Background  Oropharyngeal colonization with pathogenic organisms contributes to the development of ventilator-associated pneumonia in intensive care units. Although considered basic and potentially nonessential nursing care, oral hygiene has been proposed as a key intervention for reducing ventilator-associated pneumonia. Nevertheless, evidence from randomized controlled trials that could inform best practice is limited.

Objective  To appraise the peer-reviewed literature to determine the best available evidence for providing oral care to intensive care patients receiving mechanical ventilation and to document a research agenda for this important activity in optimizing patients’ outcomes.

Methods  Articles published from 1985 to 2006 in English and indexed in the CINAHL, MEDLINE, Joanna Briggs Institute, Cochrane Library, EMBASE, and DARE databases were searched by using the key terms oral hygiene, oral hygiene practices, oral care, mouth care, mouth hygiene, intubated, mechanically ventilated, intensive care, and critical care. Reference lists of retrieved journal articles were searched for publications missed during the primary search. Finally, the Google search engine was used to do a comprehensive search of the World Wide Web to ensure completeness of the search. The search strategy was verified by a health librarian.

Results  The search yielded 55 articles: 11 prospective controlled trials, 20 observational studies, and 24 descriptive reports. Methodological issues and the heterogeneity of samples precluded meta-analysis.

Conclusions  Despite the importance of providing oral hygiene to intensive care patients receiving mechanical ventilation, high-level evidence from rigorous randomized controlled trials or high-quality systematic reviews that could inform clinical practice is scarce. (American Journal of Critical Care. 2007;16:552-563)
Although nurses recognize that oral hygiene is an integral part of care in intensive care units (ICUs), the relationship between oral hygiene and the reduction of oropharyngeal colonization with pathogenic organisms is less recognized. The vulnerability of ICU patients to nosocomial infections underscores the importance of examining interventions and strategies to improve patients’ outcomes. Ventilator-associated pneumonia (VAP) is a leading cause of death due to nosocomial infection in ICUs. VAP occurs in 9% to 28% of patients treated with mechanical ventilation, and mortality rates for VAP are from 24% to 50%. These figures may be higher in immunocompromised patients and when the pneumonia is caused by multiresistant pathogens. Although the relationship between oral care and prevention of VAP is difficult to substantiate directly, oral hygiene is considered an important strategy in combination with a range of other activities, such as subglottal suctioning, for improving clinical outcomes.

In their guidelines for preventing healthcare-associated pneumonia, the Centers for Disease Control and Prevention recommend the development and implementation of a comprehensive oral hygiene program, potentially with the inclusion of an antiseptic agent, for settings where patients are at risk for hospital-acquired pneumonia. In support of this recommendation, researchers have advocated oral hygiene (and a subsequent reduction in the colonization of dental plaque) as an important strategy in preventing VAP. Despite these recommendations, limited evidence exists to guide nurses’ oral hygiene practice in the general ICU population. Most available evidence has been developed for oncology and cardiothoracic patients, and it is not apparent whether these guidelines are applicable to general intensive care patients. The omission of oral care in the ventilation bundle of the Institute for Healthcare Improvement challenges the recognition of the relationship between oral care and the development of VAP. The American Association of Critical-Care Nurses recently released a practice alert that supports the importance of oral care in influencing outcomes in critically ill patients.

Clearly, fundamental nursing practices such as hand hygiene, semirecumbent positioning of patients, subglottal suctioning, and reducing colonization of dental plaque by respiratory pathogens play a critical role in minimizing the incidence of VAP. Nurses admit that these elementary procedures are often relegated to a lower priority in the high-pressure, highly technological critical care environment. Such anecdotal reports are further substantiated by Grap et al, who found that a sample of 77 healthcare providers perceived oral hygiene as less important than other unspecified nursing practices to patients’ well-being. Therefore, if nurses are to appreciate the relationship between dental plaque and its colonization with respiratory pathogens potentially leading to VAP, they must have a clear understanding of the complex characteristics of the oral cavity.

