8-3-2015

Impact of Standardized Oral Health Assessment on Preventing Ventilator-Associated Events

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IMPACT OF STANDARDIZED ORAL HEALTH ASSESSMENT ON PREVENTING VENTILATOR-ASSOCIATED EVENTS

by

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EVIDENCE-BASED PRACTICE PROJECT REPORT

Submitted to the College of Nursing

of Valparaiso University,

Valparaiso, Indiana

in partial fulfillment of the requirements

For the degree of

DOCTOR OF NURSING PRACTICE

2015

8/2/2015

Student Date

8-3-15

Advisor Date

DEDICATION

For Elena and Xavier who are both equally my wellsprings of strength, happiness and inspiration. For my husband, Sekani who is a font of unwavering support. For Anita who is my steadfast friend.

ACKNOWLEDGMENTS

I extend my deep thanks and appreciation to my faculty advisor, Dr. Tom Blodgett whose sustained guidance and insight smoothed my path to completion. Many thanks to my clinical advisor, Laura Fuller whose faith and confidence got me through the last year.

I am tremendously grateful to Carol, Rachel and Janet, whose facilitation was indispensable in implementing this research. Many thanks to Janene, Mary, Chris, Irene, Sally, Erin and Melissa for your support. Finally, no amount of thanks would be adequate to express my gratitude to the dozens of critical care nurses who participated in the study - you are the embodiment of caring.

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ABSTRACT

Ventilator-associated pneumonia (VAP) is a common but preventable health-care associated infection that affects up to 20% of mechanically ventilated adult patients, resulting in estimated mortality rates ranging from 13% to 55% (Chahoud, Semaan, Almoosa, 2015; Melsen et al., 2013). In an effort to reduce morbidity, mortality and related costs, the Centers for Disease Control and Prevention (CDC) and the National Healthcare Safety Network (NHSN), proposed ventilator-associated pneumonia prevention as a national patient safety goal. In 2014, amid growing concerns that the subjectivity of existing definitions had led to inconsistent reporting, thereby impeding efforts to reduce VAP, the CDC refocused surveillance efforts on, the more broadly defined, ventilator associated events (VAE), which include VAP as well as a set of related conditions. Hospitals have been inconsistent in their adoption of evidence-based practice (EBP) to reduce the incidence of VAE. The purpose of this EBP project was to design, implement, and evaluate the use of a comprehensive oral health intervention to: (a) reduce the cumulative VAE rate at four facilities and (b) determine whether project adherence over a four month period had an impact on VAE incidence rate reduction.

The Epidemiological Triangle of Infectious Disease and Everett Rogers' Diffusion of Innovation framework guided this multisite pretest-posttest study. The study introduced oral care and biofilm elimination education for nurses, and an oral health assessment tool. Aggregated VAE data was collected from each facility's infection preventionist. The analysis involved pooled mean comparisons of data in the pre-intervention and post-intervention periods. The data showed a decrease in pooled VAE incidence rates of 1.8 per 1,000 ventilator-days, but this difference was not statistically significant, X^2 (1, N = 4,846) = .37, p = .54. There was also a moderate correlation between documentation compliance and reduction of VAE rate (r = .4). However, this correlation was not statistically significant (p = .6). These findings provide preliminary evidence that routine oral assessment and timely intervention in MV patients are useful components of comprehensive oral care practices to prevent VAE.

CHAPTER 1

INTRODUCTION

Oral care is an important nursing intervention to reduce the risk of ventilator-associated pneumonia (VAP) in the hospital setting. While the effectiveness of various oral care practices has been studied in several patient populations, the most effective oral care solutions, frequency, duration, and strategies for staff education remain unclear. The purpose of this study is to answer the PICOT question: Among mechanically ventilated patients, how does the implementation of an oral care assessment guideline combined with a mandatory staff education program affect the incidence of ventilator associated events (VAE) when compared to standard care over a four month period? This chapter will differentiate VAP from current classifications of VAE, provide an overview of how VAP develops in endotracheally intubated patients, and describe the significance of this project to prevent VAE in this population.

Background

Hospital acquired infections (HAI) encompass almost all clinically evident infections that the patient acquires during the course of hospitalization and that do not originate from the patient's original admitting diagnosis, according to Mehta et al. (2014) and Paitoonpong, Wong, & Perl (2014). Within hours after admission, a patient's flora begins to acquire characteristics of the surrounding environmental flora. Most HAIs become clinically evident after 48 hours of hospitalization. Hospital acquired infections may also become evident after the patient's discharge from the hospital. These are known as nosocomial in origin (Zimring et al., 2013).

Ventilator-associated pneumonia is a common HAI and is the leading cause of death among hospitalized patients requiring mechanically ventilated airway support (Davis, 2006; Klompas, Kleinman, & Murphy, 2014). A recent clinical survey suggests that the prevalence of VAP is 9% to 27% among all intubated patients (Dudeck et al., 2011). However, according to Choudhuri (2013), it is estimated that the prevalence of ICU-acquired VAP is 10% to 20% and

results in crude estimated mortality rates ranging from 24% to 76%. These patients are twice as likely to die during hospitalization, compared to mechanically ventilated patients without pneumonia, according to the American Thoracic Society (2005). In another study by Klompas et al., (2014), researchers concluded that the attributable mortality of VAP is estimated to be approximately 10% but varies considerably for different kinds of patient populations. Although there have been numerous advances in techniques for the management of mechanically ventilated patients, VAP continues to impact morbidity, prolongs intensive care unit (ICU) length of stay, and prolongs duration of ventilation. The estimated additional cost to treat VAP exceeds $40,000 per occurrence (Davis, 2006; Klompas, Kleinman, & Murphy, 2014).

