EFFECT OF CHLORHEXIDINE ORAL SPRAY VERSUS MECHANICAL TOOTHBRUSHING AND CHLORHEXINDINE RINSE IN DECREASING VENTILATOR ASSOCIATED PNEUMONIA IN CRITICALLY ILL ADULTS

By

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Ventilator associated pneumonia (VAP) is the most frequently occurring nosocomial infection associated with increased morbidity and mortality of patients in intensive care units. Although oral decontamination with chlorhexidine has been shown in some studies to reduce the risk of VAP, there have been few randomized controlled trials evaluating its efficacy. This study addressed two research questions: Is there a difference in the three study groups related to oral pH, oral culture scores and CPIS scores at 24 and 72 hours compared to baseline, and Do the number of decayed, missing and filled teeth, being edentulous and the presence of periodontal disease have an association with the development of ventilator associated pneumonia in critically ill adult patients? Eighty-five patients were randomized and assigned into three groups, group 1(n=29) received chlorhexidine spray 0.12%, group 2 (n=31) received chlorhexidine 0.12% and toothbrushing and group 3 (n=25) received standard or usual oral care using foam swabs (toothettes) with a variety of oral rinses.

No statistically significant differences in oral pH values occurred between the three groups. Statistically significant decreased oral culture scores occurred at 24 hours and 72 hours compared to baseline in the intervention groups indicating a possible benefit in the prevention of

VAP using chlorhexidine spray 0.12% or chlorhexidine 0.12% and toothbrushing, group 1 ($p=0.045$, $p=0.0082$) and group 2 ($p=0.0092$, $p= 0.0047$). No statistically significant differences in CPIS scores occurred in group 1 at 24 hours and 72 hours compared to baseline ($p=0.7868$, $p=0.8462$) or group 3 ($p=0.6017$, $p=0.3151$) but group 2 ($p=0.545$, $p=0.0428$) was significant at 72 hours compared to baseline, again indicating a possible benefit in preventing VAP in the chlorhexidine 0.12% and toothbrushing group. When using poor oral health and tooth condition as a risk factor for the development of VAP, subjects with periodontal disease, greater than 4 missing, decayed or filled teeth, and those who were edentulous were at higher risk ($p=0.0057$) to develop VAP. This study demonstrates that in patients in critical care units in Northeast Florida, the use of chlorhexidine 0.12% and toothbrushing is effective in preventing ventilator associated pneumonia.

CHAPTER 1
INTRODUCTION

Background of the Problem

Historically, nosocomial pneumonia is the second most common infection in patients in all healthcare settings in the United States (Cunha, 2009; Centers for Disease Control, 2004; Lode, Raffenberg, Erbes, Geerdes-Fengea & Mauch, 2000). In 2004, it was the leading cause of death from all infections, with mortality rates of 13-65% according to the Centers for Disease Control (CDC), (CDC, 2004). According to the CDC, pneumonia occurs in 25-30% of mechanically ventilated patients and increases hospital costs and patients' lengths of stays (Cunha, 2009; Munro, Grap, Sessler & Carter, 2003). The international incidence and prevalence of nosocomial pneumonia is similar to that in the United States, with 300,000 cases annually, with an associated mortality rate of 30-70% (Cunha, 2009).

Ventilator associated pneumonia (VAP) is a frequent complication of intensive care patients (Depuydt, Myny, & Blot, 2006; Salahuddin, Zafar, et al., 2004). A risk factor for the development of ventilator associated pneumonia includes oral bacterial colonization (Chulay, 2008; Rumbak, 2000; Kollef, 1999; Johanson, Pierce, Sanford & Thomas, 1972). The normal oral flora of humans may harm a debilitated host since some of these bacteria are opportunistic pathogens. These pathogens may grow and multiply in the host, and may invade tissues for example, lung tissue, that is not normally accessible to them and cause infectious disease. One of these diseases is aspiration pneumonia, or specifically ventilator associated pneumonia (Cao, Progulski-Fox, Hillman & Handfield, 2004). Surveillance data on 500,000 patients in combined medical-surgical intensive care units (ICU) showed that 68% of nosocomial infections were respiratory-related; with pneumonia as the primary diagnosis (Richards, et al., 2000). Furthermore, an intubated patient has 6-21 times the risk of developing hospital-

acquired/nosocomial pneumonia when compared to a non-ventilated patient (Ranes, Gordon & Arroliga, 2006; Tantipong, Morkchareonpong, Jaiyindee & Thamlikitkul, 2008; CDC, 2004; Scannapieco, Stuart, & Mylotte, 1992; Sole, Poalillo, Byers & Judy, 2002; Bauer, Torres, Ferrer, Heyer, Schultze-Werninghaus & Rasche, 2002). Therefore, because of these associations and the increased risk of poor patient outcomes, nursing interventions that could decrease ventilator associated pneumonia are an important healthcare issue.

Statement of the Problem

Ventilator associated pneumonia as defined by the CDC (2004), is the development of pneumonia after 48 hours of mechanical ventilation. This may be linked to decreased immune capacity and change in bacterial proliferation. Changes in the oropharyngeal environment can occur as a result of hospitalization related to diet, systemic disease, medications and oral diseases (Steifel, Damron, Sowers & Velez, 2000). Organisms that reside in the mouth of healthy individuals consist primarily of gram positive strains; with severe illness, bacterial strains shift and anaerobic gram-negative strains predominate (Myrianthefs, Kalafati, Samara, & Baltopoulos, 2004; Kite & Pearson, 1995, Rumbak, 2000). In a healthy subject, the respiratory tract is able to defend against aspirated bacteria. Mechanically ventilated patients in ICUs with no ability to clear oral secretions by swallowing or coughing are at high risk for VAP, especially if the ventilation lasts for more than 48 hours (Paju & Scannapieco, 2007).

Research data has shown a correlation of oropharyngeal bacterial colonization to the incidence of (VAP) in critically ill adults (Chulay, 2008). Dental plaque, a film of bacteria, acid, food and saliva deposited on the teeth that encourage the development of dental caries and gingivitis, accumulate along with poor oral hygiene starting a cascade of physiological oropharyngeal contamination in the critically ill patient (Heo, 2007; Munro, Grap, Elswick, McKinney, Sessler & Hummel, III, 2006; Marsh, 1999). Oropharyngeal changes can occur

rapidly as a result of medications, or disease related lower saliva production, epithelial injuries imposed by nasogastric and endotracheal intubation, the start of an antibiotic regimen, as well as, immunosuppression therapy (Munro, et al., 2006; Tantipong et al., 2008; Kaplan & Baum, 1993; Lamkin & Oppenheim, 1993; Rodriguez, Gibbons, Bitzer, Dechert, Steinberg & Flint, 1991; Daschner, Kappstein, Engels, Reuschenbach, Pfisterer, Krieg & Vogel 1988). For VAP to occur, a significant number of organisms must enter the patient's lower respiratory tract and infect susceptible tissues. In addition, oral bacterial colonization increases with poor oral health (Munro, Grap, Elswick, McKinney, Sessler, & Hummel, III, 2006; Genco, Offenbacher & Beck, 2002). Patients with poor oral health, for example, those with dental caries and periodontal disease, are at high risk of developing nosocomial pneumonia when mechanically ventilated (Koeman, et al., 2006; Scannapieco, et al., 1992; Sole, Poalillo, Byers & Judy, 2002; Bauer, Torres, Ferrer, Heyer, Schultze-Werninghaus & Rasche, 2002). Therefore, measures that could alter oropharyngeal colonization may help decrease this event (Koeman, et al., 2006; Craven & Driks, 1987).

Secondary pneumonia, related to mechanical ventilation, has a high mortality and morbidity rate (CDC, 2004; Pugin, Auckenthaler, Lew & Sutter, 1991). Patients with VAP have a 2.2 to 4.3 times higher risk of death when compared to patients in the ICU without pneumonia (Chastre & Fagon, 2002). In Pugin's study (1991), the researchers stated that diagnosis of VAP was difficult and treatment failures were common and therefore, preventive measures should be important. In a double-blind, placebo, case controlled trial, selective decontamination of the oropharynx with polymyxin B sulfate, neomycin sulfate, and vancomycin hydrochloride (PNV) in fifty-two patients requiring mechanical ventilation for 3-34 days (mean=10 days) was studied. Either PNV or placebo was administered six times daily in the oropharynx. During the first 12

days of intubation, tracheobronchial colonization by gram-negative bacteria and staphylococcus aureus, as well as pneumonia, occurred less frequently in the PNV than in the placebo group. At the conclusion of the study, hospital mortality was not different, but systemic antibiotics were prescribed less often and no resistant microorganisms emerged. Ventilator associated pneumonia was decreased by a factor of 5, the researchers reported, by interrupting the stomach-to-tracheal route of infection (Pugin, et al., 1991). This was one of the first studies linking oral antibiotic decontamination and a possible decrease in the development of VAP. It used common oral antibiotics at that time which did not include chlorhexidine.

In 1997, Abele-Horn, Dauber, Bauernfeind, Russwurum, Seyfarth-Metzger, Gleich & Ruckdeschel randomized eighty-eight patients admitted as emergencies and intubated within less than 24 hours. Study participants received systemic cefotaxime as a prophylaxis and were prospectively randomized into one of three groups receiving either amphotericin B, colistin sulfate or tobramycin which was applied to the ororpharynx. The primary pathogen identified in this study was staphylococcus aureus. The purpose of the study was to determine the influence of selective oropharyngeal decontamination on the rate of colonization and infection of the respiratory tract in intensive care patients, while also performing a financial assessment. The results of this study demonstrated a reduced colonization and pneumonia rate, but ICU stay, and duration of ventilation and mortality were similar to the control group (Abele-Horn, et al., 1997). At the end of their study, they recommended larger studies to evaluate the effect of prophylaxis oral decontamination on overall cost and prognosis of critically ill patients who are at risk of developing ventilator associated pneumonia.

Houston, Hougland, Anderson, LeRocco, Kennedy & Gentry (2002), compared phenolic mixture (Listerine) (Pfizer, New York, New York) oral mouth rinse as a control and

chlorhexidine 0.12% mouth rinse in postoperative cardiac patients in a prospective randomized controlled trial. Five hundred sixty-one cardiac surgical patients were in the study. The overall rate of nosocomial pneumonia was reduced by 52% in the chlorhexidine 0.12% mouth rinse group. These patients were generally healthier than those in the Abele-Horn, Dauber, Bauernfeind, Russwurum, Seyfarth-Metzger, Gleich & Ruckdeschel study since they were elective surgical patients. Among patients intubated for greater than 24 hours who had cultures that showed microbial growth, the pneumonia rate was reduced by 58%. In patients at highest risk for pneumonia; those intubated greater than 24 hours, with cultures showing the most growth, the rate was 71% lower in the chlorhexidine group than in the phenolic mixture group. They concluded that although the rates of nosocomial pneumonia were lower in patients treated with chlorhexidine than in the phenolic mixture group, the difference was significant only in those patients intubated greater than 24 hours who had the highest degree of bacterial colonization.

Fourrier, Cau-Pottier, Boutigny, Roussel-Delvallez, Jourdain & Chopin (2000), performed a single-blinded randomized comparative study of sixty patients to document the effect of dental plaque antiseptic decontamination versus control on the occurrence of plaque colonization by aerobic nosocomial pathogens and nosocomial infection in ICU patients. The treatment group received dental plaque decontamination with 0.2% chlorhexidine gel, three times a day during their ICU stay. The standard group received routine oral care which consisted of mouth rinsing with bicarbonate isotonic serum followed by a gentle oropharyngeal sterile aspiration four times daily. At the conclusion of the study, the treatment group had a decrease in dental bacterial colonization. Although there was a trend for reduction in mortality, length of stay and duration of mechanical ventilation, the results were not statistically significant. The study

objective was to document the effect of dental plaque antiseptic decontamination on the occurrence of plaque colonization by aerobic nosocomial pathogens and nosocomial infections, including VAP. Limitations of the study included the researchers who did not check the quality of the application of chlorhexidine gel at the bedside; therefore, patients having a prolonged length of stay may not have properly received the antiseptic gel application as described in the study.

Genuit, Bochicchio, Napolitano, McCarter & Roghman (2001) added the administration of an oral rinse of chlorhexidine gluconate 0.12% twice daily to their rapid ventilator weaning protocol for surgical patients. The addition of chlorhexidine gluconate 0.12% significantly reduced VAP, (37% overall, $p<0.05$) in comparison to rapid ventilator weaning alone. A limitation in the study design was that the researchers did not look at the incidence of VAP related to mechanically ventilated patients who were not on a rapid weaning protocol.

Chlorhexidine gluconate is a broad spectrum antibacterial agent that has been used extensively in healthy populations as a daily oral rinse to control plaque and to treat periodontal disease (Iacono, Aldredge, Luck & Schwartzstein, 1998; Eldridge, Finnie, Stephens, Mauad, Munoz & Kettering, 1998; Newman, et al., 1997; DeRiso, Ladowski, Dillon, Justic & Peterson, 1996). In a study by Grap, Munro, Ellswick, Sessler & Ward (2004), an early single post-intubation oral application of chlorhexidine gluconate 0.12% was administered immediately following intubation. Thirty-four subjects were randomly assigned to chlorhexidine gluconate spray 0.12% or swab 0.12% or to a control group. Oral cultures were obtained at baseline, 12, 24, 48 and 72 hours. At the end of the study, statistically significant reductions in oral culture scores were only found in the chlorhexidine treatment groups. The results of these three studies:

Grap, 2004; Houston, et al., 2002; and Fourier, et al., 2000 demonstrate that the use of chlorhexidine gluconate in critically ill adults may be beneficial in reducing VAP.

To enhance oral health and hygiene in hospitalized patients, nurses need to be knowledgeable about risk factors that may contribute to poor oral health, facilitate best practice and ultimately improve oral hygiene management to decrease the risk of developing ventilator associated pneumonia in critically ill adult patients. Furthermore, few randomized controlled trials have been performed that examined the effectiveness of oral hygiene protocols in the orally intubated patient. In the absence of evidence-based guidelines, nurses often perform oral care according to individual preferences or historical patterns (Munro, Grap, Jones, McClister & Sessler, 2009). These preferences are often based on a combination of availability of a product, or the nurses' knowledge and experience at the time. Therefore, a research gap exists regarding evidenced based oral hygiene protocols and the role they could play in reducing VAP in the critically ill adult patient.

Purpose of the Study

The purpose of this randomized controlled trial was to determine if there is a difference in the occurrence of ventilator associated pneumonia in three oral hygiene protocol groups at 24 hours and 72 hours compared to baseline following implementation of the following nursing oral hygiene study protocols:

The protocol groups included:

1. Group 1 consisted of the application of chlorhexidine gluconate spray 0.12% provided by the nursing staff twice daily at twelve hour intervals on the teeth, gums and oral cavity.
2. Group 2 consisted of the application of chlorhexidine gluconate 0.12% and mechanical toothbrushing provided by the nursing staff twice daily at twelve hour intervals on the teeth, gums and oral cavity.
3. Group 3 consisted of the utilization of standard nursing oral hygiene protocols. Standard oral hygiene was the hospital's policy and procedure, or the critical care unit's standard. In

most instances this was the utilization of toothette foam swabs with or without chlorhexidine 0.12% provided by the nursing staff twice daily at twelve hour intervals.

This study addressed two research questions: 1) Is there a difference in the three study groups related to oral pH, oral culture scores and CPIS scores at 24 and 72 hours compared to baseline, and 2) Do the number of decayed, missing and filled teeth, being edentulous and the presence of periodontal disease have an association with the development of ventilator associated pneumonia in critically ill adult patients?

Hypotheses

Ho1: There will be no differences at 24 hours and at 72 hours compared to baseline in the three study groups related to oral culture scores, oral pH, and CPIS scores.

Ho2: There will be no association between the number of decayed, missing and filled teeth, being edentulous, the presence of periodontal disease and the development of ventilator associated pneumonia in critically ill adult patients.

Significance of the Study

There is a lack of evidence-based nursing hygiene protocols for the prevention of ventilator associated pneumonia. Most nursing practices are not research based, especially those surrounding oral care (Berry, et al., 2007; Grap & Munro, 2004; Moore, 1995). Nursing interventions lack empirical validity. Nursing approaches are guided by past experiences of the caretakers (Walsh, 1990). Although use of an oral hygiene program is recommended, evidence to guide specific oral care practices is limited (Berry, Davidson, Masters & Royle, 2007). Evidence-based strategies will likely improve outcomes. Ventilator associated pneumonia (VAP) remains an important cause of morbidity and mortality despite advances in antimicrobial therapy, better supportive care modalities, and the use of a wide-range of preventive measures (Berry, Davidson, Masters & Royle, 2007; Tablan, Anderson, Besser, Bridges & Hajjeh, 2004;

Niederman, 1996; Craven, Kunches, Kilinisky, Lichtenberg, Make & McGabe, 1986). Endotracheal intubation and mechanical ventilation predispose a patient to VAP by interfering with the normal defense mechanisms that keep microorganisms out of the lungs. Endotracheal tubes interfere with the mucociliary transport system that helps clear airway secretions. These secretions pool below and above the endotracheal tube cuff and are an ideal growth medium for pathogens. The endotracheal tube also prevents normal closure of the epiglottis which results in an incomplete seal of the laryngeal structures that normally protect the lungs. This tube placement contributes to the aspiration of oral pathogens that can lead to the development of VAP (Pruitt & Jacobs, 2006). Ultimately, providing guidelines to decrease the incidence of VAP should be an important nursing goal.

Ventilator associated pneumonia is also significant in relation to healthcare costs. VAP has been shown to prolong hospitalization by 7-9 days and a conservative estimate of the cost for treatment of all nosocomial pneumonias in the United States is more than $2.5 billion dollars annually (Cunha, 2009; Brooks, 2001; Leu, Kaiser, Mori, Woolman & Wenzel, 1989). One example of cost savings to decrease VAP was a performance improvement project implemented at St. Joseph's Hospital in Atlanta, Georgia in 1999. It resulted in a decrease of 318 Intensive Care Unit days for an approximate savings of $349,164 (Keith, Garrett, Hickox, Echols & Comeau, 2004). Since the conclusion of the performance improvement initiative, the hospital has implemented the most recent CDC guidelines, a new ventilator assessment flow sheet and the use of an antibacterial mouth care product that utilizes chlorhexidine 0.12% and mechanical tooth brushing (Keith, et al., 2004).