The normal flora of the oral cavity may include up to 350 different bacterial species, with tendencies for groups of bacteria to colonize different surfaces in the mouth. For example, Streptococcus mutans, Streptococcus sanguis, Actinomyces viscosus, and Bacteroides gingivalis mainly colonize the teeth; Streptococcus salivarius mainly colonizes the dorsal aspect of the tongue; and Streptococcus mitis is found on both buccal and tooth surfaces. Because of a number of processes, however, critically ill patients lose a protective substance called fibronectin from the tooth surface. Loss of fibronectin reduces the host defense mechanism mediated by reticuloendothelial cells. This reduction in turn results in an environment...
Both experimental and nonexperimental study designs were included in the review. Because of the scariness of review material on ICU patients receiving mechanical ventilation, articles that focused on specific oral care tools or solutions for the seriously ill also were included in the review.

This review considered studies that included patients in ICUs who were intubated and receiving mechanical ventilation. Also included were studies that proposed a link between oral hygiene and systemic diseases. The interventions of interest were those designed to affect dental plaque specifically and oral hygiene in general. The types of outcome measures considered were general and specific indicators of oral health:

- Microbial counts
- Plaque indices
- Oral assessment scores
- Validation of tools used in the provision of oral care

Articles were excluded if the study sample consisted of healthy participants or the study was done in a setting other than a critical care environment (eg, oncology).

Articles published from 1985 to 2006 in English and indexed in the following databases were searched: CINAHL, MEDLINE, Joanna Briggs Institute, Cochrane Library, EMBASE, DARE, and the World Wide Web search engine, Google. Key search terms used in the review were oral hygiene, oral hygiene practices, oral care, mouth care, mouth hygiene, intubated, mechanically ventilated, intensive care, and critical care. This search strategy was verified by a health librarian.

Full copies of articles considered to meet the inclusion criteria (on the basis of their title, abstract, and subject descriptors) were obtained for data synthesis. Articles identified through reference lists and bibliographic searches were considered for data collection depending on the titles. Articles were independently selected according to prespecified inclusion criteria by 3 reviewers, each with a minimum of a master’s degree and certification in critical care. Discrepancies in the reviewers’ selections were resolved at meetings between the reviewers before the selected articles were included.

Until recently, one system used to grade levels of evidence was based on work by the US Agency for Healthcare Research and Quality. Because of the increasing awareness of the limitations of that system, however, the classification structure was revised by the Scottish Intercollegiate Guidelines Network. Therefore, the rating method used for categorization of levels of evidence found in this review was based on the revised system (Tables 1 and 2).

Development of evidence-based guidelines is limited by the small number of randomized controlled trials and the variability of interventions studied.
Results

Although we found a number of references for the provision of oral hygiene in the management of oncology and other medical patients, most articles related to critical care were review articles. For the prospective randomized control trials we found, meta-analysis could not be used to synthesize the results because of variations in the methods of these studies. For example, in some studies, the populations assessed differed, and for those studies in which the populations were the same, the interventions were often dissimilar. These limitations were recognized in a recent meta-analysis on the use of chlorhexidine and the incidence of nosocomial pneumonia.21

Using the classification system developed by the Scottish Intercollegiate Guidelines Network, we reviewed 11 prospective controlled trials,2,3,11,12,22-24 20 observational studies,25,29-37 and 24 descriptive studies.21,40-70 The 11 articles on prospective controlled trials are presented in Table 3. Summary tables of the observational studies (Table 4) and descriptive papers (Table 5) are available only on the American Journal of Critical Care Web site (http://www.ajcconline.org) in the full-text view of this article.

Discussion

The information available for developing evidence-based guidelines is limited by the small number of randomized controlled studies and the heterogeneity of oral hygiene solutions, tools, and techniques. These limitations are compounded by a lack of reliable outcome measures to determine the effectiveness of the oral hygiene interventions. This lack of rigorous, quality studies markedly limits the weight of evidence presented and affects recommendations for practice. Despite these limitations, however, it is important to favor judgments regarding health benefits and reduction of harm over any possible cost considerations.72 This literature review therefore is summarized as methodological issues, oral hygiene solutions and equipment, and oral health assessment strategies.

Methodological Issues

Electronic and hand searches do not completely reflect the extent of research outcomes. For example, trials reported at conferences are more likely than trials published in journals to contain negative reports. In addition, more positive than negative results tend to be reported in the literature. This failure to publish more studies with negative outcomes is due more to authors’ lack of inclination to submit such manuscripts than to the unwillingness of editors to accept such manuscripts.72 Furthermore, many studies not published in English may not be included in the most commonly used searches.73(p43) These limitations lead to a risk for systematic reviews to yield a less-balanced analysis73(p43) and may therefore affect the recommendations resulting from the reviews.