Until recently, the definition of VAP has been relatively unstandardized compared to other types of HAI. The Centers for Disease Control and Prevention (CDC) indicated that true incidence of VAP was difficult to determine due to the subjectivity of VAP surveillance (Klompas, Kleinman, & Murphy, 2014; Magill et al., 2013). As a result, from 2011 to 2012, the CDC convened a working group comprised of representatives from critical and respiratory care, infectious diseases, healthcare epidemiology, and infection prevention professional societies to develop a new approach to surveillance for mechanically ventilated patients in an attempt to standardize VAP surveillance definitions (Klompas et al., 2014; Magill et al., 2013). The working group made two recommendations: 1) to develop new definitions based on objective, quantitative criteria to increase the reliability, reproducibility, comparability, and efficiency of surveillance, 2) to broaden the scope of surveillance from pneumonia alone to encompass other complications of mechanical ventilation. In 2014, the Centers for Disease Control and Prevention (CDC) released an updated surveillance definition of VAP, which stratified VAP as one of several ventilator-associated events (VAE). These events include ventilator-associated conditions (VAC), infection-related ventilator-associated conditions (IVAC), possible VAP, and probable VAP. All of these events are of interest to this study, as they represent preventable adverse outcomes.

Ventilator associated condition (VAC) is defined as a period of sustained respiratory deterioration following a sustained period of stability or improvement while mechanically ventilated, as evidenced by changes in the daily minimum fraction of inspired oxygen (FiO_2) or daily minimum positive end-expiratory pressure (CDC, 2014).

Infection-related ventilator-associated complication (IVAC) is triggered by the presence of possible infection indicators concurrent with VAC onset. IVAC is said to have occurred in the presence of abnormal temperature, below 36°C or above 38°C, or when white blood cell count is less than 4,000 cells/mm^3 or greater than 12,000 cells/mm^3 and a new antibiotic is added and continues for at least four days along with an oxygenation change (CDC, 2014).

Possible VAP is defined as occurring on or after calendar day three of mechanical ventilation and within two calendar days before or after the onset of worsening oxygenation, when one of the following criteria is met: 1) Gram stain evidence of purulent pulmonary secretions, or; 2) a pathogenic pulmonary culture in a patient with IVAC (CDC, 2014).

Probable VAP is defined as occurring on or after calendar day three of mechanical ventilation and within two calendar days before or after the onset of worsening oxygenation, when one of the inclusion criteria in Table 1.1 is met (CDC, 2014).

Table 1.1

Inclusion Criteria for Probable VAP

Criterion	Requirements
1	Gram stain evidence of purulent pulmonary secretions **AND** one of the following: • Positive culture of endotracheal aspirate, ≥ 105 CFU/ml or equivalent semi quantitative result • Positive culture of bronchoalveolar lavage, ≥ 104 CFU/ml or equivalent semi quantitative result • Positive culture of lung tissue, ≥ 104 CFU/ml or equivalent semi-quantitative result • Positive culture of protected specimen brush, ≥ 103 CFU/ml or equivalent semi-quantitative result
2	One of the following (without requirement for purulent respiratory secretions): • Positive pleural fluid culture (where specimen was obtained during thoracentesis or initial placement of chest tube and NOT from an indwelling chest tube) • Positive lung histopathology • Positive diagnostic test for *Legionella spp.* • Positive diagnostic test on respiratory secretions for influenza virus, respiratory syncytial virus, adenovirus, parainfluenza virus.

Statement of Problem

Despite advances in knowledge about management of mechanically ventilated patients, VAP remains the most frequent infection among patients hospitalized in intensive care units (ICU). It is a nosocomial infection that develops within 48 hours of establishing mechanical ventilation and is caused by pathogens that were not present in the lungs at the time of (Davis, 2006; Horan, Andrus, & Dudeck, 2008).

Mechanical ventilation by means of endotracheal intubation is one of the most common interventions implemented in the intensive care unit. Mechanical ventilation is also a mainstay of supportive therapy for patients with acute respiratory failure. It is estimated that approximately 33% of patients admitted into the ICU are intubated with 24 hours of admission and account for a disproportionately high share of total cost of ICU treatment (Dasta, McLaughlin, Mody, & Piech, 2005). It is also estimated that ICU beds account for less than 10% of the total hospital beds in United States. However, they account for one third of total inpatient costs, an estimated national cost of $27 billion (Chalfin, Cohen, & Lambrinos, 1995; Dasta et al., 2005; Talmor, Shapiro, Greenberg, Stone, & Neumann, 2006). One study conducted from October 2008 through December 2009, concluded that the mean hospitalization costs attributable to mechanical ventilation was $59,770 and for mechanically ventilated adults diagnosed with VAP, that cost was $99,598 (Kollef, Hamilton, & Ernst, 2012). This represents an additional cost of $40,000.

Endotracheal intubation, a means of mechanical ventilation, is a necessary health care intervention to support respiration in patients who are unable to maintain adequate tissue oxygenation. The endotracheal tube bypasses several physiological barriers to respiratory tract infection, including the lips, epiglottis, cilia and mucus secreting cells. As a result, VAP is a potential outcome for nearly all patients who have undergone endotracheal intubation.

Etiology. Ventilator-associated pneumonia is caused primarily through the aspiration of oropharyngeal pathogens into the lungs as well as through cross contamination of bacteria

introduced into the oropharyngeal cavity by healthcare workers and microflora on the endotracheal tube (Hutchins, Karras, Erwin, & Sullivan, 2009; Meherali, Parpio, Ali, & Javed, 2011; Nelson & Steinhoff, 2014, p. 562). Since the endotracheal tube bypasses normal defenses by holding the mouth, epiglottis and vocal chords in open positions, pathogens are able to pass into the lungs unopposed by normal defenses. Furthermore, ineffective oral care, in conjunction with unintended contact with contaminated environmental items during hospitalization, predisposes patients to nosocomial infections. Infection of the lower respiratory tract typically arises from aspiration of secretions, colonization of the oral-gastric tract, or use of contaminated equipment. Thus, the colonization of the oral cavity and the oropharynx directly correlates with the causative agents of VAP.