At the Allegheny General Hospital in Pittsburgh, Pennsylvania in 2004, senior leadership and the hospital board of directors introduced a strong support for a culture of safety

and set a goal of zero VAP in their intensive care units (Laux & Herbert, 2006). Interventions included securing the patient's resuscitation bag in one location, maintaining the head of bed elevation to more than 30 degrees, if not contraindicated, Yankauer suction tip care, and the use of chlorhexidine 0.12% mouth rinse, resulting in the decreased incidence of VAP by 43% within a six month period (Laux & Herbert, 2006).

Another healthcare system in Indiana and Kansas, utilized a performance improvement strategy to reduce VAP by implementing standardized patient positioning, oral care, nutrition, and management of comfort drugs across their healthcare system. Standardization of these essential care practices reduced VAP in seven of their ten intensive care units, with two of them maintaining zero VAP for two years (Murray & Goodyear-Bruch, 2007).

In March 2004, the CDC presented the Guidelines for Preventing Health Care-Associated Pneumonia. In recent years, demand for protocols which may help to decrease or prevent hospital acquired ventilator associated pneumonia has been desired. In response to this, the CDC produced guidelines from the Healthcare Infection Control Practice Advisory Committee (HICPAC). The committee's guidelines for prevention of VAP, however, did not include guidelines for the prevention or modulation of oropharyngeal colonization. The guidelines distributed in March of 2004 did not provide any recommendation regarding antimicrobial agents, specifically chlorhexidine rinses or other oral decontamination agents for the prevention of healthcare associated pneumonia in any health care setting. Therefore, the purpose of this study was to identify if a nursing oral hygiene protocol consisting of application of chlorhexidine gluconate spray 0.12% or chlorhexidine gluconate rinse 0.12% in conjunction with mechanical toothbrushing would result in a decrease in VAP. If effective, this could translate to a decreased

length of stay, decreased hospital costs and ultimately a decrease in morbidity and mortality of ventilator associated pneumonia in the hospital setting for critically ill adults.

CHAPTER 2
REVIEW OF THE LITERATURE

Recent studies provide evidence that the condition of the oropharynx may contribute to the progression of ventilator associated pneumonia in critically ill adults. This chapter reviews human normal oral flora, pathogenesis of gingivitis leading to periodontal disease, oral colonization, definition and development of ventilator associated pneumonia in the ICU setting, risk factors for developing VAP and strategies to reduce its development in the critically ill adult.

Normal Oral Flora

The normal oral flora is very intricate and consists of more than 200 species of bacteria; although other microbes exist, bacteria are the most numerous microbial component of the normal flora (Todar, 2008). Developmental changes in humans such as the eruption of teeth, invariably affect the composition of the flora in the oral cavity; it has been calculated that the normal oral cavity houses about 10 to the 10^{th} power of bacteria (Todar, 2008).

Very little is known about the nature of the association between humans and their normal oral flora, but they are thought to be dynamic interactions rather than associations of mutual indifference (Todar, 2008). Both host and bacteria are thought to derive benefit from each other, and the associations are, for the most part, mutually supported. The normal oral flora derives from the host a supply of nutrients, a stable environment and constant temperature, protection, and transport. The host obtains from the normal oral flora certain nutritional benefits, stimulation of the immune system, and colonization strategies that exclude potential pathogens at the site. The normal oral flora adapts to their host probably by biochemical interactions between bacterial surface components (ligands and adhesions) and host cell molecular receptors (Merritt, Kreth, Qi, Sullivan & Shi, 2005).

In general, there are three explanations for why the normal oral bacteria are located at particular anatomical sites in the oral cavity. First, the normal oral flora exhibits a tissue preference or predilection for colonization. Certain species of oral bacteria are invariably in one locale and never in the other. This is sometimes referred to as tissue tropism. One explanation for tissue tropism is that the host provides an essential growth factor needed by the bacterium. An explanation of why an oral bacterium is not located at an alternative site is because the host inherently provides a hostile environment for the bacterium by the production of such substances as stomach acids, bile salts, and lysozymes. A second explanation is that normal oral flora specifically colonizes a particular tissue or surface using their own surface components (capsules, fimbriae, cell wall component) as specific ligands that are used for attachment to specific receptors located at the colonization site in the oral cavity. Third, indigenous bacteria are able to construct bacterial biofilm on a tissue surface; in other terms, they are able to colonize a biofilm built by another bacterial biofilm on a tissue surface. Many biofilms are a mixture of microbes, although one member is responsible for maintaining the biofilm and may predominate (Merritt, Kreth, Qi, Sullivan & Shi, 2005).

The presence of nutrients, epithelial cells and debris, as well as secretions makes the mouth a favorable habitat for colonization, disrupting the normal flora. The bacteria commonly found in the oral cavity are staphylococci, streptococci, pseudomonas aeruginosa and corynebacteria with a great number of anaerobes, especially bacteriodes. Many of the normal oral floras are either pathogens or opportunistic pathogens; of these, the ones considered potential pathogens for causing respiratory infections include: 1) staphylococcus aureus, 2) streptococcus mutans, 3) streptococcus pneumoniae, 4) pseudomonas aeruginosa, 5)

corynebacteria with bacteriodes, and 6) actinomyctes (Merritt, Kreth, Qi, Sullivan & Shi, 2005; Mayhall, 1997; Rumbak, 2000).

Staphylococci and corynebacteria normally occur in the oral cavity via the nares. Staphylococcus aureus, a potential virulent pathogen, is the leading cause of all bacterial disease in humans. It can be transmitted from the nasal membranes of an asymptomatic carrier to a susceptible host, such as a mechanically ventilated patient (Koleff, 2004; Scannapieco & Rethman, 2003).

Streptococcus mutans is the primary bacterium involved in plaque formation and initiation of dental caries. Dental plaque, which is material adhering to the teeth, consists of bacterial cells (60-70% the volume of the plaque), salivary polymers, and bacterial extracellular products. Plaque is a naturally-constructed biofilm, in which the consortia of bacteria may reach a thickness of 300-500 cells on the surfaces of the teeth. These accumulations subject the teeth and gingival tissues to high concentrations of bacterial metabolites, which result in dental disease. Viewed as an opportunistic infection, dental disease is one of the most prevalent and costly infectious diseases in the United States. After initial weakening of the enamel, various oral bacteria gain access to interior regions of the tooth. Lactobacilli and Actinomyces are commonly found in human caries (Todar, 2008), which would suggest that they are secondary invaders that contribute to the progression of lesions which can then be aspirated into the lungs and produce VAP (Kollef, 2004).

Respiratory pathogens isolated from the lung are often genetically indistinguishable from strains of the same species isolated from the oral cavity in patients who receive mechanical ventilation and are admitted to the hospital from the community (Heo, Haase, Lesse, Gill &

Scannapieco, 2008). Thus, dental plaque serves as an important reservoir for respiratory pathogens in patients who undergo mechanical ventilation.

Streptococcus pneumoniae is present in the oral and upper respiratory tract of about half the population. If it invades the lower respiratory tract it can cause VAP. Streptococcus pneumoniae causes 95 percent of all bacterial pneumonia. Streptococcus pyogenes refers to the Group A Beta-hemolytic streptococci. Streptococcus pneumonia is a leading cause of VAP (Todar, 2008; Kollef, 2004).

Gingivitis Leading to Periodontal Disease

Gingivitis is widespread with 54 percent of the population 13 years or older having bleeding on probing. The most common type of gingivitis is caused by dental plaque. Plaque in subgingival bacterial biofilm (plaque) initiates gingival inflammation (gingivitis). This in some patients may extend apically to become periodontitis (Miyasaki, 2010). Periodontitis is clinically differentiated from gingivitis by the loss of the connective tissue attachment to the teeth in the presence of concurrent gingival inflammation (Cunha, 2009).

The causes of infections related to this condition are both exotoxins and endotoxins. Exotoxins are proteins released by living cells. They secrete many gram positive and gram negative bacteria. Endotoxins, a lipopolysacharide in the cell wall of gram negative organisms, are released at cell death. They are gram negative bacteria. This process inhibits healing and allows tissues to spread bacteria (Cunha, 2009).

Bacterial exotoxins such as hyaluronidase destroy the intercellular connections between epithelial cells lining the gingival sulcus. The barrier effect of epithelial cells is reduced by a widening of intercellular spaces. This is one of the first stages in the initiation of gingivitis. This allows the penetration of other bacterial products through the epithelium to the underlying

gingival connective tissue. Other bacterial exotoxins such as collagenase can now penetrate through the epithelial cell barrier of the gingival sulcus. This results in the destruction of the basement membrane and areas of loss of the epithelial cell layer with ulcer formation. Epithelial ulceration provides a portal for subgingival bacteria and their products to the gingival connective tissue (Masada, 2006; Page, 2006). Bacteria may then enter blood vessels and cause a bacteremia. Most subgingival bacteria that penetrate into connective tissue in gingivitis do not proliferate in the tissue. This is because they are anaerobic and the tissues are aerobic. Bacterial products that contact gingival connective tissue initiate an acute inflammatory response with vasodilatation, edema and polymorphonuclear leukocyte (PMN) activation. Gingivitis is seen clinically as acute inflammation with redness and edema of tissues and exudates of inflammatory fluid from the gingival sulcus. One of the first effects of bacterial contact with gingival tissue is activation of mast cells. Mast cells are inflammatory cells of the basophil series of granular leukocytes. Mast cells have receptors which initiate production of vasoactive substances such as histamine which induce vascular permeability and vasodilatation. This vasodilatation and increased permeability of capillaries are associated with edema and diapedesis of leukocytes from the blood vessels into the connective tissue of the gingiva. Mast cells produce other inflammatory mediators such as slow-reacting substance of anaphylaxis, leukotriene C4, tumor necrosis factor alpha (TNF) and IL6. These activate the acute inflammatory response (Masada, 2006; Page, 2006).

As gingivitis develops the initial acute inflammatory response continues and a chronic inflammatory response is added. Lymphocytes and capillary proliferation characterize this chronic inflammation. B cells are lymphocytes derived from bone marrow and produce antibodies to bacterial antigens. T cells are lymphocytes derived from the thymus and initiate cell

mediated immunity by producing lymphokines. B cells interact with macrophages in gingival tissue and become plasma cells which produce antibodies. There are also B cell series that carry the memory of a particular antigen and can quickly produce antibodies. This memory is dependent on interactions with T cells. Plasma cells (B cells) produce immunoglobulins within gingival tissue which bind to and inactivate bacterial antigens including exotoxins. The antibody – antigen complexes also activate complement (Page, 2006; Masada, 2006; Miyasaki, 2010).

With chronic inflammation, gingival blood vessels and inflammatory cells proliferate into the areas of destroyed connective tissue. Acute inflammatory changes are superimposed on chronic inflammation. The combined acute and chronic inflammation seen in gingivitis and periodontitis is destructive of bacteria. It also causes damage to the connective tissue of gingival and the periodontal tissues. Another mechanism of breakdown of connective tissue in periodontal disease involves matrix metalloproteinases (MMP). These are produced by PMNs, macrophages, fibroblasts and epithelial cells. MMP8 comes from PMNs; and MMP1 comes from resident cells (Page, 2006; Masada, 2006; Miyasaki, 2010).

The bacterial induced inflammation of gingivitis can spread apically and involves the destruction of connective tissue of the periodontium including bone. This is periodontitis. The damaged epithelium of the gingival sulcus proliferates apically. As loss of attachment of connective tissue fibers to cementum occurs, the pocket epithelium migrates to line the root surface. Bone destruction is a result of osteoblasts or inflammatory cells signaling osteoclasts activation via cytokines such as IL-1 and TNF and prostaglandins (PGE). Activated osteoclasts destroy the inorganic bone components by release of acid hydrolases. MMPs from osteoblasts destroy the organic collagenous components. Possible mechanisms of bone loss in periodontitis include: 1-suppression of osteoblasts by inflammation with lowered bone production, 2- loss of

collagen attachment with reduction of tensile forces on bone, and 3-direct bacterial toxicity on osteoblasts and collagen. Other mechanisms of bone loss include: 1-regulation of cytokine and PGE secretion by inflammatory cells and 2-osteoblasts regulation of MMPs from inflammatory and connective tissue cells (Page, 2006; Masada, 2006; Miyasaki, 2010). The role of oral colonization of VAP-associated pathogens, which are atypical bacteria for the oral cavity, therefore appear to have an association in the development of hospital acquired pneumonia in patients who are mechanically ventilated (Grap & Munro, 2004).

Oral Colonization

Colonization of normal oral flora begins at birth and is of two types: 1) permanent colonization by bacteria that are expected to be a part of the normal flora at all times; and 2) transient colonization by potential pathogens. Colonization is by no means a haphazard event. Changes in normal oral flora, a shift to colonization related to diet, medications and disease may lead to biofilms on the tooth surfaces. Microorganisms have on their surfaces specialized molecules called adhesions that bind with specific receptors on host epithelial cells or with extracellular matrix materials. In respiratory infections such as VAP, viral infections facilitate invasion by colonizing bacteria, which in turn facilitates superinfection by "normal flora" species (Bryan, 2003). The primary cause then of most oropharyngeal colonization is plaque bacteria. It is this disease process that appears to contribute to orally intubated patients being at an increased risk for the development of ventilator associated pneumonia (Bryan, 2003).

Oral colonization has been reported to be the second most frequent principal diagnosis among hospitalized Medicare patients (Baine, Yu & Summe, 2001). While aspiration pneumonia doubled over the period from 1991-1998, aspiration pneumonia is still reported between 9 to 28% in hospitalized patients (Shanratzadeh, Huang, & Marrte, 2006). Risk factors for the

development of ventilator associated pneumonia include oral bacterial colonization (Tantipong, et al., 2008).

Aspiration of oropharyngeal contents with its high concentrations of anaerobic bacteria has been implicated in the pathogenesis of aspiration pneumonia (Myrianthefs, et al., 2004). The association between oral health and respiratory diseases has been suggested by a number of microbiologic and epidemiologic studies (Hayes, Sparrow, Cohen, Vokonas & Garcia, 1998; Scannapieco, Papandonatos & Dunford, 1998). It is quite possible that poor oral hygiene results in an increase in dental plaque. The result of poor oral health may promote colonization by anaerobic and gram-negative organisms. Pseudomonas aeruginosa is the quintessential opportunity pathogen of humans that can invade virtually any tissue. Oral colonization of pseudomonas aeruginosa is a leading cause of hospital acquired (nosocomial) gram-negative infections, but its source is often exogenous (from outside the host) (Kollef, 2004). One source may be the ventilator circuits and humidifiers that are connected to patients who are mechanically ventilated (Kollef, 2004). Once aspirated, it is not uncommon for the anaerobic bacteria to acquire virulence leading to pneumonia. Pharmacologic agents have shown promise in reducing aspiration pneumonia, but their efficacy has not been established in large randomized clinical trials (El Solh & Saliba, 2007; Donskey, et al., 2000).

The stomach can harbor organisms that cause nosocomial pneumonia as well. Patients on antacids and other H-2 receptor antagonists may experience bacterial overgrowth (Berry, et al., 2007; Valles, et.al., 2004; Bonten, et.al., 1996). Although colonization/infection with pseudomonas aeruginosa in intubated patients tends to be endogenous, exogenous sources should not be ruled out (Valles, et al., 2004). Bonten, et al., (1996) reported that length of ventilation also increased the risk of stomach colonization. Patient conditions that increase the risk of

aspiration of stomach contents include: repeated endotracheal intubations, presence of a nasogastric tube, supine positioning, neurological impairment, and an increased number of invasive procedures (Kollef, 2004). Several interventions have been suggested to decrease oropharyngeal and stomach colonization; one intervention includes the use of chlorhexidine as an antimicrobial agent (Koeman, et al., 2009; Leone, Delliaux, Bourgoin, Albanese, Garnier, Boyadjiev, Antonini & Martin, 2005; Kollef, 2004; DeRiso, Ladowski, Dillon, Justice & Peterson, 1996).

Development of Ventilator Associated Pneumonia in the ICU

Pneumonia is an acute inflammation of the lung parenchyma that is caused by an infectious agent that can lead to alveolar consolidation. Pneumonia can be classified as community acquired (CAP) or hospital acquired (HAP or nosocomial). Patients who develop ventilator associated pneumonia have fatality rates that exceed 50% and are more than two-fold higher than intubated patients without pneumonia (Tejerina, Frutos-Vivar, Restrepo, et al., 2006; Markowicz, Wolff, Djedini, et al., 2000; Craven & Driks, 1987). VAP continues to complicate the course of 8 to 28% of patients receiving mechanical ventilation. In contrast to infections of more frequently involved organs, such as the urinary tract and skin for which mortality is low, ranging from 1 to 4%, the mortality for VAP ranges from 24-50% and can reach as high as 76% in some specific settings or when lung infection is caused by high-risk pathogens (Tejerina, et al., 2006; Chastre & Fagon, 2002). Pathogens that can cause severe HAP include Streptococcus pneumoniae, Legionella, Klebsiella pneumoniae, Haemophilus influenza, Staphylococcus aureas, Mycloplasma pneumoniae, respiratory viruses, bacteriodes and Pseudomonas aeruginosa (May, Kelly, Mendlein & Garbe, 1991). A number of factors determine the severity of HAP. Bacterial factors include the size of the pathogen inoculum and the virulence of the organism. Pulmonary

factors include multi-lobar involvement and the presence of underlying lung disease and pulmonary neoplasms. Systemic factors include advanced age, compromised host, and the presence of congestive heart failure and hepatic/renal insufficiency (Tejerina, et al., 2006; May, Kelly, Mendlein & Garbe, 1991).

By definition, hospital acquired pneumonia includes any case of pneumonia that starts greater than 48 hours after hospital admission. Among intubated and mechanically ventilated patients, the development of VAP occurring 48 hours after admission or later is known as ventilator associated pneumonia (Kollef, 2004). Development of acute VAP implies a defect in host defenses, particularly virulent organisms, or an overwhelming inoculation event. A number of conditions predispose a patient to developing VAP. Bacterial invasion of the lower respiratory tract can occur by aspiration of organisms colonizing the oropharynx. While other factors such as spread of infections through the bloodstream, direct inoculation of organisms or spread of infection to the lungs from adjacent structures are also causes; it appears that the most common mechanism is aspiration of oropharyngeal organisms (Azarpazhooh & Leake, 2006).

