients in the treatment group than those in the control group, but no difference in the BOAS scores between the 2 groups.

13. Which of the following specimens were collected from patients in this study?

- a. Tongue scrapings and cheek swabs
- b. Cheek swabs and plaque specimens
- c. Plaque and saliva specimens
- d. Saliva specimens and tongue scrapings

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