Pathogenesis. The pathogens that commonly colonize pulmonary parenchyma in mechanically intubated patients are endemic to the ICU environment (Klompas, Kleinman, & Murphy, 2014). These microorganisms utilize a vast array of virulence factors, which are readily transmitted between each other to induce inflammation, tissue destruction and cell death. Furthermore, many microorganisms have developed mechanisms that allow them to evade detection by the host immune system and penetration by antimicrobial medications (Thomas, 2013).

Endotracheal intubation is associated with increased accumulation of dental plaque, oral debris, and biofilm; deterioration of mucous membranes, and colonization with respiratory pathogens (Fourrier, Duvivier, Boutigny, Roussel-Delvallez, & Chopin, 1998; Needleman et al., 2012). Consequently, the pathogenesis of ventilator-associated events is a function of the myriad complex relationships between pathogen, host and environment. These relationships will be further discussed in chapter 2 of this EBP project report.

Need for Project. The sites of implementation of this EBP project were four hospitals within a medium sized health care system operating in the Midwest. Each of these hospitals has a nursing procedure that identifies accepted and expected practices for providing oral care to

patients with mechanical ventilation, which include the use of several evidence-based interventions. These include mechanical brushing with chlorhexidine gluconate, head of bed elevation, subglottic suctioning and periodic sedation vacations with weaning readiness assessments.

Because there had been an increase in the incidence of VAP at one of these facilities, the critical care nurse manager and clinical nurse specialist identified the need to audit compliance with the facility's oral care nursing procedure. They discovered that oral care using the standardized supplies was not being performed as expected. Furthermore, while routine nursing assessments of overall health status were being performed according to nursing policy, oral health assessment was not included in the policy. Therefore, leaders at the four project sites identified a clear need to provide staff education about oral care and to revise their oral care protocol to include evidence-based interventions for routine oral health assessment.

Documentation of oral health assessment gives nurses a framework to evaluate the extent of oral biofilm development to observe improvement or worsening of oral health over time and to intervene in a timely manner to prevent the precursors to VAE. Biofilm can be effectively fragmented by use of the force of mechanical brushing in conjunction with chlorhexidine gluconate solution (Nicolosi, del Carmen Rubio, Martinez, González, & Cruz, 2014). When the assessment is documented on a grid or chart, it facilitates the nurse's recognition of trends toward improving or worsening oral health (Ames et al., 2011; Ridley & Pear, 2008).

Purpose of the EBP project

The purpose of this EBP project was to implement an evidence-based oral care protocol for mechanically ventilated adults to decrease the incidence of ventilator-associated events. The goal of this EBP project was to answer the clinical question: Among mechanically ventilated patients, how does the implementation of an oral care assessment guideline combined with a mandatory staff education program affect the incidence of ventilator associated events (VAE) when compared to standard care over a four month period?

This project incorporated strategies to: (a) identify evidence-based practices to prevent VAE using a protocol-based approach; (b) incorporate standardized oral health assessment into the current facility-approved oral care nursing procedure; (c) educate critical care nurses regarding facility-approved oral care procedures for patients with mechanical ventilation; (d) provide ongoing education at the bedside to support critical care nurses' use of the oral health assessment tool; and (e) evaluate the effectiveness of staff oral care education and routine oral health assessment on the incidence of VAE. Because oral plaque and biofilm tend to occur together, observed reductions in plaque should correspond with reductions in biofilm (Nelson & Steinhoff, 2014).

Significance of the project

Ventilator-associated events are common conditions in mechanically ventilated patients. They are associated with clinically and economically devastating consequences, and the incidence has not improved despite a growing body of evidence to support VAP prevention interventions. Implementation of these guidelines using a translational science theoretical framework is necessary to ensure their adoption in clinical practice.

CHAPTER 2

REVIEW OF LITERATURE

Ventilator-associated events (VAE) encompass a variety of clinical conditions that occur in people requiring mechanical ventilation, including infectious and non-infectious complications of endotracheal intubation. Those susceptible to VAE represent a specialized population within the health care system with risk factors for VAE that are avoidable or can be minimized through evidence-based nursing interventions. This first section of this chapter synthesizes the current literature regarding the relationship between hospital-acquired infections, such as VAE, and the pathobiological mechanisms and clinical features of VAE from a pathophysiological perspective. The second section of this chapter will apply the Epidemiological Triangle of Infectious Disease to discuss complex factors such as agent, host, and environmental characteristics as they relate to clinical causality in the development of ventilator-associated infections. Finally, the third section of this chapter will propose that Everett Rogers' Model of Diffusion of Innovations should guide this project's evidence-based nursing interventions to prevent ventilator associated conditions and pneumonia among mechanically ventilated critically ill adults within the critical care setting.

Summation of Current Literature

Healthcare associated infections (HAI), such as VAP, are common but preventable infectious illnesses that often result in increased morbidity, mortality, and additional medical care costs generated both in the hospital stay during which the preventable event occurs and during subsequent health care encounters that might not have otherwise been necessary (Pronovost et al., 2006). Since HAIs pose a significant health care problem to patients, clinicians, organizations and governments, prevention of HAIs has attracted increased visibility from regulatory agencies, healthcare organizations, healthcare personnel, and patient advocacy groups (Affordable Care Act, 2010; American Thoracic Society, 2005; CDC, 2004, 2014; ICSI,

2011; McKibben et al., 2005; Shi et al., 2013; Yokoe et al., 2014). Consequently, numerous initiatives have been enacted at state and national levels, by the Centers for Medicare and Medicaid Services (2013), to increase HAI transparency by requiring healthcare organizations to report HAI rates. In addition, healthcare guidelines and policy initiatives are tying prevention of HAIs to hospital reimbursement.