Colonization of the patient's oropharynyx with infectious organisms is a major contributor to the development of VAP. Oropharyngeal colonization with pathogenic organisms contributes to the development of VAP in ICUs (Berry, Davidson, Masters & Rolls, 2007). Normally, the oropharynx has a stable population of resident flora that may be anaerobic or aerobic. When stress occurs, such as with illness, surgery, or infection, pathogenic and opportunistic organisms from the oral cavity invade the lower respiratory tract causing pneumonia. Disruption of the gag and cough reflex, altered consciousness, abnormal swallowing, and artificial airways all predispose the patient to aspiration and colonization of the lungs and subsequent infection (Kollef, 2004).

Previous antibiotic therapy may also affect the resident flora population, making replacement by pathogenic organisms likely. The pathogens are then able to invade the sterile lower respiratory tract (Kollef, 2004). Histamine blockers, antacids, and enteral feedings also contribute to this problem because they raise the pH of the stomach and promote bacterial overgrowth (Kollef, 2004).

Oral and systemic disease, as well as medication use, may be contributing factor to VAP by altering the levels of oral bacteria in saliva and/or by changing the composition of the salivary flow. Aspiration of the oropharyngeal secretions and contaminants likely provide the origin of many of the anaerobic bacteria that have been cultured from aspiration pneumonia patients (Azarpazhooh & Leake, 2006). The Infectious Diseases Society of America and the recent Thoracic Society guidelines have recommended anaerobic coverage for patients with pneumonia with poor dentition who are at risk for aspiration (Diaz, Ulldemolins, Lisboa & Rello, 2009; Bouza & Burillo, 2009; Bartlett, Breiman, Mandell & File, 1998). Recent research, therefore, suggests the relative importance of oropharyngeal colonization in the development of VAP; additionally convincing evidence exists to suggest other risk factors for VAP and interventions that can be employed to reduce its occurrence (O'Keefe,Carthy, Santiago & Lau 2009; Kollef, 2004).

Risk Factors Contributing to VAP

A review of the literature by this author regarding oral health identifies at least ten actual or potential risk factors which can contribute to the colonization of the oropharyngeal area; these include 1) tooth loss 2) dental plaque 3) dental caries 4) periodontal disease 5) stomatitis 6) oral pH 7) dry mouth/xerostomia 8) conditions favoring reflux 9) prolonged use of ventilator support/potential exposure to contaminates and 10) host factors such as extremes in age,

malnutrition and severe underlying condition. Nursing knowledge regarding each of these risk factors and implementing best practice interventions can improve patient outcomes.

Tooth Loss. Most tooth loss is caused by two preventable diseases: dental caries (tooth decay) and periodontal disease (Coleman, 2002). Loss of teeth alters food selection, resulting in a carbohydrate-rich diet lacking in fiber and protein, putting the patient at risk for malnutrition. Identification of tooth loss and implementing procedures to provide replacement can help alleviate this problem. Kressin, Boehmer, Nunn and Spiro (2003) studied 735 men in the Veterans Affairs Dental Longitudinal Study utilizing a cross sectional and longitudinal self-report regarding tooth brushing, dental floss use, annual prophylaxis, and combinations of such behaviors. It was significant for the prevention of tooth loss. To examine the association between childhood dental visits and attitudes and beliefs about dental care and oral health, data from the Florida Dental Care Study (FDCS) was reviewed. The data suggests that the socialization associated with early dental visits may occur even though the experience may have been painful or frightening. Although this study design precluded direct inference about causation, these findings do support the utility of further investigations into possible causative linkages between childhood dental experiences and adult attitudinal and dental health outcomes (Riley & Gilbert, 2005).

Vitamin D and calcium are associated with increasing bone density. Increasing the intake of both has shown to reduce the rate of tooth loss. Currently one longitudinal study has found a correlation between these factors (Wactawski-Wende, Grossi & Trevisan, 1996). Nordenram & Ljunggren in 2002 studied 192 nursing home residents and determined that cognitive function influences the retention of teeth. Being dentate but having loss of cognitive functional capacity is predictive of oral treatment need among nursing home residents.

Dental Plaque. Dental plaque is material adhering to the teeth, consisting of bacteria, salivary polymers, and bacterial extra cellular products. Plaque is a naturally constructed biofilm, in which the consortia of bacteria may reach a thickness of 300-500 cells on the surfaces of the teeth. These accumulations subject the teeth and gingival tissues to high concentrations of bacterial metabolites, which result in dental disease (Azarpazhooh & Leake, 2006).

Plaque formation is initiated by a weak attachment of the streptococcal cells to salivary glycoprotein from a pellicle on the surface of the teeth. This is followed by a stronger attachment by means of extra cellular sticky polymers of glucose which is synthesized by the bacteria from dietary sugars. An enzyme on the cell surface of streptococcus mutans, glycosol transferease, is apparently involved in initial attachment of the bacterial cells to the tooth surface and in the conversion of sucrose to dextran and levan polymers which form the extra cellular matrix of plaque. Attachment of S. mutans and the formation of glucans are mediated by glycosyl transferase. The specificity of the adhesion has been proven by the fact that the attachment can be prevented by specific antibody to the enzyme (Azarpazhooh & Leake, 2006).

Nine patients at the University of Buffalo Hospital who were suspected of having VAP had samples of dental plague removed for DNA analysis. Results showed that genetic profiles of bacteria from tracheal and bronchial samples of the nine patients with pneumonia were identical to profiles of bacteria from their dental plague. Heo (2007) stated that the results suggest that the teeth likely serve as an important reservoir of infection in these high risk patients. He further stated that to prevent possible hospital acquired ventilator associated pneumonia, taking care of teeth and gums while hospitalized might be important.

Munro, Grap, Elswick, McKinney, Sessler & Hummel (2006) enrolled 66 patients within 24 hours of intubation and were followed for seven days. Patients with higher dental plaque

scores and oral organisms at baseline increased over time during the seven days of observation and showed a greater risk for ventilator-associated pneumonia, particularly for patients with a greater severity of illness.

Dental Caries. Dental caries is an infectious disease in which the destruction of the enamel, dentin or cementum of teeth is due to bacterial activities. Caries are initiated by direct demineralization of the teeth enamel due to lactic acid and other organic acids which accumulate in dental plaque. Lactic acid bacteria in the plaque produce lactic acid from the fermentation of sugars and other carbohydrates in the diet of the host. Streptococcus mutans has most consistently been associated with the initiation of dental caries, but other lactic acid bacteria are probably involved as well. These organisms normally colonize the occlusal surface and contact points between teeth and this increases the incidence of decay on these surfaces (Azarpazhooh & Leake, 2007). Dental biofilms are implicated in the formation of caries and periodontal disease. A major constituent is Streptococcus mutans, which produce lactic acid from sucrose fermentation, enhancing enamel demineralization and eventual caries development. Increasing the delivery of anticariogenic agents such as flouride into the plaque biofilm may be a useful strategy for enhancing the anticaries effects in areas of the mouth where complete biofilm removal is not possible with routine daily cleaning techniques (Aspiras, Stoodley, Nistico, Longwell & deJager, 2010).

Dental caries can result in pain, tooth loss, abscess formation and bacteremia. Lapses in oral hygiene can contribute to dental caries and ultimately risk the development of tooth loss. Hase, Attstrom, Edwardsson, Kelly & Kisch (1998) compared the use of 0.2% delmonipinol hydrochloride versus 0.2% chlorhexidine digluconate and placebo. The study demonstrated that rinsing twice daily for 60 seconds for 6 months resulted in less plaque formation and gingivitis

than with a placebo. Pearson (1996) compared foam swabs and toothbrushes to prevent dental plaque. The sample size of two participants reported no significance. Dental caries increase bacteria residing in plaque. Older adults form plaque more rapidly than younger individuals and because lapses in oral care can occur in the elderly, an increased risk of developing new and recurrent tooth decay has been seen (Terpenning, 2005).

Periodontal Disease. Periodontal disease is an inflammatory disease of the gingival structure and supporting tissues caused by bacteria residing in dental plaque. Increased populations of Actinomyces and Streptococci, as well as, gram-negative organisms have been suggested as the cause. Diseases of the gum may lead to tooth loss, diffuse progression may produce hydrolytic enzymes, endotoxins, and other toxic bacterial metabolites. Periodontal disease increases the elderly's susceptibility to pneumonia. Genult, Bochicchio, Napolitano, McCarter & Roghman (2001) performed a prospective study over ten months in surgical intensive care patients. The first 5 months no interventions were performed in the surgical intensive care unit; the second 5 months chlorhexidine 0.12% oral rinses were performed twice daily for the duration of mechanical ventilation, on a matched sample of critically ill subjects. There was no significant difference in the overall hospital or ICU length of stay between groups. Improved oral hygiene via topical chlorhexidine application in conjunction with the use of a weaning protocol was effective in reducing the incidence of VAP and the duration of mechanical ventilation in surgical ICU patients.

In 1997, Mojon, Budtz-Jorgensen, Michel & Limeback examined 302 frail elderly acutely ill patients. They reported that poor oral hygiene presents potential risk factors for respiratory tract infections in frail elderly clients. Implementing oral health protocols may be effective in reducing the risk of aspiration pneumonia, which was studied by Taylor, Loesche &

Terpenning in 2000. In their study, eighteen outpatients had oral health protocols implemented using chlorhexidine 0.12% rinses. A statistically significant reduction in bacterial plaque was noted, thereby preventing aspiration pneumonia in this study population.

Seymour, Ford, Cullinan, Leishman & Yamazaki (2007) wrote that despite 3,000 years of medical dental history demonstrating the influence of oral status on general health, it is only in recent decades that the association between periodontal disease and systemic conditions such as respiratory conditions have been realized. They stated that it is clear that oral infections may represent a significant risk factor for systemic disease and hence the control of oral disease is essential in the prevention and management of these conditions.

Stomatitis. Stomatitis is a chronic inflammation of the mucous membranes. Prevalent in surveys of institutionalized patients, it is usually due to denture wearing (Coleman, 2002). Stomatitis is also present during broad-spectrum antibiotic use, impaired salivary flow, corticosteroid therapy and immunocompromised states (Coleman, 2002). Thirty-three participants were randomized using micronized sucralfate versus salt and soda mouthwashes in a study by Dodd, et al., (1996). They utilized a randomized, double-blind, placebo controlled clinical trial for prevention of oral mucositis in patients receiving chemotherapy. Results showed there was no significant difference between the two mouthwashes, but there was a reduction in the incidence of mucositis in all clients compared to earlier studies. This may indicate that increased nursing attention to oral health in and of itself may lead to improve oral outcomes for clients.

Oral pH. Oral pH should be maintained between 6 and 7 (Coleman, 2002). Products that alter the pH, such as hydrogen peroxide, sodium bicarbonate, mouthwashes containing alcohol, as well as many medications may increase the alkalinity of the oral pH. This change in pH may

contribute to periodontal disease. Bacteria, saliva, minerals and foods eaten all play a role in helping or hindering the progress of dental caries. Cariogenic bacteria are at the heart of periodontal disease and dental caries formation. The decaying action of the bacteria depends on their ability to adhere to tooth surfaces, the degree to which they colonize and how the food residues influence the amount of acid produced by the bacteria. Acid conditions below a pH of 5.5 cause dissolution of calcium and phosphate from tooth enamel. When this occurs, tooth dimeralization exceeds the ability of recovery or remineralization.

Dry Mouth/Xerostomia. Saliva is important for the health of both soft and hard oral tissues (Defabianis & Re, 2003). Dry mouth/xerostomia may be caused by systemic disease, medications or radiation. The health of teeth, gums and soft tissues of the mouth are at risk when patients have gingivitis, which may lead to periodontal disease. Dry mouth also increases a person's risk of tooth decay and mouth infections, such as thrush. Conditions that lead to dehydration, such as fever, excessive sweating, vomiting, diarrhea, blood loss, and burns can cause dry mouth. These conditions are often seen in critically ill adult intensive care patients. In addition, we require saliva to moisten and cleanse our mouths and digest food. Saliva also prevents infection by controlling bacteria and fungi in the mouth. When adequate saliva is not produced, the mouth gets dry and uncomfortable. The placement of an endotracheal tube may alter saliva production while patients are mechanically intubated, increasing the chance of developing ventilator associated pneumonia because of the changes in the oral cavity (Liena-Puy, 2006; Hicks, Garcia-Godoy & Flaitz, 2003).

Medications used to treat psychotropic disorders such as depression and anxiety, in addition to medications to treat pain, allergies and colds (antihistamines and decongestants), obesity, acne, epilepsy, hypertension (diuretics), diarrhea, nausea, urinary incontinence, asthma

(certain bronchodilators), and Parkinson's disease have been shown to produce xerostomia. The use of muscle relaxants and sedatives also contribute to this situation. Most mechanically ventilated patients receive some type of sedation while intubated.

In addition, a side effect of the patient's medical conditions may contribute to decreased production of saliva, including Sjögren's syndrome, HIV/AIDS, Alzheimer's disease, diabetes, anemia, cystic fibrosis, rheumatoid arthritis, hypertension, Parkinson's disease, stroke, and mumps. Reduction in salivary flow is attributed to systemic conditions and medications rather than the aging process itself. More than 500 drugs contribute to xerostomia. In addition, other causes are oxygen therapy, oral suctioning and NPO status (Henshaw & Calabrese, 2001).

Damage to the salivary glands, the glands that produce saliva, for example, from radiation to the head and neck and chemotherapy treatments for cancer, can also reduce the amount of saliva produced. Nerve damage to the head and neck area from an injury or surgery or personal health habits such as smoking or chewing tobacco can affect saliva production and aggravate dry mouth. Continuously breathing with the mouth open contributes to the problem. The placement of an endotracheal tube artificially produces this effect in patients on mechanical ventilation (Defabianis & Re, 2003).

In a study by Dennesen et al., in 2003, twenty-four ventilated ICU patients and 20 coronary artery bypass grafting patients were included in a study to ascertain salivary flow. Absence of salivary flow in the ICU patients caused severe xerostomia which may have contributed to the development of oropharyngeal colonization with gram-negative bacteria, which has been shown to increase the risk for the development of VAP (Dennesen, et al., 2003). Munro, et al. (2006) in their descriptive study of 66 critically ill patients, attributed a decrease in salivary volume as a possible contributor to patients developing VAP.

Conditions Favoring Reflux. Supine positioning has been shown to be an independent risk factor for the development of VAP (Kollef, 2004; Sole, 2003). Aspiration of stomach contents is increased when patients are in the supine position. In one trial, there was a three-fold reduction in the incidence of nosocomial pneumonia when a semi-erect position was maintained (Drakulovic, et.al., 1999). Positioning affects the volume of gastric aspirate. The semi-Fowler's position (elevating the head of the bed by 30 degrees) decreases the volume of gastric juices and thereby reduces the aspiration risk (Tablan, Anderson, Besser, Bridges & Hajjeh, 2004).

Aspiration of Gastric Contents. Several studies have found an association between aspiration of gastric contents and VAP. The avoidance of gastric over-distension may reduce this complication (Torres, et al., 1996; McClave, DeMeo, DeLegge, et al., 2002). Currently available measures at avoiding gastric over-distension include reducing the use of narcotics and anti-cholinergic agents, monitoring gastric residuals, using gastrointestinal motility drugs, supplying enteral nutrition with small bore feeding tubes and administering feeding solutions directly into the small bowel instead of the stomach (Berry, et al., 2007; Kollef, 1999).

Prolonged Use of Ventilator Support/Potential Exposure to Contamination. Length of ventilation. Several studies have shown a direct relationship to the length of mechanical ventilation and the development of VAP (Cunha, 2009; Brooks, 2001). In addition, the use of the naso-pharyngeal route increases patients' risk of developing VAP (Koleff, 2004). The incidence of VAP increases with the length of stay in intensive care and the number of days mechanically ventilated (Cunha, 2009). Cook et al., (1998) reported a 3% increase in VAP per day during the first week of mechanical ventilation for every intensive care unit patient. Decreasing the time the patient is on the ventilator could help reduce the incidence of VAP Strategies that may reduce the number of ventilated days include limiting sedation and utilizing mechanical ventilator

weaning protocols aimed at early attempts to extubate the patient by allowing them spontaneous breathing (Kollef, 2004).

In a randomized control trial in a California trauma ICU, a protocol designed to assist nurses and respiratory therapists initiating a weaning process was effective in reducing the duration of mechanical ventilation without any adverse effects on patient outcomes (Marelich, et al., 2000). Six percent of the patients receiving the protocol-directed weaning developed VAP, whereas 15% of the patients in the control group developed VAP. Therefore, the evidence suggests that a weaning protocol may help to decrease ventilated days in patients in ICU and decrease their chance of developing VAP (Marelich, et al., 2000).

Potential exposure to contaminants. Secretions are common in the upper airways of intubated patients. Secretions pool above the endotracheal tube cuff allowing for leakage of contaminated secretions into the lower airway. In four studies, the effect of using an endotracheal tube that has a separate dorsal lumen, which allows continuous aspiration of the subglottic secretions, was compared with that of a conventional endotracheal tube (Smulders, van der Hoeven, Weers-Pothoff & Vandenbroucke-Granulus, 2002; Mahul, et al., 1992; Valles et al., 1995; Kollef, Nikolaos & Thoralf, 1999). Although the four randomized controlled studies showed a beneficial effect of continuous suctioning of subglottic secretions on the incidence of VAP, none of these studies showed a corresponding effect on mortality rate, length of stay in the intensive care unit, or duration of mechanical ventilation (Kollef, 2004).

Subglottic secretion drainage systems appear effective in preventing early onset of VAP in a meta-analysis review of 5 studies and 896 patients. The revised CDC guidelines suggest this specially designed endotracheal tube should be used when feasible (Fletcher, Ruffell & Young, 2009; Tablan, et al., 2004).

Nasal intubation has been identified as a risk factor promoting the development of VAP and sinusitis (Holzapfel, Chastang, Deminogeon, et al., 1999; Bert & Lambert-Zechovsky, 1996). Nasal obstruction with an endotracheal tube or feeding tube prevents the clearance of secretions from the sinuses, which plays a role in the development of sinusitis. Aspiration of infected secretions from the sinuses into the lower respiratory tract can overwhelm local host defense mechanisms allowing VAP to occur (Holzapfel, Chastang, Deminogeon, et al., 1999). Available investigations and experiences suggest that the preferred route of tracheal and gastric intubation is via the oropharynx and not the nasopharynx to prevent both hospital acquired sinusitis and VAP (Kollef, 2004).