Table 1
Guide to the levels of evidence

<table>
<thead>
<tr>
<th>Level</th>
<th>Therapy/prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1++</td>
<td>High-quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias</td>
</tr>
<tr>
<td>1+</td>
<td>Well-conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias</td>
</tr>
<tr>
<td>1-</td>
<td>Meta-analyses, systematic reviews of RCTs, or RCTs with a high risk of bias</td>
</tr>
<tr>
<td>2++</td>
<td>High-quality systematic reviews of case-control or cohort studies or high-quality case-control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal</td>
</tr>
<tr>
<td>2+</td>
<td>Well-conducted case-control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal</td>
</tr>
<tr>
<td>2-</td>
<td>Case-control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relationship is not causal</td>
</tr>
<tr>
<td>3</td>
<td>Nonanalytic studies such as case reports, case series</td>
</tr>
<tr>
<td>4</td>
<td>Expert opinion</td>
</tr>
</tbody>
</table>

Abbreviation: RCTs, randomized controlled trials.

Adapted from Harbour and Miller,6 with permission.

Table 2
Grades of recommendations

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>At least 1 meta-analysis, systematic review, or RCT rated as 1++ and directly applicable to the target population or A systematic review of RCTs or a body of evidence consisting principally of studies rated as 1+ directly applicable to the target population and demonstrating overall consistency of results</td>
</tr>
<tr>
<td>B</td>
<td>A body of evidence including studies rated as 2++ directly applicable to the target population and demonstrating overall consistency of results or Extrapolated evidence from studies rated as 1++ or 1+</td>
</tr>
<tr>
<td>C</td>
<td>A body of evidence including studies rated as 2+ directly applicable to the target population and demonstrating overall consistency of results or Extrapolated evidence from studies rated as 2++</td>
</tr>
<tr>
<td>D</td>
<td>Evidence level 3 or 4 or Extrapolated evidence from studies rated as 2+</td>
</tr>
</tbody>
</table>

No recommendation, unresolved issue Practices for which insufficient evidence or no consensus exists about efficacy

Abbreviation: RCT, randomized controlled trial.