Ventilator-Associated Pneumonia

Ventilator-associated pneumonia (VAP) is one of the most common hospital-acquired infections. It can develop in any patient on a ventilator, yet most occurrences are seen in intubated or ventilated patients after 48 hours. In these cases, the ventilator itself, or the process of intubation, acts as a source of direct entry for pathogens to gain access to the lungs (Alhazzani, Smith, Muscedere, Medd, & Cook, 2013; Barbier, Andremont, Wolff, & Bouadma, 2013; Shi et al., 2013). Despite advances in techniques for the prevention and management of VAP in mechanically ventilated patients, VAP remains the most frequent infection among patients hospitalized in intensive care units. Ventilator-associated pneumonia is a nosocomial infection that may develop following 48 hours of establishing mechanical ventilation mechanical ventilation and is caused by pathogens that were not present at the time of intubation (Davis, 2006; Horan, Andrus, & Dudeck, 2008).

Ventilator associated conditions continue to occur as defined by the new specific ICD-9 code and are associated with a significant resource utilization burden, which underscores the need for cost-effective interventions to minimize the occurrence of these complications. The true incidence of VAP is difficult to determine as surveillance definitions have changed since January 2014. However, more recent clinical surveys suggest that the point prevalence is 9% to 27% among all intubated patients (Dudeck et al., 2011). The newer classification of VAP as a subtype of VAE will likely improve the accuracy of these estimates. According to Klompas, Kleinman, and Murphy (2014), the mortality attributable to VAP is estimated to be approximately 10%, but varies considerably across ICU populations (Pereira et al., 2015).

Based on the timing of onset, associated patient risk factors, and patient exposure, VAP can be divided into early-onset or late-onset. Early onset VAP occurs in approximately one third of cases usually within three to five days following intubation. The main cause is attributed to pathogens (*Staph. pneumoniae*, *H. influenzae* and anaerobes of the oral cavity) with a favorable pattern of antibiotic sensitivity. Late onset VAP occurs in approximately two thirds of cases and is often caused by exposure to multidrug-resistant (MDR) pathogens such as *Staph. aureus*, *P. aeruginosa*, *Enterobacteriaceae* and *A. baumannii,* which are endemic to most ICU units (American Thoracic Society, 2005). Drug resistant pathogens are responsible for greater morbidity, prolonged ICU length of stay (LOS), and longer duration of ventilation, with estimated additional costs exceeding US$40,000 per occurrence (Kollef, Hamilton, & Ernst, 2012).

Although VAP is the most studied VAE type, it is important for policy and financial reasons to focus on preventing all types of VAE. The next section will describe the pathophysiological features of oral cavity, that when invaded, increase the host's susceptibility for the development of VAE.

Pathophysiology of the Oral Cavity

Mucosal Immune System. The development of oral biofilm is influenced by the immunological milieu in the oral cavity (Cutler & Sluman, 2014; Prendergast, Kleiman, & King, 2013). The host's mucosal immune system is of critical importance particularly due to its adaptive nature in protecting the host's mucosal surfaces. The mucosal immune system consists of sentinel secondary lymphoid tissue, which is rich in antigen-presenting cells, CD4+ T cells and B cells, which are present at the portals of entry to the body and extend to the respiratory system, digestive tract, the genitourinary tract, eyes and mammary glands (Cole, Wirth & Bowden, 2013). Secretory immunoglobulin A (SIgA) antibodies, primarily found on mucosal surface layers and in exocrine secretions, are protective through a non-inflammatory mechanism that neutralizes toxins and facilitates removal of endogenous oral microorganisms which may be detrimental to the host due to unimpeded proliferation (Cole et al., 2013). This

protective mechanism is carried out by salivary flow of secretions which block the adhesion or aggregation to epithelia receptors on microbial cells thus inhibiting microbial growth and mediating direct bacterial lysis (Cerrutti & Rescigno, 2008; Cole et al., 2013).

Oral Pharyngeal Structures. Motility of saliva is associated with the pharynx and esophagus. From the mouth, the uppermost portion of the pharynx is the nasopharynx; it extends from the posterior upper surface of the palate, posteriorly to the nasal fossa, to the occipital bone (Sherwood, 2010, p. 463). The nasopharynx is surrounded by the salingopharyngeal fold and tubal tonsils, which become inflamed when infected. It also contains the adenoids and eustachian tube openings that provide drainage for lymphatic fluids into the throat, nose, and ears (Sherwood, 2010, p. 463). The adenoids function to detect and destroy pathogens entering the nasopharynx via the air. The uvula, a conic projection from the posterior edge of the middle of the soft palate, is instrumental during swallowing and functions to close off the nasopharynx to prevent foodstuff from back flowing into the nasal cavity (Sherwood, 2010, p. 463).

Oropharynx. The next portion of the pharynx is the oropharynx. It is positioned behind the oral cavity and extends from the posterior aspect of the soft palate to the epiglottis. Additional oropharynx structures include the epiglottic vallecula, palatine and lingual tonsils, and the epiglottis (Marieb & Mallatt, 1997). The oropharynx aids in swallowing, respiration and as an immunological defense within the host. During swallowing, the epiglottis closes over the glottis to prevent aspiration into the airway (Marieb et al., 1997). Immunologically, the palatine tonsils, located laterally in the walls of the fauces, are responsible for T-cell activation following microbiological exposure (Marieb et al., 1997; Sherwood, 2010).