Host Factor Extremes: Age, Malnutrition, Underlying Conditions

Nosocomial pneumonia represents the third most frequent hospital diagnosis among patients aged 65 years or older (May, Kelly, Mendlein, & Garbe, 1991). Systemic factors contributing to VAP include advanced age, compromised host, and the presence of congestive heart failure and hepatic/renal insufficiency.

Poor nutritional status is an independent risk factor for poor outcomes in ventilator associated patients. Malnutrition has been correlated with increased incidence of sepsis, prolonged ventilator dependence and increased mortality. Given that nutritional deficits have been reported in 35% of the elderly population, it is not surprising that nutritional modulation of immune function acting in concert with coexistent chronic diseases predisposes those for a worse prognosis (Reinhardt, Myscofski, Wilkens, Dobrin, Mangan, & Stannard, 1980).

Ford (2008) found that although the provision of mouth care has gained momentum, oropharyngeal morbidity can cause pain and disordered swallowing leading to reluctance in

commencing or maintaining an adequate dietary intake. The neglect of oral care, he found, can be detrimental to surgical outcomes.

The number of decayed teeth and the frequency of brushing teeth in conjunction with functional dependency for oral care have been significantly associated with VAP. Poor oral hygiene is common in the elderly population. Patients needing assistance in tooth brushing were found by Jette (2003) to have more plaque and gingivitis than those who brushed their own teeth. Similarly, Nakayama, Washio, & Mori (2004) found a high correlation between oral disease and dependence for activities of daily living, including self-care among older persons. Others have documented that a relatively large proportion of the independent and institutionalized, older adult population has dental disease and that they rarely seek dental services (Samaranayake, Wilkieson, Lamey & MacFarlane, 1995; Ettinger, Warren, Levy, Hand, Merchant, & Stromquist, 2004). Patients needing assistance with tooth brushing or oral care have been shown to have an increase in poor nutrition and malnutrition.

Bacterial flora in the oropharynx can be altered by severe underlying disease, inactivity, or malnutrition (Marshall, Warren, Hand, Xie, & Stumbo, 2002). A more direct cause of altered colonization in the oropharynx is the presence of oral or dental disease. The shedding of bacteria from the buccal mucosa, tongue dorsum, gingival sulcus, and the teeth is about tenth to eleventh power for bacteria per day. Plaque, gingivitis, periodontal disease and tooth decay will alter the flora within the mouth and could change the bacterial composition of saliva. Reduced salivary flow, a common side effect of many medications increase the concentration of bacteria in the saliva and if the saliva is aspirated or mixed with food or liquid, it changes to 100,000,000 bacteria/ml saliva that could enter the lungs. The saliva can then become problematic if it contains bacterial pathogens (Marshall, et al., 2002).

Strategies to Decrease Ventilator Associated Pneumonia

Critically ill adults have many needs related to physiological stability while hospitalized in an ICU. Intensive care unit nurses prioritize care related to immediate medical problems (Berry, et al., 2007; Fitch, et al., 1999). However, in addition to planning and delivering nursing care related to the medical reasons for admission, nurses have a responsibility to keep patients comfortable, prevent complications and maintain patients' functions at the highest level possible. Providing evidence-based strategies to prevent VAP should be a nursing goal. This includes providing the best oral care possible to patients.

Oral Assessment Tools. In 1977, Maurer wrote that the assessment tool for evaluating the general oral health of patients should state concisely the areas to be evaluated and the descriptive criteria to be used to show the changes from normalcy to deterioration that can occur if proper oral care is not provided. Twenty five years later, there is not a routine oral assessment tool utilized in most healthcare settings. Several studies have cited the ability to decrease VAP when oral assessment tools were implemented (Fitch, 1999; Moore, 1995; Fitch, Munro, Glass & Pelligrini, 1997). Developing an improved assessment tool for intubated patients was the purpose of Steifel, Damron, Sowers & Velez (2000) work.

A pilot study adapted Eller's (1988) oral assessment tool in order to improve oral hygiene and standardize procedures for intubated clients. The study was significant, although the sample size consisted of only eight patients. Treloar and Stechmiller (1995) developed an assessment tool for orally intubated clients. The sample size in their study was 16 and demonstrated that oropharyngeal cultures of 37.5% of orally intubated critical care patients grew nosocomial bacterial fungal pathogens and those same pathogens were cultured from sputum specimens. Thus, more serious nosocomial infections, such as VAP might be avoided by preventing

pathogen colonization of the oropharynx by better oral assessments. Kayser-Jones' oral assessment instrument was designed to for use in nursing home patients to improve oral assessments by nurses and nursing assistants. Utilization of the Kayser-Jones' (1995) oral assessment instrument in nursing home patients has shown to decrease the development of community acquired aspiration pneumonia.

An accepted oral health assessment tool or related instrument for use at the bedside is an important consideration (Binkley, Furr, Carrico & McCurren, 2004). Such an instrument reminds the bedside nurse to remember the issue of oral care, provides critical thinking cues as to who is at high risk for problems related to oral contamination, and provides a method for monitoring the effectiveness of interventions. The researchers surveyed 102 intensive care units within the United States with 556 respondents; 97% registered nurses. The participants in the study reported that despite efforts to perform oral care, the oral status of their patients continued to decline. The use of an oral assessment tool might avoid this problem (Binkley, Furr, Carrico & McCurren, 2004). Research has demonstrated that utilizing an oral assessment tool improves oral hygiene of patients; therefore, systemic oropharyngeal assessments in critically ill ventilated adult patients may prevent more serious infections such as VAP.

Chlorhexidine Use. Preventive strategies to reduce oral respiratory colonization and respiratory infections include selective oropharyngeal decontamination with topically applied antibiotics (Hutchins, et al., 2009; Munro, Grap, Jones, McClister & Sessler, 2009; Grap, Munro,Elswick, Sessler, & Ward, K. 2004. Bergman, Bonten, Gaillard, Paling, van der Geest, Van Tiel, et al., 2001; Abele-Horn, Dauber, Bauerfeind, Russwurm, Seyfarth-Metzger, Gleich et al., 1997; Pugin, Auckenthlaer, Lew & Suter, 1991), application of the antimicrobial agent chlorhexidine gluconate (DeRsio, Ladowski, Dillon, Justice & Peterson, 1996; Fourrier, Cau-

Pottier, Boutigny, Roussel-Delvaliez, Jourdain & Chopin, 2000; Genuit, Bochicchio, Napolitano, McCarter & Roghman, 2001) and toothbrushing combined with dental prophylaxis (Yoshida, Yoneyama & Aagawa, 2001; Coleman, 2002; Steifel, Damron, Sowers & Velez, 2000). Oral decontamination of mechanically ventilated adults using antiseptics was associated with a lower risk of VAP, although in Chan, Ruest, Meade & Cooke's (2007) literature review there was no reduction in mortality, duration of mechanical ventilation or stay in the intensive care unit. The use of topically-applied antibiotics has not been widely accepted because of concerns about the development of antibiotic resistance. Chlorhexidine is an easily applied and relatively inexpensive preventive measure with minimal side effects.

Studies have investigated the use of chlorhexidine gluconate as an adjunct to reducing nosocomial ventilator associated pneumonia (Berry, et al., 2007: Koeman, et al., 2006; DeRiso, et al., 1996; Houston, Hougland, Anderson, LaRocco, Kennedy & Gentry, 2002). In addition, the use of chlorhexidine has also been utilized in the elderly and to decrease the risk of developing pneumonia in the community (Clavero, Baca, Junco, & Gonzalez, 2003). Although there is concern regarding increasing antibiotic resistance, the most recent studies demonstrate improved outcomes with its use if the duration is limited (Berry, et al., 2007: Koeman, et al., 2006; Kollef, 2004).

Several clinical trials have utilized chlorhexidine in the following areas. Two studies in cardiovascular patients demonstrated a reduction in respiratory tract infections with the use of chlorhexidine gluconate before elective coronary artery bypass grafting procedures (DeRiso, Ladowski, Dillon, Justice & Peterson, 1996; Houston, Hougland, Anderson, LaRocco, Kennedy & Gentry, 2002). These researchers randomized ICU patients into one hundred and eighty treatment patients and one hundred and seventy three control patients. Patients rinsed with 0.12%

chlorhexidine twice daily in the treatment group and the control group received standard oral care. Results of the study demonstrated a 69% reduction in incidence of respiratory infection and a 43% reduction in intravenous antibiotic use.

In the Genuit, et al. study (2000), a prospective randomized intervention trial using chlorhexidine and a rapid weaning protocol was performed. There were 30 control subjects who received rapid weaning protocol intervention alone, and then 56 patients received rapid weaning and chlorhexidine 0.12% that was swabbed in the posterior oropharynx. A 75% reduction in late onset (5 days or greater) VAP developing after intubation was reported with a 43% reduction in mortality.

Ercole, et al. (2009) used chlorhexidine 0.12% with fifteen subjects compared to ten subjects in a control group which did not receive chlorhexidine after dental implant. Results showed that chlorhexidine appears to be an effective method for the reduction of bacterial colonization of the implant cavity and improves the health status of the peri-implant tissue. In a study by Heitz, Heitz-Mayfield & Lang (2004) post-surgical peri-implant patients were assigned to one of two groups. One group rinsed twice daily for 1 minute with 0.12% of chlorhexidine for 4 weeks and one group rinsed in addition to applying chlorhexidine gluconate locally using a special soft toothbrush. Both groups resulted in successful wound healing and optimal closure suggesting that the introduction of mechanical toothbrushing in addition to chlorhexidine gluconate may be recommended for decreasing post surgical infections and increasing wound healing. In another study of implant surgical patients, Francetti, Del Fabbro, Basso, Testori, Taschieri, & Weinstein (2004) indicated that chlorhexidine spray or mouth rinse significantly lowered dental plaque and improved dental wound healing.

In a study by Tantipong, Morkchareonpong, Jaiyindee, & Thamlikitkul (2008) conducted in Thailand; oral decontamination with 0.2% chlorhexidine solution was an effective and safe method for preventing VAP in patients who received mechanical ventilation. Of the 102 treated subjects, oropharyngeal colonization with gram negative bacilli was either reduced or delayed in the chlorhexidine treatment group. Chlebicki and Safdar's (2007) article on the use of chlorhexidine for prevention of VAP, which was a meta analysis review; stated that Koeman, et al., (2005) study was conducted in the Netherlands using a 0.2% chlorhexidine concentration. The higher chlorhexidine concentration in both these studies , may have partially explained the benefit of reducing VAP that was reported in both these studies.

In a randomized, double blind, placebo-controlled trial with three arms: chlorhexidine 0.12%, chlorhexidine 0.12% with colistin and a placebo conducted by Koeman, et al. (2006), 127 of the chlorhexidine treated patients and 128 of the chlorhexidine and colistin treated patients compared to the placebo group demonstrated a significant decrease in the development of VAP in both treatment groups compared to the control group. Hutchins, et al. (2009) conducted a quality improvement project in their facility between 2004 and 2007. Oral care was provided every four hours and the teeth were brushed with cetylpyridium chloride during the years 2004 and 2005. In 2007, the procedure was changed and they started using chlorhexidine 0.12% and a suction toothbrush to cleanse the oral cavity and applied mouth moisturizers as needed. In addition, deep oropharyngeal suctioning was performed and suction catheters were used to control secretions routinely. At the conclusion of their quality improvement project, VAP had been reduced 89.7% in their patient population following the addition of chlorhexidine 0.12%.

Chlorhexidine appears to be the most effective agent for the reduction of both plaque and gingivitis (Ciancio, 1991). Chlorhexidine is sold in the United States by prescription in a 0.12%

concentration as a mouth rinse, Peridex, which is approved by the Council on Dental Therapeutics of the American Dental Association (ADA). In Europe and other countries, chlorhexidine is available in a variety of concentrations, with 0.2% being most often used and is available as a mouth rinse and gel. Due to the availability of 0.12% chlorhexidine, which would not need FDA approval, the decision to use the ADA approved chlorhexidine concentration for this study was deemed the most appropriate.

Toothbrushing. Toothbrushing at least twice per day has been shown to reduce pneumonia in dependent nursing home patients and is also more cost-effective than routine use of foam swabs (Steifel, Damron, Sowers & Velez, 2000). Fitch (1999) performed a longitudinal intervention evaluation and observational study utilizing thirty patients in the treatment and control groups. Pediatric toothbrushes, toothpaste, ethyl alcohol-free antibacterial mouthwash, moisturizing gel to mucous membranes and petroleum jelly to the lips were applied every 12 hours. Results of the study showed decreased gingival inflammation and the nurses preferred the oral protocol to their previous standard routine.

The toothbrush has been shown to perform substantially better than foam swabs or toothettes in the ability to remove dental plaque and an electric toothbrush reduces plaque significantly better than manual toothbrushes (Pearson, 1996; Day, Martin & Chin, 1998). Electric or powered toothbrushes have also been shown to improve the quality of care and are easier to use than manual brushes when health care workers provide care for dependent patients (Day, Martin & Chin, 1998). In these studies, frequency of oral care ranged from 2 to 12 hours (Binkley, et al., 2004). Although some evidence-based oral care protocols and oral preventive care measures for VAP have been published, there is little information on current practices, oral care training, time, frequency, product and nurse's attitudes. In a systematic literature review by

Azarpazhooh and Leake (2006), they found good evidence (I, grade A recommendations) that improved oral hygiene reduces the progression or occurrence of respiratory diseases among high risk elderly adults in the ICUs.

Nursing Knowledge. A survey of oral care practices in the United States in intensive care units was conducted by Binkley, Furr, Carrico & McCurren (2004). Oral care methods were not consistent with current research and oral care protocols. The authors concluded that translation of oral care research into practice in the ICUs may improve the quality of care and decrease the incidence of VAP.

Wardth, Hallberg, Berggren, Anderson & Sorensen (2000) interviewed 22 nurses and reported that increasing nurses knowledge on oral hygiene was important to decreasing bacterial colonization. Paulsson, Soderfeldt, Nederfors & Fridlund (2002) reported that nurses did not consider oral hygiene an important aspect of nursing care. Furr, Binkley, McCurren & Carrico (2004) reviewed factors that affect the quality of oral care in ICUs. They concluded that improving the quality of oral care in intensive care units is a multi-layered task. Reinforcing proper oral care in education programs, de-sensitizing nurses to the often-perceived unpleasantness of cleaning oral cavities, and working with hospital managers to allow sufficient time to attend to oral care was recommended to decrease VAP and other respiratory infections.

At the Aga Khan University Hospital, six hundred and seventy-seven adult patients were included in the study that introduced evidence-based practice guidelines for preventive oral care practices at the bedside. VAP rates were reduced by 51% from a mean of 13.2 +/-1.2 in the pre-intervention period to 6.5+/-1.5/1000 device days in the post intervention period. The authors felt that a multidisciplinary education program geared towards ICU staff can successfully reduce the incidence rates of VAP (Salahuddin, et al., 2004).

Ross and Crumpler (2007) found that despite strong evidence in the literature on the role of oral care in the prevention of VAP, nurses continue to view oral care as a comfort measure with low priority and utilize foam swabs rather than toothbrushes. Additionally, Cason, et al. (2007) provided a 29-item questionnaire about the type and frequency of oral care provided to nurses attending education seminars in the United States. Twelve hundred nurses completed the questionnaire. The study found that nurses in hospitals with oral care protocols reported better compliance with hand washing, maintaining head-of bed elevation, were more likely to provide oral care, were more familiar with rates of ventilator-associated pneumonia and the organisms involved than were nurses working in hospitals without such protocols.

Therefore, a focused education intervention can dramatically decrease the incidence of VAP. Education programs should be more widely employed for infection control in the intensive care unit setting and could lead to substantial decreases in cost and patient morbidity attributed to hospital acquired VAP (Zack, et al., 2002).

Questionnaires were distributed and collected during the annual congress of the Flemish Society of Critical Care Nurses (Labeau, Vandijck, Blaes, VanAken & Blot, 2007). There were 855 registered participants, of which 638 completed the questionnaire. The results demonstrated that nurses valued non evidence based practice as much as they did evidence based nursing protocols. Therefore, nurses' lack of knowledge may be a barrier to adherence to evidence-based guidelines for preventing ventilator associated pneumonia.

Conclusion

Reducing the risk of bacterial colonization and ultimately aspiration into the lungs can help reduce aspiration pneumonia. 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 (Berry, et al., 2007). As stated, the limited number of randomized controlled trials conducted to reduce VAP. The effectiveness of oral hygiene and the use of antimicrobial agents appear to be promising; therefore, research in the area should be conducted. In addition, increasing nurses knowledge in these areas may help reduce the incidence. The CDC reports that aspiration of oral pharyngeal pathogens places patients at high risk for developing aspiration pneumonia and VAP. Interventions aimed at preventing bacterial colonization have not been well studied. Improving clinical knowledge and procedures may help establish education programs, oral assessment tools and procedures that will decrease the incidence of VAP. Integrating knowledge of best practices may also help to contribute standards for oral care of patients at risk of developing ventilator associated pneumonia.

Summary

This chapter has reviewed the current literature related to ventilator associated pneumonia, factors contributing to the incidence, recommendations from the Centers for Disease Control, the research gaps and the significance to nursing. Aspiration of contaminated secretions is the most likely cause of transmission of bacteria into the lungs, resulting in VAP in mechanically ventilated patients. The predominant use of foam swabs and no current evidence based oral protocols or oral assessment tools may indicate that the current oral care efforts are ineffective and should be studied further.

CHAPTER 3
METHODOLOGY

This study was designed to determine if there is a difference in the occurrence of ventilator associated pneumonia at 24 hours and 72 hours compared to baseline following implementation of three different nursing hygiene protocols. This study addressed two research questions: 1) Is there a difference in the three study groups related to oral pH, oral culture scores and CPIS scores at 24 and 72 hours compared to baseline, and 2) Do the number of decayed, missing and filled teeth, being edentulous and the presence of periodontal disease have an association with the development of ventilator associated pneumonia in critically ill adult patients?

The Clinical Pulmonary Infection Score (CPIS) includes: white blood cell count, temperature, tracheal secretions, oxygenation (calculated by PaO2/FiO2), chest radiograph and tracheal aspirates). The CPIS is a risk assessment and diagnostic tool developed by Pugin (1991) to identify patients at risk to develop VAP. This chapter is divided into four sections. In the first section, the sample of respondents is described. The study design and procedures used to collect the data are included in the second section of the chapter. The instrumentation section is described in the third section. The fourth section includes a description of the statistical analysis of the research questions used to guide the study.