Adapted from Harbour and Miller,6 with permission.
When we reviewed the 11 prospective controlled trials, a number of methodological issues became evident. First, the samples were taken from a range of critically ill patients. Some studies were limited to cardiac surgical patients, and even within these studies further variances occurred. For example, some participants remained in the study after extubation, thereby resulting in a mix of intubated and extubated patients with vastly different accessibility for the provision of oral hygiene. The extubated patients were able to eat and drink fluids, yet no allowance was made for the stimulation of saliva and its effects during mastication. When we reviewed the 11 prospective controlled trials, a number of methodological issues became evident. First, the samples were taken from a range of critically ill patients. Some studies were limited to cardiac surgical patients, and even within these studies further variances occurred. For example, some participants remained in the study after extubation, thereby resulting in a mix of intubated and extubated patients with vastly different accessibility for the provision of oral hygiene. The extubated patients were able to eat and drink fluids, yet no allowance was made for the stimulation of saliva and its effects during mastication.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type of trial</th>
<th>No. of participants</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koeman et al,22 2006</td>
<td>PRCT</td>
<td>385 General ICUs</td>
<td>Chlorhexidine, chlorhexidine and colistin, placebo</td>
</tr>
<tr>
<td></td>
<td>Level of evidence: 1+</td>
<td></td>
<td>Significant risk of bias: the control group received no reported oral hygiene except application of petroleum jelly</td>
</tr>
<tr>
<td>Mori et al,23 2006</td>
<td>Nonrandomized trial with historical controls</td>
<td>1666 ICU patients</td>
<td>Preintervention group received no oral care</td>
</tr>
<tr>
<td></td>
<td>Level of evidence: 2-</td>
<td></td>
<td>Intervention consisted of toothbrush, oral assessment score, povidone-iodine swab, 300 mL weakly acidic water for rinsing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Significant risk of bias: the control group received no oral hygiene</td>
</tr>
<tr>
<td>Fourrier et al,13 2005</td>
<td>PRCT</td>
<td>228 ICU patients</td>
<td>2 treatment groups: chlorhexidine 0.2% gel vs placebo gel applied 3 times a day</td>
</tr>
<tr>
<td></td>
<td>Level of evidence: 1+</td>
<td></td>
<td>Significant risk of bias: control group received no oral hygiene, and toothbrush was not allowed; inclusion criteria included mechanical ventilation but patients remained in the study after extubation and were able to eat and drink</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No allowance was made for the stimulation of saliva and its effects during mastication</td>
</tr>
<tr>
<td>Grap et al,14 2004</td>
<td>PCT</td>
<td>34</td>
<td>2 treatment groups: chlorhexidine 0.12% by spray or swab Risk of bias: control group received unreported type of usual care</td>
</tr>
<tr>
<td>Taylor-Piliaie et al,24 2004</td>
<td>PCT</td>
<td>19</td>
<td>Treatment group: toothbrush and toothpaste</td>
</tr>
<tr>
<td></td>
<td>Level of evidence: 1-</td>
<td></td>
<td>Control: metal forceps with cotton wool soaked in thymol</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Small sample size reduced proposed causal effect</td>
</tr>
<tr>
<td>Houston et al,1 2002</td>
<td>PRCT</td>
<td>561 cardiac surgery patients</td>
<td>Chlorhexidine 0.12% rinse compared with Listerine rinse No mention of tooth brushing; further study required before results can be adopted in broader ICU population</td>
</tr>
<tr>
<td>Yates,21 2002</td>
<td>PCT</td>
<td>22</td>
<td>Test group: nurses received comprehensive oral care training and used toothbrushes, salt, soda, floss, and sage product (not described)</td>
</tr>
<tr>
<td></td>
<td>Level of evidence: 2-</td>
<td></td>
<td>Control group: followed unit routine and used sage product (neither routine nor product described)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Small sample size reduced proposed causal effect</td>
</tr>
<tr>
<td>Fourrier et al,26 2000</td>
<td>PCT</td>
<td>60</td>
<td>Chlorhexidine gel 0.2% dental plaque decontamination 3 times daily, compared with bicarbonate solution rinse 4 times daily followed by oropharyngeal suctioning</td>
</tr>
<tr>
<td></td>
<td>Level of evidence: 1-</td>
<td></td>
<td>No mention of use of toothbrush</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Extubated patients could eat/drink, yet no allowance was made for the stimulation of saliva and its effects during mastication</td>
</tr>
<tr>
<td>DeRiso et al,4 1996</td>
<td>PRCT</td>
<td>353 cardiac surgery patients</td>
<td>Compared effectiveness of chlorhexidine 0.12% mouth rinse with alcohol-based placebo in reducing the incidence of VAP</td>
</tr>
<tr>
<td>Holberton et al,27 1996</td>
<td>PCT</td>
<td>47 ICU patients</td>
<td>Compared tap water, normal saline, and 1:1 solution of saline and hydrogen peroxide</td>
</tr>
<tr>
<td></td>
<td>Level of evidence: 2-</td>
<td></td>
<td>Questionable use of hospital tap water as an oral rinse because of its reputation for contamination</td>
</tr>
<tr>
<td>Liwu,28 1990</td>
<td>PCT</td>
<td>40 ICU patients</td>
<td>Compared Ultrafresh solution/swab stick with saline/swab stick Because of the small sample, risk that relationship is not causal</td>
</tr>
<tr>
<td></td>
<td>Level of evidence: 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: ICU, intensive care unit; PCT, prospective controlled trial; PRCT, prospective randomized controlled trial; VAP, ventilator-associated pneumonia.
Reduction in daily risk of VAP in both treatment groups but no difference in hours of mechanical ventilation, length of stay in ICU, or ICU survival