Laryngopharynx. The inferior-most portion of the pharynx is the laryngopharynx. Like the oropharynx, it facilitates digestion and respiration. It is lined with stratified squamous tissue and extends from the hyoid bone to the larynx, inferior to the epiglottis. Continuous with the esophagus, the laryngopharynx bifurcates into the larynx where sound is produced (Marieb &

Mallatt, 1997; Sherwood, 2010). At the most inferior aspect of the laryngopharynx, the epiglottis and vocal cords serve as physical barriers to potential pathogens entering the lower respiratory tract.

Trachea. The trachea is lined with cilia and mucus-secreting goblet cells, which trap and carry potential pathogens from the lower respiratory tract to the mouth where they can be expectorated or swallowed (Marieb & Mallatt, 1997; Sherwood, 2010). The trachea bifurcates into two bronchi that lead into the right and left lungs. Both lungs are contained within the rib cage and are positioned superiorly to the diaphragm. In the patient without an artificial airway, potential pathogens are unlikely to reach the lungs unless they are particularly virulent or the host has nonfunctional protective mechanisms in the mouth, pharynx, larynx, and trachea due to structural disease (e.g. throat cancer), immunosuppression, or mechanical failure of the epiglottis from neurological dysfunction (e.g. cerebrovascular accident). The bronchial walls contain mucus producing goblet cells and participate in the mucociliary transport system, similarly to the trachea. However, excessive mucus production can easily obstruct airflow through the relatively smaller bronchi. Coughing facilitates the removal of excessive mucus in the host with an intact cough reflex.

Epithelium. The host and environment interface in two major ways, both of which offer protection to the host from potential agents in the environment. The skin and nails cover the human body and have a surface area of approximately two square-meters. The mucous membranes, which line the gastrointestinal, respiratory, and urogenital tracts, cover a surface area in excess of 400 square-meters (Cerrutti & Rescigno, 2008). Constant interactions with micro- and macro-organisms occur on epithelial and mucosal portals of entry (e.g. gastrointestinal tract, respiratory and urogenital tracts). Physiological interaction with these microorganisms leads to colonization of epithelial and mucosal surfaces and this co-existence is largely commensal (Cole, Wirth & Bowden, 2013; Hansen, Gulati, & Sartor, 2010). However, when the protective functions of these tissues are compromised, exogenous bacteria invade the

nutrient rich environment of the human body and cause infectious disease to develop, often with deadly results (Hansen et al., 2010).

Artificial Airway. An artificial airway, such as an endotracheal tube or tracheostomy tube, allows potential pathogens in the lower respiratory tract to evade mucociliary removal, and the use of sedating medication (which is extremely common in patients who are mechanically ventilated) or the presence of neurological impairment diminishes or inhibits the cough reflex. In these patients, the only remaining natural defense mechanism against infection is the host inflammatory response in the alveoli. This response consists of pre-existing alveolar macrophages and the recruitment of neutrophils to the alveoli through cytokine and complement activation and vasodilation of the alveolar capillaries. This host response is a powerful mechanism to destroy invading pathogens, but it is nonspecific and can cause life-threatening inflammatory injury within the alveoli. Clinical features of alveolar inflammation include respiratory distress, cyanosis, leukocytosis, fever, hypoxia, respiratory acidosis, and respiratory arrest. Radiographic evidence of widespread alveolar consolidation may be present. Oxygen therapy, antimicrobial medications, anti-inflammatory medications, chemical paralysis, and a variety of specialized mechanical ventilator settings can support respiration, but these therapies have severe clinical and economic consequences. Because artificial airways bypass nearly all host protective mechanisms, and the remaining mechanisms can be both ineffective and counterproductive, prevention and early identification of oral cavity colonization is of paramount importance in this population.

Endotracheal intubation is associated with increased accumulation of dental plaque, oral debris, biofilms, deterioration of mucous membranes, and colonization by potential respiratory pathogens (Fourrier, Duvivier, Boutigny, Roussel-Delvallez, & Chopin, 1998; Needleman et al., 2012). Consequently, the pathogenesis of VAE is a function of the myriad complex relationships between pathogens, host, and environment. Colonization of the oropharynx by potential respiratory pathogens contributes to VAE. Further, ineffective oral care, in conjunction with

unintended contact with contaminated environmental items during hospitalization, predisposes patients to nosocomial infections. Infection of the lower respiratory tract typically arises from aspiration of secretions, colonization of the oral-gastric tract, or use of contaminated equipment. Thus, the colonization of the oral cavity and the oropharynx directly correlates with the causative agents of VAE.

Oral Biofilm. The most common agents of VAE are the bacteria *S. aureus, P. aeruginosa, Enterobacteriaceae* and *A. baumannii*. These species express specialized virulence factors that enable a variety of survival advantages within the host, including: adherence to biomedical devices, direct physical damage to cells lining the respiratory tract, nutrient acquisition, resistance to antimicrobial medications, host immune factors, and development of protective microbial communities called biofilms (Brennan et al., 2004; Dubey & Ben-Yehuda, 2011; Mohapatra, & Biswas, 2013).

Genetic and phenotypic variability within oral biofilm pathogens leads to biodiversity and pathogenic genetic adaptation (Goulhen, Grenier, & Mayrand, 2003; Kumar, Mason, & Yu, 2013). This process occurs through cell-cell communication, gene transfer via conjugation and plasmid exchange, and resistance to antimicrobial medications, heat, and gastrointestinal acid, according to Kumar and colleagues (2013). Genetic regulation allows oral microflora to express different characteristics within the oral cavity. This process confers advantages not only to other co-existing bacteria, but also to the human host in some cases (Kumar et al., 2013).