Sample

Selection of research participants

Permission to conduct the study was first obtained through the Institutional Review Board of the University of Florida Health Science Center, Gainesville and Jacksonville. Following approval, a convenience sample of 109 patients was selected. A total of 85 critical care patients were enrolled in the study.

The sample consisted of 85 patients obtained from acute care not-for-profit facilities in the Northeast Florida area. Sample size was calculated using the correlation coefficient with an effect size estimated at 0.50, two-tailed alpha 0.05, and a beta of 0.20, power .80. This was chosen since the data collected was in a continuous format and a moderate effect size, 20%, would be observable. The effect size selected was to observe a decrease in CPIS < 6, indicating no VAP.

Inclusion criteria for the recruitment of participants included those who were anticipated to be orally intubated for greater than 72 hours and over the age of 18. This age group was chosen as those representing adults that would be admitted to an adult critical care unit. Subjects of any ethnic group or sex were included. Methods of recruitment included physician and nursing referrals. Exclusion criteria included the following: 1) admitting diagnosis of pneumonia, 2) nasally intubated patients, and 3) patients who were expected to be extubated in less than 24 hours such as those undergoing coronary artery bypass surgery. Attrition for statistical analysis were patients who were not orally intubated for 72 hours. The attrition rate for this study was 10%.

Characteristics of the Sample

Table 1 displays the admitting diagnosis for the study participants in each group. The effectiveness of chlorhexidine 0.12% to reduce the development of VAP and oral colonization has been documented in several research studies within limited patient populations, those being cardiovascular and surgical (Koeman, et al., 2006). The majority of subjects recruited for this study were from combined medical/surgical units. Patients in these units had high Apache II scores > 24, defining them as high risk. This is a typical ICU patient population in mixed medical/surgical units.

A total of 85 adults orally intubated, without an admitting diagnosis of pneumonia participated in the study. Forty-six were female and thirty-nine were male. They ranged in age from 22 to 92, with 44 (approximately 50%) between the ages of 39-68. Mean age was 57, with a standard deviation of 17.51. An additional 21 subjects were 69 years of age and over with three over the age of 85; one 87 years of age, one 88 years of age and one 92 years of age respectively. Fifteen subjects were 43 years of age or younger, the youngest being 22.years of age (Table 1). The subject's admitting diagnoses included cardiovascular, pulmonary, neurologic, gastroenteric, trauma, and general medical/surgical problems. In general there are eight categories of diseases and disorders that are regarded as justification for admission to an ICU, of which the above are listed (Lott, et al., 2009). (Table 3-1)

Additionally, over fifty-percent of the subjects had co-morbidities including a history of hypertension, diabetes mellitus, and coronary artery disease. Subjects in Group 1 and 2 had greater than fifty-percent of these co-morbidities, while the control group had twenty-percent.

Table 3-1. Descriptive Statistics of Study Participants

	Group 1	Group 2	Group 3	Mean	SD
Age, yr (mean)	63	60	57	57.11	17.51
Male sex	11 (29)	16 (31)	11 (25)		
Cardiovascular (MI, CABG, HTN)	8	2	3		
S/P Cardiac Arrest	2				
Pulmonary (Asthma, COPD)	7	5	5		
Neurologic (Altered mental status, CVA, S/P neurological surgery/interventional procedures	5	2	2		
Gastro enteric			1		
Trauma	1	1			
General Post Operative	2	12	4		
Sepsis		1			
Renal		1	1		
Metaboloic			1		
Hematologic (DIC, sickle cell crisis)	2		1		
Post Partum	1	1			
Mental Health			1		
Periodontal Dx		1			
Other	1	5	6		

Risk factors for development of VAP include changes in the oral cavity and dental health. Table 3-2 displays the modified oral assessment tool used to capture the subjects baseline oral and dental health related to decayed, missing or filled teeth, periodontal disease, dentures, edentulous, mucous membranes and lips.

Table 3-2. Modified Oral Assessment Tool

Teeth or Dentures		Mucous membranes		Lips	
Clean	1	Pink and moist	1	Smooth/moist	1
Plaque/debris in localized areas	2	Reddened/coated	2	Dry/cracked	2
Plaque/debris along gum line	3	White areas	3	Bleeding	3
lll fitting dentures/caries/missing teeth/ edentulous/ periodontal disease	4	Ulcerated/bleeding	4	Ulcerated	4

Study Design and Procedures

A quasi experimental randomized controlled clinical trial was performed. The study was prospective and longitudinal. Subjects were randomly assigned to one of three oral care hygiene groups; Group 1- chlorhexidine gluconate spray 0.12% twice daily at twelve hour intervals, Group 2- chlorhexidine gluconate 0.12% with toothbrushing twice daily at twelve hour intervals and Group 3- standard oral hygiene care with toothette foam swabs. Subjects were randomized utilizing a random tables generated by the Office of Research and Development in the Department of Nursing at the University of Florida.

The dependent variables were: oral pH, oral cultures, Clinical Pulmonary Infection Score (CPIS), which includes 1- white blood cell count, 2- temperature, 3- cultures of oral secretions, 4- oxygenation (calculated by PaO2/FiO2), 5- chest radiograph, and 6- tracheal aspirate culture. Additionally, the descriptive variable of number of decayed, missing, and filled teeth, (DMF scores) being edentulous and the presence of periodontal disease was assessed at baseline prior to the implementation of the study protocol. Other demographic variables collected included age, sex, and admitting diagnosis.

Measures

Oral pH. Actual oral pH was charted at baseline, 24 and 72 hours after implementation of study protocol. pH paper was used to document the oral pH in the right or left buccal area of the mouth. The primary investigator performed all measures. Confirmation of pH was done with the primary nurse assigned to the patient at the time of measurement.

Oral Culture. Utilizing Grap, Munro, Elswick, Sessler & Ward's (2004) analysis for oral cultures, oral cultures were assigned a (0-3) ranking, 0=no growth, 1= few, 2=moderate or 3=many/large. The analysis was performed by the microbiology department at the facilities. Each oral culture was observed by the same microbiologists to assure inter-rater reliability. These values were assigned by the microbiologists participating in the study.

Clinical Pulmonary Infection Score (CPIS). Each variable in the CPIS (temperature, white blood cell count, chest radiograph (radiologist's interpretation), tracheal secretions, oxygenation (calculated by PaO2/FiO2), and tracheal aspirate culture) was assigned points, and a total CPIS was calculated, with a final score ranging from 0-12. A score of 6 or more was considered to indicate risk for or diagnosis of pneumonia. The investigator assigned the CPIS score based on review of the medical record, attending physician and infectious disease physician chart notations and daily rounding.

Oral Assessment Tool. An oral assessment tool derived from Kayser-Jones (1995) and Treloar and Stechmiller (1995) was utilized to determine tooth loss, periodontal disease, moisture and dental caries on admission to the study. These oral assessment tools have shown a high rate of inter-rater reliability and validity in previous studies, 80% inter-rater reliability for both with $p<.001$. Validity for both instruments is from literature review and construct and face validity by dentists, nurses, and dental hygienists.

Assumptions of the Study

VAP risk and diagnosis is a condition that has been measured with the CPIS score. The clinical assessment of VAP is usually based on the presence of fever (core temperature of more than 38.3° C), blood leukocytosis (more than 10,000 per mm^3), or leukopenia (less than 4,000per mm^3), purulent tracheal secretions, and the presence of a new and/or persistent radiographic infiltrate. However, these parameters taken separately have limited diagnostic value (Fartoukh, et al., 2003). Pugin and colleagues (1991) combined body temperature, white blood cells count, volume and appearance of tracheal sections, oxygenation (PaO2/FiO2), chest X-ray, and tracheal aspirate cultures into a clinical pulmonary infection score (CPIS) as a diagnostic tool for pneumonia. They found that a CPIS of more than six was associated with a high likelihood of pneumonia with a sensitivity of 93% and a specificity of 100%. VAP risk in this study was diagnosed utilizing the CPIS score and the determination of the development of VAP was by independent infectious disease physicians' consults.

Demographic Variables. Demographic data was obtained from chart review and placed in a collection data format which included: age, gender and admitting diagnosis. Charts were reviewed for presence of illness or conditions that might contribute to poor oral health including DMF (decayed, missing or filled) teeth, being edentulous and presence of periodontal disease.

Procedures

After receiving approval from the Institutional Review Board of the hospital and the University of Florida, the investigator met with nursing staff and physicians from the facilities to inform them of the purpose of the study and data collection activities. The nursing staff received in-service training on how to perform the oral hygiene protocols, the use of the oral assessment instrument and utilization of the data collection tool. The researcher performed all the oral

assessments. To ensure consistency in nursing oral hygiene protocol interventions, the researcher observed the nurses performing the oral care interventions ensuring inter-rater reliability and consistency of application of chlorhexidine 0.12% via spray and rinse with toothbrushing. Documentation of oral care was placed on the medication administration record. A data collection tool was provided for the nursing staff to record initiation of the protocol and collection of descriptive data. Informed consent was obtained by the principal investigator when appropriate patients were identified. Once consent was obtained, a medical chart review was performed by the researcher to screen for inclusion and exclusion criteria. If the patient was eligible then the patient was randomized to a group, with baseline data obtained at that time by the researcher. The procedure for the oral assessment consisted of using an oral assessment tool adapted by the principal investigator derived from previous assessment tools noted in the literature (Treloar & Stechmiller, 1995; Kayser-Jones, Bird, Long & Schnell,1995). Oral assessments were performed by the researcher after randomization and before the initial oral hygiene intervention was performed. Table 3-2.

The inservice training of the nursing staff included the following:

1. Review of the oral assessment tool
2. Instruction for the oral hygiene protocols

Group 1 Procedure:

1. Set up suction equipment.
2. Position patient's head to the side and maintain in semi-fowler's position.
3. Don gloves.
4. Provide deep suction, as needed.
5. Assess oral cavity and document on oral assessment instrument (baseline, 24, and 72 hours).
6. Obtain oral pH with litmus paper placed on inside of right or left cheek (baseline, 24 and 72 hours).
7. Obtain oral and sputum cultures (baseline, 24 and at 72 hours).
8. Suction oral cavity as necessary.
9. Apply chlorhexidine spray 0.12% inside mouth applying to all teeth and gum surfaces.
10. Apply lip moisturizer if needed.

11. Document on data collection form.

Group 2 Procedure

1. Set up suction equipment.
2. Position patient's head to the side and maintain in semi-fowler's position.
3. Don gloves.
4. Provide deep suction, as needed. Assess oral cavity and document on oral assessment instrument (baseline, 24 and 72 hours).
5. Obtain oral pH with litmus paper placed on inside of right or left cheek (baseline, 24 and 72 hours).
6. Obtain oral and sputum cultures (baseline, 24 and at 72 hours).
7. Suction oral cavity as necessary.
8. Apply chlorhexidine 0.12% to pediatric toothbrush.
9. Brush teeth using a small, soft pediatric toothbrush.
10. Brush teeth for approximately 1-2 minutes, using gentle pressure in short horizontal and circular strokes and brushing all teeth and gum areas.
11. Gently brush tongue.
12. Apply lip moisturizer if needed.
13. Document on data collection form.

Group 3 Procedure

1. Follow hospital policy and procedure or unit protocol for oral hygiene.
2. Assess oral cavity and document on oral assessment instrument (baseline, 24 and at 72 hours).
3. Obtain oral pH with litmus paper placed on inside of right or left cheek (baseline, 24 and 72 hours).
4. Obtain oral and sputum cultures (baseline, 24 and at 72 hours).
5. Document on data collection form.

3- Review of Protection of Human Subjects

Patients charts were identified through a color coded protocol driven sheet so all staff were aware that the patient was involved in a research study and which protocol to use. The principal investigator, along with the nurse managers of each unit, ensured that the protocols were followed. In addition, the principal investigator rounded daily to ensure that protocols as defined were being followed.

Statistics

Data obtained from the daily assessments were transcribed onto a data collection form formulated specifically for this study. See appendix. All participant data, forms, study results and

informed consents were kept confidential and secured in a locked file during every phase of the study. An informed consent was placed in the medical record and a copy was provided to the patient and/or party authorized to provide consent, usually a family member. No participant or their family requested that they be removed from the study. Data was entered onto an excel spreadsheet and then statistical software (SPSS) for analysis using standard procedures was used. There were three serious adverse events reported to the IRB, none were deemed associated with the research study.

Descriptive analyses were done on the demographic data to determine number and characteristics of the sample that were evaluated at baseline and on the study variables including oral pH, oral culture scores, and CPIS scores. Analysis of variance was used to determine if the observed differences among the groups' set of means would be greater than expected by chance alone. Continuous data analysis and repeated measures analysis was used for categorical data. Descriptive statistics to define group characteristics is provided.

CHAPTER 4
RESULTS

This study was designed to determine if there is a difference in the occurrence of ventilator associated pneumonia at 24 hours and 72 hours compared to baseline following implementation of three different nursing oral hygiene protocols. The first research question was to determine if there were no differences at 24 and 72 hours compared to baseline in the three study groups related to oral pH, oral culture scores and CPIS. The hypothesis; Ho1: There will be no differences at 24 hours and at 72 hours compared to baseline in the three study groups related to oral culture scores, oral pH, and CPIS scores.

The secondary research question was to determine if the number of decayed, missing and filled teeth, being edentulous and having periodontal disease have an association with the development of ventilator associated pneumonia in critically ill adult patients. The hypothesis Ho2: There will be no association between the number of decayed, missing and filled teeth, being edentulous, the presence of periodontal disease and the development of ventilator associated pneumonia in critically ill adult patients.

A description of the oral pH scores with means and standard deviations for the three groups at baseline, 24 hours and 72 hours are presented in Table 4-1.

Table 4-1. Oral pH means and standard deviations at baseline, 24 hours and 72 hours

	Oral pH Mean /SD at baseline	Oral pH Mean /SD at 24 hours	Oral pH Mean /SD at 72 hours
Group1	6.48/0.602	6.48/0.607	6.47/0.597
Group 2	6.53/0.618	6.56/0.495	6.51/0.564
Group 3	6.60/0.612	6.50/0.661	6.56/0.557

Oral pH levels at baseline and differences at 24 hours and 72 hours compared to baseline after intubation were comparable in all 3 groups and differences were not statistically significant. (Table 4-2).

Table 4-2. Oral pH differences between groups at baseline, 24 hours, and 72 hours.

		Oral pH baseline to 24 hours between groups		Oral pH baseline to 72 hours between groups	
Group 1		p=0.589		p= 0.713	
Group 2		p=0.3392		p=0.3256	
Group 3		p=0.7514		p=0.3067	
Oral pH	df	Sum of Squares	Mean Squares	F value	Significance
between groups	2	0.446	0.223	0.72	p=0.4904

Oral Cultures scores were performed utilizing Grap, et al. (2004) analysis for oral cultures. Oral cultures were assigned a (0-3) ranking, 0=no growth, 1= few, 2=moderate or 3=many/large. Mean and standard deviation results for the three groups at baseline, 24 hours and 72 hours are shown in Table 4-3.

Table 4-3. Oral culture score means and standard deviations for each group at baseline, 24 hours and 72 hours.

	Oral culture scores at baseline Mean/SD	Oral culture scores at 24 hours Mean/SD	Oral culture scores at 72 hours Mean/SD
Group 1	1.862/1.381	1.172/1.255	1.480/1.194
Group 2	1.516/1.287	1.419/1.232	1.375/1.209
Group 3	1.480/1.194	1.225/1.175	1.208/1.120

Overall differences in oral culture scores between the three groups at 24 and 72 hours compared to baseline were analyzed and found to be statistically significant at 24 hours (p=0.0001) and 72 hours (p=0.0005). Statistically significant oral culture scores occurred at 24 hours and 72 hours compared to baseline in the intervention groups indicating a possible benefit in the prevention of VAP with chlorhexidine spray 0.12% and chlorhexidine 0.12% and toothbrushing (group 1 (p=0.045, p=0.0082) and (group 2 (p=0.0082, p= 0/0047). The control

group's differences in oral culture scores were not statistically significant at 24 hours and 72 hours compared to baseline (p=0.1797, p=0.1028) (see Table 4-4).

Table 4-4. Differences in Oral Culture Scores between groups at 24 hours and 72 hours compared to baseline

	Oral culture scores at baseline	Oral culture scores at 24 hours	Oral culture scores at 72 hours
Group 1	10 of 29 (34.5%)	6 of 29 (20.7%)	1 of 24 (4.2%)
	Comparison to baseline	S = 4 p = 0.0455*	S = 7 p = 0.0082*
Group 2	13 of 31 (41.9%)	4 of 28 (14.3%)	2 of 24 (8.3%)
	Comparison to baseline	S = 7 p = 0.0082*	S = 8 p = 0.0047*
Group 3	10 of 25 (40%)	7 of 23 (30.4%)	5 of 21 (23.8%)
	Comparison to baseline	S = 1.8 p = 0.1797	S = 2.67 p = 0.1025
Overall	33 of 85 (38.8%)	17 of 80 (21.2%)	8 of 69 (11.6%)
	Comparison to baseline	S = 17.19 p < 0.0001*	S = 12.25 p = 0.0005*

Oral cultures were performed and results indicated that potential VAP pathogens were found in 13 of the 85 subjects either in oral or endotracheal cultures at baseline (Table 4-5). Of the 13 positive oral cultures for potential VAP pathogens at baseline, the same pathogen was found in both oral and endotracheal cultures consistently across subjects. The potential VAP pathogens that were found at baseline included, methicillin-resistant Staphylococcus aureus (MRSA), Pseudomonas aeruginosa, Staphylococcus aureus, Streptococcus pneumoniae, Moraxella catarrhalis, and Acinetobacter baumanii. Of these 13 positive cultures, six subjects were considered by the CPIS score as having VAP (CPIS >6), but clinical correlation by radiograph and infectious diseases consultation concluded that the patients were not considered to have clinically developed VAP. The 13 subjects with VAP pathogens at baseline, (six in group 1, three in group 2 and four in group 3) did not have these pathogens present at 24 and 72

hours, demonstrating a possible correlation of the intervention to prevention of VAP. Differences in oral culture scores demonstrated an apparent trend for the percentages in each group to decline over time, and this trend seemed stronger in the intervention groups than in the control group. A description of the oral culture pathogens present and CPIS scores with means and standard deviations for the three groups at baseline, 24 hours and 72 hours are presented in Table 4-5.

Table 4-5. A Description of Pathogens Present at Baseline according to CPIS Score and Actual Development of VAP at 72 hrs.