<table>
<thead>
<tr>
<th>Results</th>
<th>Recommendations/comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence of VAP significantly lower in treatment group</td>
<td>Large-scale multicenter trial on the efficacy of oral care for VAP prevention</td>
</tr>
<tr>
<td>Day 10 cultures of dental plaque that showed growth were less common</td>
<td>Further study to determine if combined dental plaque, oropharyngeal, and salivary decontamination will decrease VAP in ICU</td>
</tr>
<tr>
<td>Ability to reduce incidence of respiratory infections due to multiresistant bacteria was not significant</td>
<td></td>
</tr>
<tr>
<td>Reduction in oral culture and Clinical Pulmonary Infection Score in treat-</td>
<td>Use of chlorhexidine early after intubation or before intubation may reduce incidence of VAP</td>
</tr>
<tr>
<td>ment group compared with control group</td>
<td></td>
</tr>
<tr>
<td>VAP developed in 1 control and 3 study group participants</td>
<td>No recommendations</td>
</tr>
<tr>
<td>Oropharyngeal colonization increased 25% in control vs 10% in study group</td>
<td>Limitation of study size acknowledged</td>
</tr>
<tr>
<td>VAP reduced by 52% in chlorhexidine group overall and 71% lower in the chlorhexidine group intubated &gt;24 hours</td>
<td>Chlorhexidine is worth considering for patients undergoing cardiovascular surgery Extremely cost-effective compared with 1 case of VAP</td>
</tr>
<tr>
<td>No statistical difference between groups in Clinical Pulmonary Infection Score, oral assessment scores, mucosal plaque scores, or inoculum of plaque</td>
<td>Oral care, including oral assessment, is a risk reduction technique to prevent further infection in hospitalized patients</td>
</tr>
<tr>
<td>Reduced plaque colonization in the treatment group on days 5-7</td>
<td>A double-blind placebo-controlled study must be done to confirm these results</td>
</tr>
<tr>
<td>Nosocomial infection rate significantly reduced in the treatment group with a trend to a reduction of mortality, length of stay, and duration of mechanical ventilation</td>
<td></td>
</tr>
<tr>
<td>Incidence of VAP was 4.6% in the chlorhexidine group and 13% in the control group</td>
<td>Chlorhexidine is an inexpensive and effective agent for reducing VAP in patients undergoing heart surgery</td>
</tr>
<tr>
<td>Reduction in mortality was 5.5% in the chlorhexidine group and 1% in the control group</td>
<td></td>
</tr>
<tr>
<td>Statistical analysis was not reported</td>
<td>Larger study required</td>
</tr>
<tr>
<td>Patients tolerated tap water best and then saline</td>
<td></td>
</tr>
<tr>
<td>Solution of peroxide and saline was not tolerated</td>
<td></td>
</tr>
<tr>
<td>No difference between worst scores between both groups</td>
<td>Further research needed to determine impact of endotracheal tubes on oral mucosa and to evaluate effectiveness of mouth care agents</td>
</tr>
<tr>
<td>Swab sticks were ineffective for removing oral debris</td>
<td></td>
</tr>
</tbody>
</table>

Saliva during mastication and the subsequent production of immune substances. Examples include substances such as immunoglobulin A, which obstructs microbial adherence in the oral cavity, and lactoferrin, which inhibits bacterial infection. These important considerations may have influenced a study’s outcome. In their 2005 study, Fourrier et al. also did not permit the use of a toothbrush in the protocol, so in effect the control group received only a neutral gel for the provision of oral care. It is not surprising, therefore, that the trial group had a reduced colonization of dental plaque.  

Reduction in mortality was 5.5% in the chlorhexidine group and 1% in the control group. Statistical analysis was not reported.

Results

- Incidence of VAP significantly lower in treatment group
- No significant difference in hours of mechanical ventilation or length of stay in ICU
- Ability to reduce incidence of respiratory infections due to multiresistant bacteria was not significant
- No statistical difference between groups in Clinical Pulmonary Infection Score, oral assessment scores, mucosal plaque scores, or inoculum of plaque
- Reduced plaque colonization in the treatment group on days 5-7
  - Nosocomial infection rate significantly reduced in the treatment group with a trend to a reduction of mortality, length of stay, and duration of mechanical ventilation
- Incidence of VAP was 4.6% in the chlorhexidine group and 13% in the control group
  - Reduction in mortality was 5.5% in the chlorhexidine group and 1% in the control group
- Patients tolerated tap water best and then saline
  - Solution of peroxide and saline was not tolerated

Recommendations/comments

- Large-scale multicenter trial on the efficacy of oral care for VAP prevention
- Use of chlorhexidine early after intubation or before intubation may reduce incidence of VAP
- Chlorhexidine is worth considering for patients undergoing cardiovascular surgery
  - Extremely cost-effective compared with 1 case of VAP
- Oral care, including oral assessment, is a risk reduction technique to prevent further infection in hospitalized patients
- A double-blind placebo-controlled study must be done to confirm these results
- Chlorhexidine is an inexpensive and effective agent for reducing VAP in patients undergoing heart surgery
- Larger study required
- Further research needed to determine impact of endotracheal tubes on oral mucosa and to evaluate effectiveness of mouth care agents

Further study to determine if combined dental plaque, oropharyngeal, and salivary decontamination will decrease VAP in ICU.
at day 10; one could argue that any form of oral hygiene is likely to produce a better result than none at all.