Artificial Airways

Patients with artificial airways are uniquely susceptible to respiratory tract infections. In patients without artificial airways, several structures and substances are present that prevent lower respiratory tract infection. Saliva in the oral cavity provides several protective mechanisms against infection, including physical removal of microorganisms through swallowing, a high concentration of immunoglobulin A and complement, and a liquid environment that prevents biofilm formation on dental enamel and oral mucous membranes. In addition, saliva also

contains numerous non-specific protective factors such as lysozyme, lactoferrin, histatins, mucins and peroxidases that have a protective function at mucosal surfaces. Moreover, salivary flow buffers oral pH, thus neutralizing acid production in order to maintain dental and mucosal integrity and facilitate oral particulate clearance (Cerrutti & Rescigno, 2008; Cole, Wirth & Bowden, 2013; Hajishengallis, 2014).

Statistically, up to one-third of critically ill patients are susceptible to developing a lower respiratory infection such as VAP (Armstrong & Mosher, 2011; DeKeyser Ganz et al., 2009). It is not possible to determine which critically ill patients will develop hospital acquired pneumonia as a result of bypassing their physiological protective structures without assessing their oral cavity. It has been determined that poor oral health among mechanically ventilated patients increases the bacterial virulence of oropharyngeal secretions that lead to the subsequent development of nosocomial infections (Paju & Scannapieco, 2007) However, despite of the American Association of Critical Care Nurses (AACN) recommendations advocating for oral care, fewer than 44% of critical care nurses report brushing teeth (DeKeyser Ganz et al., 2009). Therefore, translation of evidence-based oral care practice guidelines is important to improving patient outcomes for critically ill, mechanically ventilated, care-dependent patients (CDC, 2014; ICSI, 2011; Shi et al., 2013).

Oral Hygiene

Acutely ill patients are reliant upon nursing staff to perform oral hygiene. However, studies report that staff are lacking in appropriate knowledge regarding the tools to adequately and consistently assess and provide oral care (Ames et al., 2011; Chan, Lee, Poh, Ling, & Prabhakaran, 2011; DeKeyser Ganz er al., 2009; Muscedere et al., 2011; Nicolosi et al., 2014; Prendergast, Kleiman, & King, 2013; Richards, 2013; Ross & Crumpler, 2007). Oral care of the critically ill hospitalized patient is an essential component of nursing care; therefore it is a nursing responsibility. This care is particularly important to mechanically ventilated patients when both disease and treatments lead to the deterioration of the oral membranes and teeth.

This deterioration is primarily due to the marked decline in salivary secretions resulting from disease processes and adverse effects related to medication regimens (Holmes & Mountains, 1993). Oral care is an important intervention that can augment the progression of microbial proliferation in the mouth (Garcia et al, 2009). A thorough oral assessment is required to provide clinicians with the patient's baseline oral health status, monitor response to therapies, identify new problems, and to decrease the risk of having commensal microflora with the oral cavity from potentially proliferating to a pathogenic state thus increasing the risk of pneumonia as a result of intubation or aspiration.