	Virulent Pathogens Present at Baseline	CPIS Score at Baseline	Actual Development of VAP at 72 hours
Group 1	1- Pseudonomas	10	No
	2- MRSA	9	No
	3- Staph Aureus	9, 6	No, No
	4- Strep Pneumonia	3	No
	5- Acinobacter	2	No
Group 2	1- Moraxella	7	No
	Catarrhais	7	No
	2- Staph Aureus	5	No
	3-MRSA		
Group 3	1-Staph Aureus	7	No
	2- MRSA	5,4, 3	No, No, No

A description of the CPIS scores with means and standard deviations for the three groups at baseline, 24 hours and 72 hours are presented in Table 4.6. No statistically significant differences in CPIS scores occurred in group 1 at 24 hours and 72 hours compared to baseline (p= 0.7868, p=0.8462) or for group 3 (p=0.6017, p=0.3151); but group 2 (p=0.545, p=0.0428) was statistically significant at 72 hours, indicating a possible benefit in preventing VAP in the chlorhexidine 0.12% and toothbrushing group (Table 4-7 and 4-8).

Table 4-6. CPIS score means and standard deviations between groups at baseline, 24 hours and 72 hours

	CPIS score Mean /SD at baseline	CPIS Mean /SD at 24 hours	CPIS Mean /SD at 72 hours
Group 1	5.137/2.35	5.172/2.17	4.880/2.14
Group 2	5.129/1.70	5.172/2.17	5.00/1.84
Group 3	5.120/1.39	5.227/1.47	5.190/1.56

Table 4-7. Oral culture pathogens present and CPIS score Means/SD scores at baseline, 24 hours and at 72 hours

	CPIS Mean /SD baseline	Pathogens Present	CPIS Mean /SD at 24 hours	Pathogens Present	CPIS Mean /SD at 72 hours	Pathogens Present
Group 1	5.137/2.35	1- Staph Aureus 2- Strep Pneumonia 3- Pseudomonas 4- Staph Aureus 5- Acinetobacter 6-MRSA	5.172/2.17	none	4.880/2.14	none
Group 2	5.129/1.70	1- MRSA 2- Moraxella Catarrhais 3- Staph Aureus	5.172/2.17	none	5.00/1.84	none
Group 3	5.120/1.39	1-Staph Aureus 2- MRSA 3- MRSA 4- MRSA	5.227/1.47	none	5.190/1.56	none

Considering using tooth condition, the number of decayed, missing and filled teeth, and the relationship to developing VAP was also analyzed. A score on the oral assessment tool of 12 or below was considered low risk and a score greater than 12 was considered high risk. Group 1 had 13 subjects in the low risk group and 16 in the high risk group, group 2 had 19 subjects in the low risk group and 12 subjects in the high risk group, and group 3 had 13 subjects in the low

risk group and 12 subjects in the high risk group (Table 4-9). Based on the relationship of tooth condition and oral assessment to determine VAP, patients in the high risk group had a 19.51% greater chance of developing VAP than the low risk group. Subjects who were considered at high risk were those subjects with periodontal disease, greater than four missing teeth, decayed or filled teeth, and those who were edentulous. These patients were compared to those with less than four missing, decayed, or filled and who were not edentulous and who did not display periodontal disease; this was shown to be statistically significant (p=.0057) (Table 4-10).

Table 4-8. CPIS Scores for each group at 24 and 72 hours compared to baseline.

	CPIS score at 24 hours compared to baseline	CPIS score at 72 hours compared to baseline
	F(2,77)=0.26 p value=0.7700	F(2,67)=1.00 p value=0.3743
Group 1	n = 29, M = 0.035 S = 0.681, t = 0.27 p value = 0.7868	n = 25, M = -0.04 S = 1.020, t = -0.20 p value = 0.8462
Group 2	n = 29, M = -0.086 S = 0.7567, t = -0.61 p value = 0.545	n = 24, M = -0.500 S = 1.142, t = -2.14 p value = 0.0428*
Group 3	n = 22, M = -0.136 S = 1.2069, t = -0.53 p value 0.6017	n = 21, M = -0.286 S = 1.271, t = -1.03 p value = 0.3151
Between Groups	F(2,77) = 0.26, p value = 0.77	F(2,67) = 1.0 p value = 0.374

Table 4-9. Oral assessment scores for high and low risk for poor oral health for each group on admission

	Low Risk Poor Oral Health Patients on Admission: No periodontal disease, less than 5 missing, decayed or filled teeth and not edentulous	High Risk Poor Oral Health Patients on Admission: Presence of periodontal disease, greater than 4 missing, decayed or filled teeth, edentulous
Group 1	n=13	n=16
Group 2	n=10	n=12
Group 3	n=13	n=12

Table 4-10. The relationship of tooth condition and oral assessment with CPIS score to determine risk of VAP at 72 hours compared to baseline

	N	CPIS VAP at 72 hours	
Group 1 (good oral health)	37		0.0%
Group 2 (bad oral health)	33		19.51%
	DF	Value	Probability
Chi-Square	12	8.0466	0.0046

P<= 0.0057

CHAPTER 5
DISCUSSION

Ventilator associated pneumonia (VAP) is the most frequently occurring nosocomial infection associated with increased morbidity and mortality of patients in intensive care units. (Koeman, et al., 2006). Although oral decontamination with chlorhexidine has been shown in some studies to reduce the risk of VAP, there have been few randomized controlled trials to support its effectiveness. VAP is a condition that has been measured with the clinical pulmonary infection score (CPIS) risk tool developed by Pugin and colleagues (1991) which combines body temperature, white blood cells count, volume and appearance of tracheal sections, oxygenation (PaO2/FiO2), chest X-ray, and tracheal aspirate cultures as a diagnostic tool for pneumonia. They report that a CPIS score of six or more was associated with a high likelihood of ventilator associated pneumonia. This study was designed to determine if there is a difference in the occurrence of ventilator associated pneumonia at 24 hours and 72 hours compared to baseline following implementation of three different nursing oral assessment and hygiene protocols including chlorhexidine spray 0.12%, chlorhexidine 0.12% and toothbrushing and standard or usual oral care using foam swabs (toothettes) with a variety of oral rinses.

This study addressed two research questions: Is there a difference in the three study groups related to oral pH, oral culture scores and CPIS scores at 24 and 72 hours compared to baseline, and Do the number of decayed, missing and filled teeth, being edentulous and the presence of periodontal disease have an association with the development of ventilator associated pneumonia in critically ill adult patients? Eighty-five patients were randomized and assigned into three groups, group 1(n=29) received chlorhexidine spray 0.12%, group 2 (n=31) received chlorhexidine 0.12% and toothbrushing and group 3 (n=25) received standard or usual oral care using foam swabs (toothettes) with a variety of oral rinses.

No statistically significant differences in oral pH values occurred between the three groups. Statistically significant decreased oral culture scores occurred at 24 hours and 72 hours compared to baseline in the intervention groups indicating a possible benefit in the prevention of VAP using chlorhexidine spray 0.12% or chlorhexidine 0.12% and toothbrushing, group 1 ($p=0.045$, $p=0.0082$) and group 2 ($p=0.0092$, $p= 0.0047$). No statistically significant differences in CPIS scores occurred in group 1 at 24 hours and 72 hours compared to baseline ($p=0.7868$, $p=0.8462$) or group 3 ($p=0.6017$, $p=0.3151$) but group 2 ($p=0.545$, $p=0.0428$) was significant at 72 hours compared to baseline, again indicating a possible benefit in preventing VAP in the chlorhexidine 0.12% and toothbrushing group. Chlorhexidine appears to have an excellent antibacterial effect on gram negative oral pathogens (Koeman, et al., 2006). While chlorhexidine has been used in healthy patients as a daily oral rinse to control plaque and to prevent gingivitis, studies to determine its effectiveness on critically ill subjects has been limited. In addition, although studies in other populations have compared chlorhexidine rinses with swab administration and found equal efficacy, there has not been a published study comparing two different modes of applications of chlorhexidine 0.12% and its effectiveness to prevent or decrease VAP.

This study showed that thirteen subjects admitted to ICUs in the Northeast Florida area had virulent oral pathogens present at baseline (less than 24 hours after hospital admission and oral intubation) and were identified as high risk for development of VAP. These oral pathogens included methicillin-resistant Staphylococcus aureus (MRSA), Pseudomonas aeruginosa, Staphylococcus aureus, Streptococcus pneumoniae, Moraxella catarrhalis, and Acinetobacter baumanii. Additionally, risk for VAP using the modified oral assessment tool (Kayser-Jones, Bird, Long & Schnell, 1995; Treloar & Stechmiller, 1995) was statistically significant for

subjects with periodontal disease, greater than 4 missing, decayed or filled teeth and those who were edentulous at baseline. When using poor oral health and tooth condition as a risk factor for the development of VAP, subjects with periodontal disease, greater than 4 missing, decayed or filled teeth, and those who were edentulous were at higher risk ($p=0.0057$) to develop VAP. There is a firm body of evidence that oropharyngeal colonization is pivotal in the pathogenesis of VAP. More than 25 years ago, Johanson, et al., (1972) described the association between increasing severity of illness, higher occurrence of oropharyngeal colonization and the increased risk to developing VAP. This study demonstrated that VAP pathogens were present on admission especially in patients with poor oral health. Earlier studies, (Horan, et al., 1986; Johanson, et al., 1988) had shown a change in the oropharyngeal flora within 48 hours of admission to the intensive care units; however, this study data supports that of Grap, Munro, Elswick Sessler & Ward's (2004) that virulent VAP pathogens may be present in the oral cavity earlier than previously documented.

Considerable evidence exists to support a relationship between poor oral health, the oral microflora and bacterial pneumonia, especially ventilator-associated pneumonia. Teeth or dentures have nonshedding surfaces on which oral biofilms (that is, dental plaque) form that are susceptible to colonization by respiratory pathogens. Subsequent aspiration of respiratory pathogens shed from oral biofilms into the lower airway increases the risk of developing a lung infection. In addition, patients may aspirate inflammatory products from inflamed periodontal tissues into the lower airway, contributing to lung insult (Scannapieco & Rathman, 2003). This study supports these previous findings and suggests that identification of high risk patients and early oral care interventions may prove to decrease VAP.

Oral care assessment tools are also not routinely utilized in critical care. While some mention of the mouth may be documented on nursing flow sheets, a routine oral assessment is not common practice. As this study indicates, patients on admission with poor oral health were at higher risk to developing VAP. The use of a routine oral assessment tool on admission may help to direct nurses to identify and intervene earlier in the prevention of VAP in high risk patients. Clinicians should use oral health assessment tools to determine individual treatment and approaches to promote oral health. Garcia, et al. (2009) implemented a comprehensive oral and dental care system and protocol in their facility. Patients whose oral cavity was assessed, along with other interventions such as toothbrushing, had a reduction in the development of VAP and a decrease in mechanical ventilation and length of stay in the ICU. In addition, mortality was decreased. Therefore, the use of a valid oral assessment tool in coordination with an effective oral hygiene protocol could significantly reduce costs and decrease mortality in critically ill adults in the ICU.

Interestingly, study findings indicated that none of the patients in groups 1, 2 & 3 developed a documented VAP during the study duration (years 2006-2009). The determination of VAP was independently validated by board certified infectious disease physicians employed by the critical care medicine service at the study sites. This finding may be due to the increased attention to oral care as a result of the implementation of this study. Contamination of the control group was unpreventable and the nursing staff became more aware of oral assessment and oral care using chlorhexidine 0.12%. During the study, all subjects were provided the preventive strategies recommended by the Institute for Healthcare Improvement (IHI) for VAP prevention (the VAP Bundle). These included: semi recumbent positioning (not less than 30°), daily "sedation vacations," an assessment of readiness to be extubated, deep vein thrombosis

prevention, and peptic ulcer disease prophylaxis. Additionally, all subjects were orally intubated, had a gastric tube (placed orally) to help prevent aspiration of gastric contents, and the majority had endotracheal tubes with a sideport for continuous oral secretion evacuation.

Study Limitations

This study was conducted in two not for profit facilities in Northeast Florida and cannot be generalized to other populations. While the aim was to include all consecutive subjects identified for inclusion, actual recruitment depended on the willingness of physicians, patients and patient families' informed consent; therefore, the sample size was small. Additionally, the prediction of whether a patient was expected to remain intubated for more than 48 hours was left to the discretion of the responsible physician.

The development of documented VAP was consistently documented in both facilities by independent infectious disease physician consultants. While several patients would have been considered to be positive for VAP, according to Pugin's criterion, no patients in the study were documented as developing VAP. Others reviewing this data may consider this a conflict of interest, but since VAP had been previously recorded in these intensive care units by the same physicians and reported through their infectious disease divisions, this was considered appropriate for this study. Although the CPIS has good reliability and acceptable sensitivity and specificity, articles by Rea-Neto, et al., (2006) and Swoboda, Dixon & Lipsett, (2006) both state that better strategies should be developed for identification of pneumonia in the ICU than just using CPIS. The authors stated that an integrated approach should be followed in diagnosing and treating patients with the risk for and diagnosis of VAP and should include clinical response and results of bacteriologic cultures. Swoboda, Dixon, & Lipsett (2006) stated that a pneumonia

review committee of physicians resulted in fewer patients believed to have had pneumonia than was identified using the CPIS. This also supports the results of this study.

This study only examined the first four days of intensive care and the development of VAP. There is an increasing desire to determine whether present strategies to prevent VAP are effective in the prevention of late onset VAP.

Daily notation of the maintenance of the Institute for Healthcare Improvements (IHI) VAP Bundle was recorded. The IHI bundle included daily breaks from sedation if stable, daily assessment of readiness to extubate, prophylaxis for peptic ulcer disease, deep vein thrombosis prophylaxis and elevation of the head of the bed at or equal to 30 degrees. In addition, whether an endotracheal tube with a subglottic side port for continuous low suction was in place was recorded. These two unit protocols were already established in the units to prevent the development of VAP prior to the start of the study and continued through the study's implementation. Most subjects in the study had a dual lumen side port endotracheal tube in place for continuous low suction. It should also be noted that during the last months of the study, the majority of subjects were recruited from the medical/surgical intensive care unit, which had a previously documented VAP rate of 7.09 using rates per 1,000 patient days and ventilated days. During the study and for the next three months after subject recruitment was closed, the VAP rate remained at zero.

Another limitation of the study could have been this researcher's daily presence in the intensive care units involved in the study and interaction with the multidisciplinary teams involved in patient care. Nurses, physicians, respiratory therapists and any other direct caregivers were instructed on the study design and its study aims. A recent article by Ross and Crumpler (2007) discussed the impact of an evidence-based practice education program on the role of oral

care in the prevention of VAP. The study suggested that although an evidence-based oral care protocol existed prior to the study start and best practice oral care tools were available, the VAP rates had not significantly decreased even though nurses reported providing oral care. The nursing staff received an educational inservice program prior to implementation of the study regarding the importance of oral care and all protocol interventions that would be investigated. The direct care nurses were involved in data documentation and received monthly quality improvement reports on the unit's VAP incidence at staff meetings. After the first month of no patients developing VAP, the unit-based nursing staff became even more engaged in the study and were excited to see the difference in patient outcomes. This may have made them more vested in the positive patient outcomes observed and reported. This may be evident by the results of the patients in the standard unit protocol group who also did not develop VAP during the study.

Recommendations for Further Research and Education

Links continue to be made between oral health and the development of VAP, although establishing cause and effect can be complex and confounded by a myriad of variables. Additionally, even in the reported randomized controlled trials, different products, different strengths of chlorhexidine, different applications and different timing intervals are noted. Therefore, to continue to build the scientific evidence necessary to determine best oral care interventions, additional randomized controlled trials must be conducted, with large sample sizes and replicating previous study designs.

The lack of published protocols for oral care in intubated patients has been noted in the clinical nursing literature (Anderson & Lester, 1999). During the first 24 to 48 hours of admission to critical care units, nurses' attention is usually focused on physiological stability and

oral care may not be seen as a priority. Therefore, evidence-based education regarding the importance of oral care and its relationship to the reduction of VAP in critically ill patients is clinically significant.

Research should proceed on the implementation and evaluation of effectiveness of oral care assessment tools. A cost/benefit ratio may be obtained if patients' oral cavities are routinely assessed on admission and patients at high risk have evidence based oral hygiene protocols implemented quickly. A reduction in mortality, length of ventilation and morbidity should be evaluated using a validated tool. Presently, there are no consistent oral assessment tools being utilized in acute critical care units. All assessment tools reviewed have guides using a three or four-point numerical and descriptive scale, with low scores representing best oral cavity health. Information obtained from studies using oral assessment tools could further guide nursing practice.

Oral care is usually documented in the nursing notes of most patients. During this study, with the help of the pharmacists at both facilities, oral care intervention with chlorhexidine 0.12% and the appropriate protocol was documented on the medication administration record. All nurses commented on this as a positive reinforcement and they felt this also improved compliance in providing oral care at the appropriate timed intervals.

Conclusions

Although colonization of dental plaque with respiratory pathogens correlates with occurrence of ventilator associated pneumonia, nursing oral care protocols based on research studies for best practice are limited. Therefore, oral care is often performed according to individual preferences, unit protocols and historical patterns. It is important then that nurses continue to research this clinical issue. In addition, only a few studies have addressed nurses'

perceptions of the importance of oral hygiene and the barriers that prevent adherence to evidence based protocols so further research in this area is also needed.

Therefore, ongoing research should address the following: 1) well designed clinical trials to determine the most effective product, time interval and solution strength for patients receiving mechanical ventilation, 2) development of a standardized oral assessment tool not only for research but also for assessing patients, evaluating practice and improving the quality of care, and 3) assessment of nurses' perceptions and knowledge about the importance and possible benefits related to oral care and the development of VAP in critically ill adult patients.

APPENDIX
DATA COLLECTION TOOL

Questions? Call Peggy McCartt, RN, PhD (c), CCRN, ARNP (904) 501-3364

Apply Patient Label

Group 2 Protocol Initial after X in box when complete	Baseline	24 hours	72 hours	Yes/No/ Comments
Date:				
a) Verify/obtain consent from family/patient before starting	X			
b) Set up suction equipment				
c) Position patient's head to the side or in semi-fowler's position				
d) Suction as needed				
e) Obtain oral pH inside right or left cheek- document once daily	X	X	X	
f) Obtain oral culture/swab and sputum culture via ET tube- send lab research slips with specimen once daily	X	X	X	
g) Brush teeth/tongue with pediatric toothbrush and chlorhexidine rinse 0.12% for approximately 1-2 minutes, using gentle pressure in short horizontal and circular strokes twice a day (twelve hours apart) for the next three days- chart on Medication Administration Record and this form	X X	X X	X X	
h) Apply lip moisturizer if necessary				
i) Mark on this form as completed				

LIST OF REFERENCES

Abele-Horn, M., Dauber, A., Bauernfeind, A., Russwurm, W., Seyfarth-Metzger, I., Gleich, P. & Ruckdeschel, G. (1997). Decrease in nosocomial pneumonia in ventilated oropharyngeal patients by selective oropharyngeal decontamination. *Intensive Care Medicine,* 23, 187-195.