A number of other researchers also did not mention use of a toothbrush in their protocols. Liwu, on the other hand, mentioned the use of swab sticks and reported that they were ineffective in removing debris between the teeth and gum borders.

The protocol used by DeRiso et al included a mint-flavored alcohol and water-based mouth rinse as the control versus a 0.12% chlorhexidine rinse. Although the placebo contained less than one-third the alcohol content of the chlorhexidine, the antiseptic properties of alcohol may have had an additional therapeutic effect.

In the protocols of 2 studies, hospital tap water was included as an oral rinse. Because hospital tap water is a source of nosocomial infections, its use as an oral rinse in critically ill patients is questionable.

Finally, the protocols of 3 studies included systematic oral assessment, but we were unable to ascertain whether the frequency of assessments and outcomes measures were similar in the studies or how these related to the oral hygiene provided to the study participants.

Oral Hygiene Solutions and Equipment

A range of oral rinse solutions and equipment are discussed in the literature, and these data and recommendations are briefly summarized here.

- Chlorhexidine gluconate mouthwash is an antiplaque agent with potent antimicrobial activity that, without causing increased resistance of oral bacteria, is effective at low concentrations. Chlorhexidine gluconate mouth rinse or gel has been used in a number of clinical trials, primarily in cardiac surgery patients, to improve gingival health and to treat oral infections. Chlorhexidine mouth spray or rinse appears to be effective in reducing oral colonization of gram-negative bacteria and subsequent respiratory infections in cardiac surgical patients receiving mechanical ventila-

tion in the ICU. Also, significant cost savings and decreased mortality may be apparent for such patients. Further research is required to determine the frequency of use of chlorhexidine and the relationship between chlorhexidine use and reduction in the incidence of VAP in the broader ICU population.

Recommendation: B

- Sodium bicarbonate mouth rinse is a cleaning agent that can dissolve mucus and loosen oral debris. This rinse was used as a control substance in a study by Fourrier et al, who compared it with a chlorhexidine gel. Although the frequency of colonization of plaque on day 5 was higher in the sodium bicarbonate group, by day 10 no significant difference could be detected between groups. To date, no reports of results of randomized controlled studies that support the use of sodium bicarbonate over any other mouth rinse in critical care patients have been published.

Recommendation: Unresolved issue

- Houston et al used the essential oil mouth rinse Listerine (Pfizer, New York, New York) as a control when testing the effect of chlorhexidine mouth rinse. Other than that study, essential oils remain untested in ICU patients. Houston et al did not find any significant difference between chlorhexidine and Listerine with regard to cultures of sputum samples from postoperative cardiac patients with growth of microorganisms.

Recommendation: Unresolved issue

- Hydrogen peroxide mouth rinse has been used untested for many years in ICU patients. Although their study was excluded from this review because it included healthy participants, Tombes and Gallucci found significant mucosal abnormalities in patients treated with hydrogen peroxide mouth rinse. Holberton et al reported that some ICU patients found hydrogen peroxide mouth rinse distasteful and refused to use it. The effectiveness of foam sticks impregnated with hydrogen peroxide also has not been rigorously tested for the provision of oral hygiene in critically ill patients.

Recommendation: Unresolved issue

- Physiological salt solution (normal saline), because of its tendency to cause drying, has limited use as a mouth rinse in critical care settings. In fact, in a small study of 47 participants, the participants did not tolerate the use of physiological salt solution as a mouth rinse.

Recommendation: Unresolved issue
Tap water, although readily available and free, can be a source of nosocomial infections in hospitals.\textsuperscript{74,75} 

\textit{Recommendation: Not recommended for use as a mouth rinse in critically ill patients}

Sterile water used as a mouth rinse is cost-effective, but such use has not been rigorously tested. 