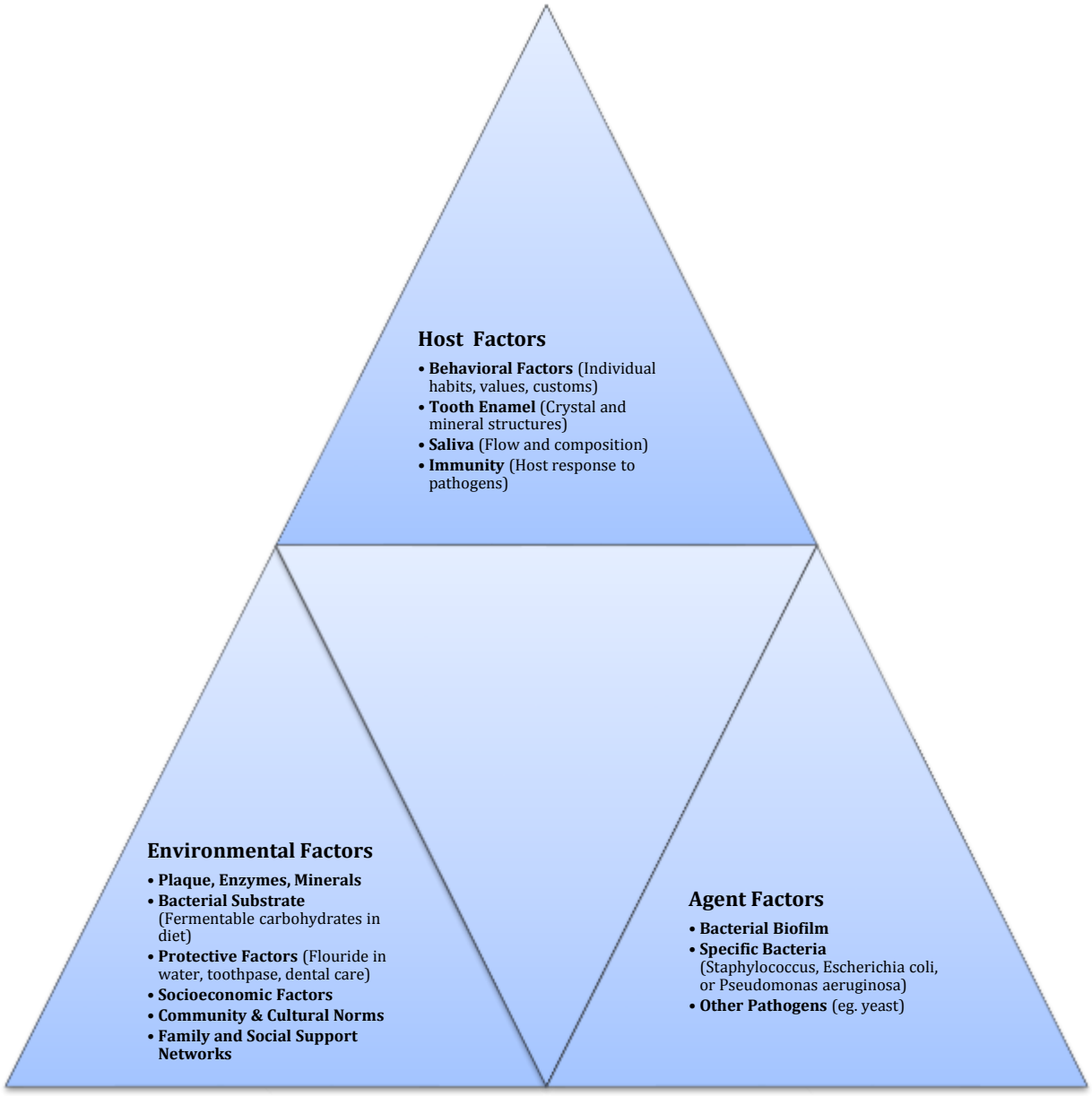
Oral Assessment Role

Human disease does not arise in a vacuum nor does it occur by chance. Epidemiology, the study of the determinants and distribution of disease, forms the research basis of public health interventions, including those that are implemented in health care facilities to prevent nosocomial infections. Epidemiology is based on two fundamental principles that state that disease does not occur at random and that disease is preventable (Nelson, 2014). Although some diseases are genetic in origin, most human diseases, particularly infectious diseases such as those included in ventilator-associated events, are caused by events, clinical conditions, host characteristics, or a complex combination of these factors. Research methods, driven by an epidemiological framework that links the host, an agent, and the environment, can be used to evaluate the different factors or characteristics that favor the development, acquisition, and transmission of infectious disease and its burden on populations. Furthermore, epidemiological studies can be used to evaluate these multifactorial relationships in an effort to alter or intervene in the disease cycle (Gange & Golub, 2014).

In summary, the mouth is a window to the overall health of the patient. Poor oral health represents a general balance among host's physiology, ongoing disease processes, and adequate oral care aimed at preventing oral biofilm build-up, aspiration, and decompensation. Oral deterioration and respiratory decompensation occurs when the balance is altered by

changes in the interacting relationships among the stated factors. Prevention is concerned with maintaining or initiating a balance of these factors to reduce the likelihood of oral infectious processes that may lead to VAE development. The next section will describe the features that agent, host, and environment as they relate to the Epidemiological Triangle of Infectious Disease.

Figure 2.1. Epidemiological Triangle



Epidemiological Triangle of Infectious Disease

The Epidemiologic Triangle (Figure 2.1) is a conceptual framework that can be used to model the transmission dynamics of an infectious disease (Friss & Sellers, 2014). The three essential characteristics of the Epidemiological Triangle include the susceptible host, infectious agent, and the environment. These three elements are depicted in Figure 2.1. The Epidemiological Triangle describes disease by identifying the patterns of acquisition/exposure, transmission, and risk factors inherent to a disease, in order to predict and thereby control or prevent its transmission among a population within a particular setting (Friss & Sellers, 2014; Gange & Golub, 2014). The epidemiological framework will guide the explanation of how agent, host, and environmental factors jointly contribute to the development of VAE.

Agent

Within the epidemiologic triangle, an agent is a factor whose presence, absence, excess or deficit is necessary for a particular disease or injury to occur. Bacteria, protozoa, and viruses are examples of agents that have the potential to cause infectious disease depending on their pathogenicity, virulence and infectivity. The pathogenicity of an organism is its ability to cause disease (Nelson, 2014, p. 27). Virulence is the degree of pathogenicity within a group or species of microorganisms as indicated by case fatality rates and/or the ability of the organism to invade the tissues of the host (Nelson, 2014). Infectivity refers to the ability of a pathogen to establish an infection (Nelson, 2014). These terms attempt to describe various aspects of the agent's impact on infectious disease. By measuring the pathogenicity, virulence, and infectivity of a microorganism, clinicians can reduce the impact of the agent on the susceptible host (Gange & Golub, 2014, p. 44).

Infective agents that exist and flourish within protective biofilms have been the source of disease throughout evolutionary history. Biofilms affect the course and pathogenesis of a number of systemic diseases including diabetes, cardiovascular disease, preterm birth, and VAP (Igari, Kudo, Toyofuku, Inoue, & Iwai, 2014). Biofilms form tightly on biological and

synthetic surfaces. This bacterial structure provides advantages and protection for species such as *S. aureus*, *P. aeruginosa*, *S. mutans* and *Enterobacteriaceae*, from the host immune system and from antimicrobial penetration (Chestre & Fagon, 2002). Biofilm formation enables planktonic single celled microorganisms to adhere to each other and to a variety of moist surfaces such as living tissues, indwelling medical devices, water system piping and natural aquatic systems. This dynamic adherence process, of highly differentiated organisms, is triggered in response to environmental changes, forming matrix-enclosed bacterial populations in an effort to facilitate survival within adverse environments (Høiby, Bjarnsholt, Givskov, Molin, & Ciofu, 2010; Nobbs, Jenkinson, & Jakubovics, 2011). After attachment, bacteria produce a very sticky substance known as extracellular polymeric substance that traps nearby planktonic bacteria and cements them into the biofilm, a process known as coadhesion.

As biofilm grows, nearby planktonic bacteria bind together through a process known as coaggregation in preparation for adhesion to a larger microenvironmental matrix structure (Huang, Li, & Gregory, 2011). These processes form three important survival advantages for bacteria in the oral cavity. First, bacteria that are tightly aggregated to one another and adhered within a biofilm are no longer influenced by the flow of saliva and cannot be swallowed or otherwise removed from the oral cavity (Hannig & Hannig, 2009; Huang et al., 2011). Second, bacteria in close contact with other bacteria can freely exchange plasmids and pathogenicity islands that encode for more pathogenic virulence factors (Hannig et al., 2009; Hojo, Nagaoka, Ohshima, & Maeda, 2009; Huang et al., 2011). In fact, even commensal non-pathogenic bacteria in the oral cavity can become highly virulent within a biofilm with other highly virulent bacteria. Third, the extracellular polymeric substance is impermeable to antimicrobial molecules and soluble immune factors such as the complement system and immunoglobulins (Huang et al., 2011). These important features of biofilms allow pathogens to thrive in the oral cavities of patients with artificial airways.