Anderson J, & Lester J. (2009). Can a patient who has an endotracheal tube and is on mechanical ventilation be given ice chips? *Critical Care Nurse,* (19), 95–96.

Aspiras, M., Stoodley, P., Nistico, L., Longwell, M. & deJager, M. (2010). Clinical implications of power toothbrushing on fluoride delivery: effects on biofilm plaque metabolism and physiology. *Infectious Journal of Dentistry,* April 2010, 651-689.

Azarpazhooh, A. & Leake, J.L. (2006). Systematic review of the associate between respiratory diseases and oral health. *Journal of Periodontology,* 77 (9), 1465-1482.

Baine, W., Yu, W. & Summe, J. (2001). Epidemiologic trends in the hospitalization of elderly Medicare patients for pneumonia, 1991-1998. *American Journal of Public Health,* 91 (7), 1121-1130.

Bartlett, J., Breiman, R., Mandell, L. & File, T. (1998). Community-acquired pneumonia in adults: guidelines for management. The infectious diseases society of America. *Clinical Infectious Diseases,* 26 (4), 811-38.

Bauer, T., Torres, A., Ferrer, R., Heyer, C., Schultze-Weninghaus, G. & Rasche, K. (2002). Biofilm formation in endotracheal tubes. Association between pneumonia and the persistence of pathogens. *Monaldi Archives of Chest Disorders*, 57 (1). 84-87.

Bergman, D., Bonten, M., Gaillard, C., Paling, J., van der Geest, S., Van Tiel F. (2001). Prevention of ventilator-associated pneumonia by oral decontamination: a prospective, randomized, double-blind, placebo-controlled study. *American Journal Respiratory Critical Care Medicine,* 164, 282-288.

Berry, A., Davidson, P., Masters, J. & Rolls, K. (2007). Systematic literature review of oral hygiene practices for intensive care patients receiving mechanical ventilation. *American Journal of Critical Care,* 16 (6), 552-562.

Bert, F. & Lambert-Zechovsky, N. (1996). Sinusitis in mechanically ventilated patients and its role in the pathogenesis of nosocomial pneumonia. *European Journal of Clinical Microbiology and Infectious Disease.* 15 (7), 533-544.

Binkley, C., Furr, L.A., Carrico, R. & McCurren, C. (2004). Survey of oral care practices in united states intensive care units. *American Journal Infection Control,* 32, 161-169.

Bonten, M., Gaillard, C., de Leeuw, P. (1996). Role of colonization of the upper intestinal tract in the pathogenesis of ventilator-associated pneumonia. *Clinical Infectious Disease,* 24, 309-319.

Bouza, E. & Burillo, A. (2009). Advances in the prevention and management of ventilator-associated pneumonia. *Current Opinion Infectious Diseases,* (4), 345-351.

Brooks, N. (2001). Length of stay in community hospitals. *Nursing Standards.* 15 (27), 33-38.

Bryan, J. (2003). Clinical management. takes your breath away. *Health Services Journal,* 113 (5871), 31.

Cao, S., Progulski-Fox, A., Hillman, J & Handfield, M. (2004). In vivo induced antigenic determinants of actinobacillus actinomycetemcomitans. *FEMS Microbiology Letter*. 237 (1), 97-103.

Cason, C., Tyner, T., Saunders, S. & Broome, L. (2007). Nurses' implementation of guidelines for ventilator-associated pneumonia from the centers for disease control and prevention. *American Journal of Critical Care,* 16, 28-37.

Centers for Disease Control. (2004). Community preventive services. U.S. department of health and human services. www.cdc.gov (Nov 2009).

Centers for Disease Control and Prevention. (2004). An overview of ventilator-associated pneumonia. U.S. department of health and human services. www.cdc.gov. (Nov 2009).

Chan, E. Y., Ruest, A., Meade, M.O. & Cook, D. (2007). Oral decontamination for prevention of pneumonia in mechanically ventilated adults: a systematic review and meta-analysis. *British Medical Journal,* 334 (7599) 861-862.

Chastre, J. & Fagon, J. (2002). Ventilator-associated pneumonia. *American Journal Respiratory Critical Care Medicine,* 165 (7), 867-903.

Chlebicki, M. J. & Safdar, N. (2007). Topical chlorhexidine for prevention of ventilator-associated pneumonia: a meta-analysis. *Critical Care Medicine,* 35, 595-601.

Chulay, M. (2008). Ventilator associated pneumonia. aacn practice alert. *American Association of Critical Care Nurses.*

Ciancio, S.G. Agents for the management of plaque and gingivitis. (1992). *Journal of Dental Research,* 71, 1450-1454.

Clavero J, Baca P, Junco P, & González, M. (2003). Effects of 0.2% chlorhexidine spray applied once or twice daily on plaque accumulation and gingival inflammation in a geriatric population. Journal of Clinical Periodontology, 30 (9),773-777.

Coleman, P. (2002). Improving oral health care for the frail elderly: a review of widespread problems and best practices. *Geriatric Nursing,* 23, 189-199. Congress. 107th session. (2001). A bill to expand the availability of oral health services by strengthening the dental workforce in designated underserved areas.

Craven, D. & Driks, M.R. (1987). Nosocomial pneumonia in the intubated patient. *Seminar in Respiratory Infections,* 2 (1), 20-33.

Craven, D., Kunches, L., Kilinsky, V., Lichtenberg, D., Make, B. & McCabe, W. (1986). Risk factors for pneumonia and fatality in patients receiving continuous mechanical ventilation. *American Reviews of Respiratory Disease,* 133 (5), 792-796.

Cunha, B.A. (2009). Nosocomial pneumonia. emedicine.medscape.com (Jan 2010).

Daschner, F., Kappstein, I., Engels, I., Reuschenbach, K., Pfisterer, J., Krieg, N. & Vogel, W. (1988). Stress ulcer prophylaxis and ventilation pneumonia: prevention and antibacterial cytoprotective agents? *Infection Control Hospital Epidemiology,* 9 (2), 59-65.

Day J, Martin MD, Chin M. (1998). Efficacy of a sonic toothbrush for plaque removal by caregivers in a special needs population. *Special Care Dentistry*, 18 (5), 202-206.

Defabianis, P. & Re, F. (2003) The role of saliva in maintaining oral health. *Minerva Stomatology,* 52 (6), 301-308.

Dennesen, P., van der Ven, A., Vlasveld, M., Lokker, L., Ramsay, G., Graham, M., Kessels, A., van den Keijbus, P., van Mieuw Amerongen, A. & Veerman, E. (2003). Inadequate salivary flow and poor oral mucosal status in intubated intensive care unit patients. *Critical Care Medicine,* 31 (3), 781-786.

Depuydt, P.O., Myny, D. & Blott, S.I. (2006). Nosocomial pneumonia: aetiology, diagnosis and treatment. *Current Opinion in Pulmonary Medicine,* 12, 192-197.

DeRiso, A., Ladowski, J., Dillon T., Justice, J. & Peterson, A. (1996). Chlorhexidine gluconate 0.12% oral rinse reduces the incidence of total nosocomial respiratory infection and nonprophylactic systemic antibiotic use in patients undergoing heart surgery. *Chest,* 109, 1556-1561.

Dezfullan, C., Shojania, K., Collard, H.R., Kim, H.M., Mathay, M.A. & Saint, S. (2005). Subglottic secretion drainage for preventing ventilator-associated pneumonia: a meta-analysis. *American Journal of Medicine,* 118 (1), 11-18.

Diaz, E., Ulldemolins, M, Lisboa, T. & Rello, J. (2009). Management of ventilator-associated pneumonia. *Infectious Disease Clinics of North America,* (3), 521-533.

Dodd, M., Larson, P., Dibble, S., Miaskowski, C., Greenspan, D., MacPhail, L., Hauck, W., Paul, S., Ignoffo, R. & Shiba, G. (1996). Randomized clinical trial of chlorhexidine versus placebo for prevention of oral mucositis in patients receiving chemotherapy. *Oncology Nursing Forum,* 23, (6), 921-927.

Donskey, C., Chowdhry, T., Hecker, M., Hanrahan, J., Hiu, A., Hutton-Thomas, R., Whalen, C., Bonomo, R. & rice, L. (2000). Effect of antibiotic therapy on the density of vancomycin-resistant enterococci in the stool of colonized patients. *New England Journal of Medicine,* 343 (26), 1925-1932.

Dravulovic, M. Torres, A., Bauer, T., Nicolas, J., Nogue, S. & Ferrer, M. (1999). Supine body position as a risk factor for nosocomial pneumonia in mechanically ventilated patients: a randomized trial. *Lancet,* 354 (9193), 1861-1868.

Eldridge, K., Finnie, S., Stephens, J., Mauad, A., Munoz, C. & Kettering, J. (1998). Efficacy of an alcohol–free chlorhexidine mouthrinse as an antimicrobial agent. *Journal of Prosthetic Dentistry,* 80 (6), 685-690.

Ellers, J. Berger, A. M., & Peterson, M.C. (1988). Development, testing, and application of the oral assessment guide. *Oncology Nursing Forum*. 15 (3), 325-330.

El Solh, A. & Saliba, R. (2007). Pharmacologic prevention of aspiration pneumonia: a systematic review. *American Journal of Geriatric Pharmacotherapy,* 5 (4), 352-362.

Ercole, S. Tet, S., Catano, G., Summartine, G., Femminella, B., Tripodi, D., Sporto, G. & Paslantonio, M. (2009). Microbiological and biochemical effectiveness of an antiseptic gel on the bacterial contamination of the inner space of dental implants- a 3 month human longitudinal study. *International Journal of Immunopathology Pharmacology,* 22 (4), 1019-1026.

Ettinger, R., Warren, J., Levy, S., Hand, J., Merchant, J. & Stromquist, A. (2004). Oral health perceptions of need in a rural iowa county. *Special Care Dentistry,* 24 (1), 13-21.

Fitch, J. Munro, D. Glass, C. & Pelligrini, J. (1999). Oral care in the adult intensive care unit. *American Journal of Critical Care,* 8 (5), 314-318.

Fletcher, A.J., Ruffell, A. J. & Young, A. J. (2009). The lotrach system: its role in the prevention of ventilator-associated pneumonia. *Nursing Critical Care,* 13 (5), 260-268.

Fourrier, F., Cau-Pottier, E., Boutigny, H., Roussel-Delvallez, M. Jourdain, M. & Chopin, C. (2000). Effects of dental plaque antiseptic decontamination on bacterial colonization and nosocomial infections in critically ill patients. *Intensive Care Medicine,* 26, 1239-1247.

Ford, S. J. (2008). The importance and provision of oral hygiene in surgical patients. *International Journal of Surgery,* 6 (5), 418-419.

Francetti, L., Del Fabbro,M., Basso, M., Testori, T., Taschieri, S., & Weinstein, R. (2004). Chlorhexidine spary versus mouthwash in the control of dental plaque after implant surgery. *Journal of Clinical Periodontology*. 31 (10), 857-862.

Furr, L.A., Binkley, C.J., McCurren, C. & Carrico, R. (2004). Factors affecting quality of oral care in intensive care units. *Journal of Advanced Nursing,* 48 (5), 454-462.

Garcia, R. Jendresky, L. Colbert, L. Bailey, A., Zaman, M.,& Majurnder, M. (2009). Reducing ventilator-associated pneumonia through advanced oral-dental care: a 48-month study. *American Journal of Critical Care*, , 18 (6), 523-532.

Genco, R., Offenbacher, S. & Beck, J. (2002). Periodontal disease and cardiovascular disease: epidemiology and possible mechanisms. *Journal of American Dental Association,* 33, 14-25.

Genuit, T., Bochicchio, G., Napolitano, L., McCarter, R., & Roghman, M. (2001). Prophylactic chlorhexidine oral rinse decreases ventilator-associated pneumonia in surgical ICU patients. *Surgical Infections,* 2 (1), 5-18.

Grap, M. & Munro, C. (2004). Preventing ventilator-associated pneumonia: evidenced based care. *Critical Care Nursing Clinics of North America,* 16 (3), 349-358.

Grap, M. & Munro, C. (2004). Oral health and care in the intensive care unit: state of Science. *American Journal of Critical Care,* 13 (1), 25-33.

Grap, M., Munro, C., Elswick, R., Sessler, C. & Ward, K. (2004). Duration of action of a single early application of chlorhexidine on oral microbial flora in mechanically ventilated patients: a pilot study. *Heart and Lung,* 33 (2), 83-91.

Hase, J. Attstrom, R., Edwartsson, S., Kelly, E., & Kisch, J. (1998). 6-month use of 0.2% delmopinol hydrochloride in comparison with 0.2% chlorhexidine digluconate and placebo. Effect on plaque formation and gingivitis. *Journal of Periodontology*, 25 (9), 746-753.

Hayes, C., Sparrow, D., Cohen, M., Vokonas, P. & Garcia, R. (1998). The association between alveolar bone loss and pulmonary function: the va dental longitudinal study. *Annals of Periodontology,* 3 (1), 257-261.

Heitz, F., Heitz-Mayfield, L., & Lang, N. (2004).Effects of post-surgical cleansing protocols on early plaque control in periodontal and/or periimplant wound healing. Journal of Clinical Periodontology, 31(11), 1012-1018.

Henshaw, M. & Calabrese. (2001). Oral health and nutrition in the elderly. *Nutrition in Clinical Care,* 4 (4), 34-42.

Heo, S. M. (2007). Bacteria from patient's dental plaque causes ventilator-associated pneumonia. Bio-Medicine. University of Buffalo presentation National Institute of Dental and Craniofacial Research.

Heo, S.M., Haase, E.M., Lesse, A.J., Gill, S.R. & Scannapieco, F.A. (2008). Genetic relationships between respiratory pathogens isolated from dental plaque and bronchoalveolar lavage fluid from patients in the intensive care unit undergoing mechanical ventilation. *Clinical Infectious Diseases,* Nov 2008.

Hernadez, C., el-Ebiary, M., Gonzalez, J., de le Bellacasa, J., Monton, C. & Torres, A. (1996), Relationship between ventilator-associated pneumonia and intramucosal gastric pHi: a case-control study. *Journal of Critical Care,* (3), 122-128.

Hicks, J., Garcia-Godoy, F. & Flaitz, C. (2003). Biological factors in dental caries: role of Saliva and dental plaque in the dynamic process of demineralization and reminerlazation (part 1). *Journal of Clinical Pediatric Dentistry,* 28 (1), 47-52.

Holzapfel,L., Chastang, C., Deminogeon, G., Bohe, J., Piralia, B. & Coupry, A. (1999). A randomized study assessing the systematic search for maxillary sinusitis in nasotracheally mechanically ventilated patiets. influence of nosocomial maxillary sinusitis on the occurrence of ventilator-associated pneumonia. *American Journal of Respiratory Critical Care,* 159 (3), 695-701.

Horan, T.C. White, J.W., Jarvis, W.R., Emor, T.G., Culver, D. H., Munn, V.P., Thornsberg, C., Olson, D.R. & Hughes, J.M. (1986). Nosocomial infection surveillance, 1984. *MMRW CDC Surveillance.* 35 (1), 17SS-29SS.

Houston, S. Hoagland, P., Anderson, LaRocco, M., Kennedy, V. & Gentry, L.O. (2002). Effectiveness of 0.12% chlorhexidine gluconate oral rinse in reducing prevalence of nosocomial pneumonia in patients undergoing heart surgery. *American Journal of Critical Care*, 11, 567-570.

Hutchins, K., Karras, G., Erwin, J. & Sullivan, K. (2009). Ventilator-associated pneumonia and oral care: a successful quality improvement project. *American Journal Infection Control,* 37, 590-597.

Iacono, V., Aldredge, W., Lucks, H & Schwartzstein, S. (1998). Modern supragingival plaque control. *International Dentistry Journal,* 48, 290-297.

Jette, A. M. (2003). Assessing disability in studies on physical activity. *American Journal Preventative Medicine,* 25, 122-128.

Johanson, W.G. Jr., Pierce, A.K., Sanford, J.P. & Thomas, G.D. (1972). Nosocomial respiratory infections with gram-negative bacilli. The significance of colonization of the respiratory tract. *Annals of Internal Medicine,* 77, 701-706.

Kaplan, M & Baum, B. (1993). The function of saliva. *Dysphagia,* 8 (3), 225-229.

Kayser-Jones, J., Bird, W., Long, P., & Schnell, E. (1995). An instrument to assess the oral health status of nursing home residents. *Gerontologist,* 35, 814-824.

Keith, D., Garrett, K., Hickox, G., Echols, B. & Comeau, E. (2004). Ventilator-associated pneumonia: improved clinical outcomes. *Journal of Nursing Care Quarterly,* 19 (4), 328-333.

Kite, L. (1995). Changing mouth care practice in intensive care: implications of the clinical setting context. *Intensive Critical Care,*11, 203-209.

Koeman, M., van der Ven, J.A., M., Hak, E., Joore, H. A., Kaasjager, K., de Smet, A. G., Ramsay, G., Dormans, T., Aarts, L. de Bel, E., Hustinx, W., van der Tweel, I., Hoepelman, A. & Bonten, M. (2006). Oral decontamination with chlorhexidine reduces the incidence of ventilator-associated pneumonia. *American Journal of Respiratory Critical Care Medicine,* 173, 1348-1355.

Kollef, M. (2004). Prevention of hospital-associated pneumonia and ventilator-associated pneumonia. *Critical Care Medicine,* 32 (6), 1396-1405.

Kollef, M. H. (1999). The prevention of ventilator-associated pneumonia. *New England Journal of Medicine,* 340 (8), 64A-64GG.

Kollef, M. H., Nikolaos, J. & Thoralf, M. (1999). A randomized clinical trial of continuous aspiration of subglottic secretions in cardiac surgery patients. *Chest.* 116, 1339-1346.