\textit{Recommendation: Unresolved issue}

Use of a toothbrush and toothpaste is recommended by several authors.\textsuperscript{40,57(pp1-4),81} Furthermore, a toothbrush with toothpaste is more effective than foam swabs for the removal of plaque.\textsuperscript{82} Griffiths et al\textsuperscript{57(pp1-4)} recommend a very small, soft-bristled toothbrush because it can reach the most posterior aspects of the mouth. Such a toothbrush is also useful for cleaning the tongue and gums in edentulous patients. For any patient who has sensitive gums, gentle cleaning is of paramount importance. Although bacteremia after tooth brushing in healthy persons is rare,\textsuperscript{83} care is advised when this procedure is used in immunocompromised critically ill patients. Furthermore, because toothbrushes must be treated as potential sources of contamination, thorough cleaning and protected storage of the brushes after each use should be mandatory.

\textit{Recommendation: D}

Foam and cotton swabs generally are not effective for removing debris and plaque.\textsuperscript{82,84,85} Even so, Ransier et al\textsuperscript{85} suggest the use of foam swabs soaked in chlorhexidine if a toothbrush is considered inappropriate. Roberts\textsuperscript{86} raises concern, although it is not substantiated in the literature, about the possible detachment of foam from the swab stick during the provision of oral hygiene in less compliant patients.

\textit{Recommendation: Unresolved issue}

Although swabs impregnated with lemon and glycerol have been used for some time, their value has been questioned, and such swabs may actually have deleterious effects such as xerostomia and decalcifying of tooth enamel.\textsuperscript{41,54,67} 

\textit{Recommendation: Unresolved issue}

Suction devices. No published reports describe a comparison between the various suction devices used to provide oral hygiene. Devices such as suction foam swabs and rigid suction tools (eg, Yankauer device) are only generally effective for clearing secretions from the oral cavity. However, because the importance of removing secretions from the subglottic area is well known,\textsuperscript{10,11,64,69} use of a flexible suction catheter when rinsing the mouth after oral hygiene is essential.

\textit{Recommendation: D}

\section*{Oral Health Assessment Strategies}

Reliable and valid assessment tools are needed to document nurses’ assessments of the oral cavity as well as the effectiveness of oral hygiene interventions. The paucity of data related to solutions and techniques is paralleled by the limited data available on assessment tools. The oral assessment tool used by Fitch et al\textsuperscript{41} reportedly included assessment of several oral components, such as dental plaque, inflammation, salivary flow, bleeding, candidiasis, purulent matter, calculus, staining, and caries. When scores were compared between dental hygienists and nurses trained in the use of the tool in a study\textsuperscript{41} of 60 adult ICU patients, the correlations were positive. This result indicated that nurses who used this tool were adept at assessing changes in the oral cavities of their patients.

\textit{Recommendation: D}

\section*{Implications for Clinical Research and Practice}

Although colonization of dental plaque with respiratory pathogens correlates with occurrence of pneumonia,\textsuperscript{13} protocols based on research studies for best practice in providing oral care in ICUs are rare.\textsuperscript{51} Therefore, in the absence of evidence-based guidelines to direct best practice, critical care nurses often perform oral hygiene according to their individual preferences and historical patterns.\textsuperscript{11} These preferences are often based on a combination of availability of one product over another and the nurse’s experience and knowledge underpinning this practice. Clearly, these are important issues to address, especially because of the relationship between poor oral hygiene and the incidence of VAP.\textsuperscript{46,90}

Finally, although nurses’ self-reporting of oral hygiene practices has been examined in 3 studies,\textsuperscript{17,30,31} the studies do not fully explore nurses’ perceptions of the importance of these practices. That is, nurses regularly undertake a number of routine practices in the care of critically ill patients, but little evidence is available to measure nurses’ sense of the importance of these practices and how optimizing
the structure of these practices may affect the overall health of ICU patients. For example, reported statements such as “Mouthcare is very important to my care unless … [there’s] no time for it”10 imply that oral hygiene is not considered part of the essential care required by ICU patients. It would be noteworthy, for instance, if this same statement was made with regard to administration of medications, yet oral hygiene is an important strategy not only for patients’ comfort but for improving clinical outcomes.

It is therefore vital that adequately powered, randomized, controlled clinical trials be undertaken to develop and evaluate oral hygiene practices for critically ill patients. These data are essential to optimize oral hygiene practices and inform evidence-based practice. The potential for oral care guidelines to contribute to reducing the incidence of VAP is an important area for ongoing research in the ICU.

The following conclusions can be drawn from this systematic literature review:

- Apart from the possible use of chlorhexidine mouth rinse in cardiothoracic intensive care patients, high-level evidence that could inform clinical practice regarding oral hygiene in ICUs is limited. That is, meta-analysis is hindered by the absence of standardized processes such as use of solutions and oral hygiene tools and by the lack of outcome measures such as validated oral assessment scales relative to ICUs.
- Only a few small studies have addressed nurses’ perceptions of the importance of oral hygiene practices and the barriers that prevent or strategies that facilitate adherence to evidence-based practice guidelines.
- Because oral care may contribute to improved clinical outcomes, further research is warranted for establishing best-practice guidelines. Also, the provision of protocols and the capacity for monitoring and evaluating these processes could improve clinical outcomes.

These limited data make oral care a fertile area for ongoing nursing research. Topics for potential further research include the following:

- Well-designed, adequately powered clinical trials to determine the most effective techniques for oral hygiene for reducing the incidence of dental plaque, with respect to the most effective use of solutions, equipment, and procedure for adults receiving mechanical ventilation.
- Development of standardized oral assessment techniques and tools not only for research but also for assessing patients, evaluating practice, and improving the quality of care.
- Assessment of nurses’ attitudes and beliefs about the importance and possible benefits of oral hygiene in the ICU.

FINANCIAL DISCLOSURES
None reported.

REFERENCES

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1. Based on their literature review, the authors state that recommendations for practice are affected by which of the following?
   a. Lack of rigorous quality studies
   b. An overabundance of studies
   c. Homogeneity of oral hygiene solutions
   d. Evidence of reliable outcomes

2. Which of the following can result in a less balanced analysis of systematic reviews?
   a. Foreign studies, which are an integral part of research literature
   b. The increasing number of studies with negative outcomes
   c. The small number of published studies with positive outcomes
   d. The lack of published studies with negative outcomes

3. Which of the following oral hygiene solutions would be recommended based on the literature review described in this study?
   a. Sodium bicarbonate
   b. Hydrogen peroxide
   c. Chlorhexidine gluconate
   d. Tap water

4. According to the literature review in this article, which oral hygiene equipment would be best?
   a. Toothbrush with toothpaste
   b. Foam swabs
   c. Lemon/glycerin swabs
   d. Swabs with rigid suction device

5. Which of the following decreases the incidence of ventilator-associated pneumonia?
   a. Reduction of dental plaque
   b. Bacterial colonization
   c. Oral hygiene
   d. Loss of fibronectin

6. According to this article, critical care nurses perceived which of the following as a low priority?
   a. Bathing
   b. Oral care
   c. Medication administration
   d. Range of motion exercises

7. Which of the following was a limitation in this study’s literature review?
   a. Too many studies were not in the critical care area
   b. Most articles in critical care were scientific control studies
   c. Variations in the methods of the studies
   d. Inconsistencies in the medical and critical care literature

8. What were the limitations in the literature review as related to oral hygiene assessment strategies?
   a. No verified assessment tools
   b. Incongruity of nursing training on tools
   c. Lack of data
   d. Nursing reluctance about using tool

9. Which of the following influences oral hygiene practices by nurses?
   a. Evidence-based research
   b. Standing protocols
   c. Physicians’ orders
   d. Individual preferences

10. According to the authors, which of the following would be an important area for ongoing research in critical care?
    a. Oral care as related to the incidence of sepsis
    b. Ventilator-associated pneumonia and oral hygiene practices
    c. Analysis of various oral hygiene solutions
    d. Nursing perception of oral care

11. In reference to oral care research, the authors suggest which of the following?
    a. Controlled randomized studies of oral care equipment
    b. Establishing best practice guidelines
    c. Developing oral assessment tools for nurses
    d. Comparing critical care nursing research with medical surgical nursing research

12. Which of the following methods was chosen to review literature pertinent to oral hygiene for this study?
    a. Systematic evaluation
    b. Subjective overview of descriptive articles
    c. Analysis of various oral hygiene solutions
    d. Comparing critical care nursing research with medical surgical nursing research