Kressin, N., Boehmer, U., Nunn, M., & Spiro, A. (2003). Increased preventive practices lead to greater tooth retention. *Journal of Dental Research,* 82 (3), 223-227.

Labeau, S., Vandijck, D.M., Claes, B., Van Aken, P. & Blot, S.I. (2007) Critical care Nurses' knowledge of evidence-based guidelines for preventing ventilator associated pneumonia: an evaluation questionnaire. *American Journal of Critical Care,* 16 (4), 371-377.

Lamkin, M & Oppenheim, F. (1993). Structural features of salivary function. *Critical Review Oral Biology Medicine,* 5 (3-4), 241-249.

Laux, L. & Herbert, C. (2006). Decreasing ventilator-associated pneumonia: getting on board. *Critical Care Nursing Quarterly,* 29 (3), 253-258.

Leone, M., Delliaux, S., Bourgoin, A., Albanese, J., Garnier, F., Boyadjiev, I., Antonini, F. & Martin, C. (2005). Risk factors for late-onset ventilator-associated pneumonia in trauma patients receiving selective digestive decontamination. *Intensive Care Medicine,* (1), 64-70.

Leu, H., Kaiser, D., Mori, M., Woolson, R. & Wenzel, R. (1989). Hospital-acquired pneumonia. Attributable mortality and morbidity. *American Journal of Epidemiology,* 129 (6), 1258-1267.

Liena-Puy, C. (2006). The role of saliva in maintaining oral health and as an aid to diagnosis. *Medical Oral Pathology,* 11 (5), 448-455.

Locker, D. & Matear, D. (2002). Oral disorders, systemic health, wellbeing, and the quality of life: a summary of recent research evidence. University of Toronto: community dental services research unit. *Community Dental Health,* 19 (2), 90-97.

Lode, H. Raffenberg, M., Erbes, R., Geerdes-Fengea, H. & Mauch, M. (2000). Nosocomial pneumonia: epidemiology, pathogenesis, diagnosis, treatment, and prevention. *Current Opinion Infection Disease,* 13, 377-384.

Loesche, W., Schork, A., Terpenning, M.S., Chen, Y.M., Dominquez, B.L. & MacEntee, M.I., Stolar, E., & Glick, N. (1993). Influence of age and gender on oral health and related behaviors in an independent elderly populations. *Community Dental Oral Epidemiology,* 21 (4), 234-239.

Lott, J., Iwashyna, T., Christie, J., Asch, D., Kramer, A. & Kahn, J. (2009), Critical illness outcomes in specialty versus general intensive care units. *American Journal of Respiratory and Critical Care Medicine,* 179, 676-683.

Mahul, P., Auboyer, C., Jospe, R., Ross, A., Guerin, C., el Khouri, Z., Galliez, M., Dumont, A. & Gaudin, O. (1992). Prevention of nosocomial pneumonia in intubated patients: respective role of mechanical subglottic secretions drainage and stress ulcer prophylaxis. *Intensive Care Medicine*. 18, 20-25.

Marelich, G. P., Murin, S. Barristella, F., Inciardi, J., Vierra, T. Roby, M, (2000). Protocol weaning of mechanical ventilation in medical and surgical patients by respiratory care practitioners and nurses: effect on weaning time and incidence of ventilator associated pneumonia. *Chest*, 118 (2), 459-467.

Markowicz, P., Wolff, M., Djedaini, K., Cohen, Y., Chastre, J., Delclaux, C., Merrer, J., Herman, B., Veber, B., Fontaine, A. & Dreyfus, D. (2000). Multicenter prospective study of ventilator-associated pneumonia during acute respiratory distress syndrome. Incidence, prognosis, and risk factors. ards study group. *American Journal of Respiratory Critical Care Medicine,* 161 (6), 1942-1948.

Marsh, P. (1999). Microbiologic aspects of dental plaque and dental caries. *Dental Clinics of North America,* 43 (4), 599-614.

Marshall, T., Watten, J., Hand, J., Xie, X. & Stumbo, P. (2002). Oral health, nutrient intake and dietary quality in the very old. *Journal of the American Dental Association,* (133),1369-1379.

Masada, Marvin. (2006). Measurements of interleukin-1a and-1 b in gingival crevicular fluid: implications for the pathogenesis of periodontal disease. *Journal of Periodontal Research,* 25 (3), 145-153.

Maurer, J. (1977). Providing optimal oral health. *Nursing Clinics of North America,* 12 (4), 671-685.

May, D., Kelly, J., Mendlein, J. & Garbe, P. (1991). Surveillance of major causes of hospitalizations among the elderly in 1988. *MMWR CDC Surveillance Summary,* 40 (91), 7-21.

Mayhall, C. (1997). Nosocomial pneumonia. diagnosis and prevention. *Infectious Disease Clinics of North America,* 11 (2), 427-457.

McClave, S., DeMeo, M., DeSArio, K., Heyland, D., Maloney, J., Moore, F., Scolapio, J., Spain, D. & Saloga, G. (2002). North american summit on aspiration in the critically ill patient: consensus statement. *Journal of Parenteral and Enteral Nutr*ition, Dec Supplement, S80-85.

Merritt, J., Kreth, J., Qi, F., Sullivan, R. & Shi, W. (2005). Non-disruptive, real-time analyses of the metabolic status and viability of streptococcus mutans cells in response to antimicrobial treatments. *Journal Microbiological Methods,* 61 (92), 161-170.

Miyasaki, K. Periodontal Immunology. http://www.dent.ucla.edu/pic/members/immunology/immunology2.html (2010).

Mojon, P., Buditz-Jorgensen, E., Michel, J. & Limeback. (1997). Oral health and history of respiratory tract infection in frail institutionalized elders. *Geriodontology,* (1), 9-16.

Moore, J. (1995). Assessment of nurse-administered oral hygiene. *Nursing Times,* 91, 40-41.

Munro, C. Grap, M.J., Elswick, R.K., McKinney, J. Sessler, C. & Hummel, R. III. (2006). Oral health status and development of ventilator-associated pneumonia: a descriptive study. *American Journal of Critical Care,* 15 (5), 342-360.

Munro, C., Grap, M.J., Jones, D.J., McClister, D. K. & Sessler, CN. (2009). Chlorhexidine, toothbrushing and preventing ventilator-associated pneumonia in critically ill adults. *American Journal Critical Care,* 18 (5), 428-437.

Munro, C., Grap, M.J., Sessler, C. & Carter. (2003). Victory over ventilator associated pneumonia. NTI presentation at AACN conference. May 2003.

Murray, T. & Goodyear-Bruch, C. (2007). Ventilator-associated pneumonia improvement program. *AACN Advanced Critical Care,* 18 (2), April/June, 190-199.

Myrianthefs, P.M., Kalafati, M.P., Samara, I. & Baltopoulos, G.J. (2004). Nosocomial pneumonia. *Critical Care Nursing Quarterly Advanced Respiratory Management,* 27 (3), 241-257.

Nakayama, Y., Washio, M. & Mori, M. (2004). Oral health conditions in patients with parkinson's disease. *Journal of Epidemiology,* 14 (5), 143-150.

Needleman, I., McGrath, C., Floyd, P. & Biddle, A. (2004). Impact of oral health on the life quality of periodontal patients. *Journal of Clinical Periodontology,* 31(6), 454-457.

Newman, H., Eaton, K., Rimini, F., Zak, E., Brookman, D., Hopkins, L., Canneli, P., Yates, L. & Morrice, C. (1997). The effects of a 0.12% chlorhexidine-digluconate-containing mouthrinse versus a placebo on plaque and gingival inflammation over a 3-month period. A multicentre study carried out in general dental practices. *Journal of Clinical Periodontology,* 24 (3), 189-197.

Niederman, M.S. (1996). Guidelines for the management of respiratory infection: why do we need them, how should they be developed, and can they be useful? *Current Opinions in Pulmonary Medicine*, 2 (3), 161-165.

Nordenram, G. & Ljunggren, G. (2002). Oral status, cognitive and functional capacity versus oral treatment need in nursing home residents: a comparison between assessments by dental and ward staff. *Oral Disease,* 8, (6), 296-302.

O'Keefe, M., Carthy, S., Santiago, C. & Lau, G. (2009). Ventilator-associated pneumonia bundled strategies: an evidence-based practice. *Worldviews Evidence Based Nursing,* 5 (4), 193-204.

O'Neal, P.V., Munro, C. L., Grapy, M.J. & Rausch, S. M. (2007). Subglottic secretion viscosity and evacuation efficiency. *Biological Research Nursing,* 8 (3), 202-209.

Page, R. (2006). The role of inflammatory mediators in the pathogenesis of periodontal disease. *Journal of Periodontal Research,* 26 (3), 230-242.

Paju, S. & Scannapieco, F.A. (2007). Oral biofilims, periodontitis, and pulmonary infections. *Oral Disease,* 13 (6), 508-512.

Paulsson G, Söderfeldt B, Nederfors T, Fridlund B. (2002). Nursing personnel's views on oral health from a promotion perspective: a grounded theory analysis. *Acta Odontology Scandinavian,* 60 (1), 42-48.

Pearson, L. (1996). A comparison of the ability of foam swabs and toothbrushes to remove dental plaque: implications for nursing practice. *Journal of Advanced Nursing,* 23, 62-69.

Pruitt, B. & Jacobs, M. (2006). Best practice interventions: how can you prevent ventilator-associated pneumonia? *Nursing 2008,* 36 (2), 36-41.

Pugin, J., Auckenthlaer, R., Lew, D. & Sutter, P. (1991). Oropharyngeal decontamination decreases incidence of ventilator-associated pneumonia: a randomized, placebo-controlled, double-blind clinical trial. *JAMA,* 265, 2704-2710.

Pugin, J., Auckenthaler, R., Mili, N., Janssens, J. Lew, P. & Sutter, P. (1991). Diagnosis of ventilator-associated pneumonia by bacteriological analysis of bronchoscopic versus nonbronchoscopic "blind" bronchoalveolar lavage fluid. *American Journal Respiratory Critical Care Medicine,* 143, 1121-1129.

Ranes, J. Gordon, S., Chen, P., Falica, C., Hammel, J., Gonzales, J. & Arroliga, A. (2006). Predictors of long-term mortality in patients with ventilator-associated pneumonia. *American Journal of Medicine,* 19 (10), 13-29.

Rea-Neto, A., Youssef, N.C., Tucha, F., Brunkhorst, F., Ranieri, V.M., Reinhart, K. & Sakr, Y. (2008). Diangosis of ventilator-associated pneumonia: a systematic review of the literature. *Critical Care*, 12 (2), 56-60.

Reinhardt, G., Myscofski, J., Wilkens, D., Dobrio, P., Mangan, J & Stannard, R. (1980). Incidence and mortality of hypoalbuminemic patients in hospitalized veterans. *Journal of Parenteral and Enteral Nutrition,* 4 (4), 357-359.

Richards, M., Edwards, J., Culver, D. & Gaynes, R. (2000). Nosocomial infections in combined medical-surgical intensive care units in the united states. *Infection Control Hospital Epidemiology.* (8), 510-515.

Riley, J & Gilbert, G. (2005). Childhood dental history and adult dental attitudes and beliefs. *Infectious Dentistry Journal,* 55 (3), 142-150.

Rodriguez, J., Gibbons, K., Bitzer, L., Dechert, L., Steinberg, S. & flint, L. (1991). Pneumonia: incidence, risk factors, and outcome in injured patients. *Journal of Trauma,* 31 (7), 907-912.

Ross, A. & Crumpler, J. (2007). The impact of an evidence-based practice education program on the role of oral care in the prevention of ventilator-associated pneumonia. *Intensive Critical Care Nurse,* 23 (3), 132-136.

Rumbak, M.J. (2000). Ventilator-associated pneumonia. *Journal Respiratory Diseases,* 21, 321-327.

Salahuddin, N., Zafar, A., Sukhyani, L., Rahim, S., Noon, M.F. Hussein, K. & Siddiqli, S. (2004). Reducing ventilator-associated pneumonia rates through a staff education programme. *Journal Hospital Infection,* 57 (3), 223-227.

Samaranayake L., Wilkieson C., Lamey P., & MacFarlane,T. (1995). Oral disease in long term hospital care. *Oral Diseases,* 1 (3), 147-161.

Scannapieco, F. (1998). Role of oral bacteria in systemic disease. *Periodontology,* 70 (7), 792-801.

Scannapieco, F. A., Bush, R., & Paju, S. (2003). Associations between periodontal disease and risk for nosocomial bacterial pneumonia and chronic obstructive pulmonary diseases. a systemic review. *Annals of Periodontology,* 8 (1), 54-69.

Scannapieco, F., Papandonatos, G. & Dunford, R. (1998). Associations between oral conditions and respiratory diseases in national sample survey population. *Annals of Periodontology,* 3 (1), 251-256.

Scannapieco, F. & Rethman, M. (2003). The relationship between periodontal diseases and respiratory diseases. *Dentistry Today,* 22 (8), 79-83.

Scannapieco, F., Stewart, E. & Mylotte, J. (1992). Colonization of dental plaque by respiratory pathogens in medical intensive care patients. Critical Care Medicine, 20, 740-745.

Scannapieco, F., Yu, J., Raghavendran, K., Vancentil, A., Owens, S.I., Wood, K. & Mylotti, J.M. (2009). A randomized trial of chlorhexidine gluconate on oral bacterial pathogens in mechanically ventilated patients. *Critical Care Medicine,* 13 (4), 117-124.

Seymour, G. J., Ford, P.J., Cullimna, M.P., Leishman, S. & Yamazaki, K. (2007). Relationship between periodontal infections and systemic disease. *Clinical Microbiology Infections,* 13 (4), 3-10.

Shanratzadeh, M.R., Huang, J.Q. & Marrte, T. J. (2006). Differences in the features of aspiration pneumonia according to site of acquisition: community or continuity care facility. *Journal of the American Geriatric Society,* 54 (2), 362-364.

Smulders, K., van der Hoeven, H., Weers-Pothoff, I. & Vandenbroucke-Granuls, G. (2002). A randomized clinical trial of intermittent subglottic secretion drainage in patients receiving mechanical ventilation. *Chest,* 121 (3), 858-862.

Sole, M., Poalillo, F., Byers, J & Judy, J. (2002). Bacterial growth in secretion and on suctioning equipment of orally intubated patients: a pilot study. American Journal of Critical Care, 11 (2), 141-149.

Stiefel, K., Damon, S., Sowers, N., & Velez, L. (2000). Improving oral hygiene for the seriously ill patient: implementing research-based practice. *Medsurg Nursing,* 9 (1), 403- 406.

Swoboda, S., Dixon, T. & Lipsett, P.A. (2006). Can the clinical pulmonary infection Score impact ICU antibiotic days? *Surgical Infections*, 7 (4), 331-339.

Tablan, O., Anderson, L., Besser, R., Bridges, C., Hajjeh, R. & CDC; Healthcare Infection control Practices Advisory Committee. (2004). Guidelines for Preventing Health-care-associated pneumonia, 2003: recommendations of CDC and the healthcare infection control practice advisory committee. *MMWR Recommendations,* 53, 1-36.

Tantipong, H. Morkchareonpong, C. Jaiyindee, S. & Thamilikitkul, V. (2008). Randomized controlled trail and meta-analysis of oral decontamination with 2% chlorhexidine solution for the prevention of ventilator-associated pneumonia. *Infection Control and Hospital Epidemiology,* 29 (2), 131-136.

Taylor, L., Loesche, W., & Terpenning, M. (2000). Impact of oral diseases on systemic health in the elderly: diabetes mellitus and aspiration pneumonia. *Journal of Public Health Dentistry,* 60 (4), 313-320.

Tejerna, E., Fructos-Vivar, F., Restrepo, M., Abrough, F., Palizras, F., Gonzalez, M., D'Empaire, G., Apezteguia, C. & Esteban, A. (2006). Incidence, risk factors, and outcomes of ventilator-associated pneumonia. *Journal of Critical Care,* (1), 56-65.

Terpenning, M. (2005). Geriatric oral health and pneumonia risk. *Clinical Infectious Diseases,* 40 (12), 1897-1910.

Todar, K. (2008). Todar's online textbook of bacteriology. www.textbokofbacteriology.net. (Nov 2008).

Torres, A., El-Ebiary, M., Soler, N., Monton,C., Fabregas, N. & Hernandez, C. (1996). Stomach as a source of colonization of the respiratory tract during mechanical ventilation: association with ventilator-associated pneumonia. *European Respiratory Journal*. 9 (8), 1729-1735.

Treloar, D. & Stechmiller, J. (1995). Use of a clinical assessment tool for orally intubated patients. *American Journal of Critical Care,* 4 (5), 355-360.

Valles, J., Mariscal, D., Cortes, P., Coll, P., Villagra, A., Diaz, E., Artigas, A., & Rel, J. (2004). Patterns of colonization by pseudomonas aeruginosa in intubated patients: a 3-year prospective study of 1,607 isolates using pulsed-field gel electrophoreses with implications for prevention of ventilator-associated pneumonia. *Intensive Care Medicine,* 30 (9), 1768-1775.

Valles, J., Artigas, A., Rello, J., Bonsoms, N., Fontanals, D., Blanch, L., Fernandez, R., Balgoni, F. & Meitre, J. (1995). Continuous aspiration of subglottic secretions in Preventing ventilator-associated pneumonia. *Annals of Internal Medicine*. 122, 179-186.

Wactawski-Wende, J., Grossi, S., & Trevisan, M. (1996). The role of osteopenia in oral bone loss and periodontal disease. *Journal of Periodontology,* 66, 1076-1084.

Walsh, J. (1990). The three levels of nursing care. *Professional Nurse,* 5 (12), 666.

Wårdh I, Hallberg LR, Berggren U, Andersson L, Sörensen S. (2000). Oral health care--a low priority in nursing. In-depth interviews with nursing staff. Scandinavian Journal of Caring Science, 14 (2), 137-142.

Yoshida, M., Yoneyama, T. & Aagawa, Y, (2001). Oral care reduces pneumonia of older adults in nursing homes, irrespective of dentate or edentate status. *Nippon Ronan Igakkai Zashi,* 38 (4), 481-493.

Zack, J.E., Garrison, T., Travillion, E., Clinkscale, D., Coopersmith, C.M., Fraser, V. J. & Kollef, M. H. (2002). Effect of an education program aimed at reducing the occurrence of ventilator-associated pneumonia. *Critical Care Medicine,* 30 (11), 2407-2412.

BIOGRAPHICAL SKETCH

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