Aggressive and ongoing interventions that focus on removal of bacteria from the artificial airway, dental enamel, and mucosal membranes are necessary to prevent the initial processes of biofilm formation. Bacterial communication, within and between species, occurs through molecular biochemical signaling within the oral biofilm matrix. The signal molecules, termed autoinducers (AI), allow both monospecies and multispecies communities to synchronously regulate gene expression (via a positive feedback loop), and therefore behavior, on a community-wide scale (Huang, Li, and Gregory, 2011; Li & Nair, 2012; Mohapatra, & Biswas, 2013). The process of cell-cell communication in bacteria, known as quorum sensing (QS), plays a critical role in shaping the composition of oral microflora by regulating gene expression in a cell-density-dependent manner (Huang et al., 2011; Li & Nair, 2012). Bacteria use QS to coordinate cellular functions such as biofilm formation, virulence, and antibiotic resistance, based on the local density of the bacterial population, according to Li and Nair (2012). When a biofilm becomes too densely populated, pathogens near the surface of the biofilm convert to their planktonic form and leave the biofilm in search of a new location within the oral cavity or respiratory tract.

These pathogens, which commonly colonize pulmonary parenchyma in mechanically intubated patients, are endemic to healthcare settings as shown by Klompas and colleagues (2014). In hospitals, biofilms form on durable medical equipment (i.e. mechanical ventilators) enabling pathogenic organisms to persist as reservoirs and readily spread to patients. These microorganisms utilize a vast array of virulence factors, which are readily transmitted between each other within biofilms, to induce inflammation, tissue destruction, and cell death. Biofilm can develop both in the community environment and in the healthcare setting. In hospitals, biofilms form on medical equipment enabling pathogenic organisms to persist as reservoirs and readily spread to patients. Inside the host, biofilms allow pathogens to subvert innate immune defenses and are thus associated with long-term persistence. As these pathogens reproduce, they exchange genetic material, leading to genetic and phenotypic variability, as well as antimicrobial

resistance to infectious agents within the oral biofilm matrix (Huang, Li, and Gregory, 2011; Kumar, Mason, & Yu, 2013).

Genetic variability is a measure of the tendency of individual genotypes in a population to vary from one another by means of genetic exchange (Cummings & Lessler, 2014). In essence, genetic variability leads to genetic biodiversity within a population (Frankham, 2005). Genetic and phenotypic variability is essential for populations to adapt to environmental changes. This is true in nature, as well as in the human mouth. In nature, two historical occurrences illustrate this adaptation method. The genetic variability allowed pathogens to spread and transmit over time to millions of people (Cummings et al., 2014). Furthermore, because each of these adaptations is associated with a simultaneous change in antigenic structure, the host's immune system becomes less effective at recognizing the pathogen. This leads to uninhibited microbial reproduction and damage to host cells.

In summary, the agent's adaptability, virulence, resistance and stealth allows for its pathogenicity. Pathogens have the ability to communicate and adapt to changing environments allowing them to survive and develop highly virulent characteristics over time due to genetic and phenotypical variability.

Host

A host is the individual susceptible to the infectious agent. In a health care setting, the host may be a patient, visitor, or health care worker; although most of the emphasis of health care associated infection prevention is placed on the patient. When the host has adequate protection against infectious agents, it is less susceptible to infection. A host's innate defenses (i.e. normal flora, skin, epiglottis, sphincters, complement, neutrophils, macrophages) and acquired defenses (e.g. antibodies, lymphocytes) provide this protection, but they can be weakened by age, medical comorbidities, poor nutrition, genetic mutations, medications, invasive devices or procedures, and the patient's environment (Margolick, Markham, & Scott, 2014; Nelson & Steinhoff, 2014).

Individuals with invasive devices, such as artificial airways, are at particularly high risk for the development of health care associated infections once they are exposed to an infectious agent. Invasive biomedical devices are inserted into the host to facilitate medical care, but they bypass one or more primary lines of host defense. In the case of an artificial airway, the epiglottis is maintained in an open position, which permits bacteria and yeast from the oral cavity to migrate into the respiratory tract causing infection. Furthermore, an invasive biomedical device provides a surface to which infectious agents, particularly bacteria, can adhere, form biofilm, and more easily migrate into the lungs (Thomas, 2013).

Environment

The transmission of infectious agents from contaminated sources external to the host can lead to the development of a hospital acquired infection (HAI). The environment plays an important role in infectious disease epidemiology. A host's environment is comprised of the host's physical surroundings and includes inanimate objects, air, water, and human contact (Coffin et al., 2008; Mehta et al., 2014; Paitoonpong, Wong, & Perl, 2014). Particularly in the intensive care unit, environmental factors, such as medical equipment, beds, furniture, and other persons, harbor and promote the spread of pathogens (De la Fuente-Núñez, Reffuveille, Fernández, & Hancock, 2013; Paitoonpong et al., 2014).

Many virulence factors expressed by pathogens, including adhesions, pili and fimbriae, facilitate tight adherence of the pathogen to both inanimate and live surfaces. Moreover, some bacteria can produce spores, which contain viable pathogen DNA and permit prolonged pathogen survival within even the most hostile environmental surroundings.

Pathogens can be transmitted in a variety of ways through the environment, including through direct physical contact, droplet nuclei in the air and direct inhalation of the organism. Organisms such as those that cause VAE are spread primarily through direct physical contact. Humans live in continuous interaction with their environment. Patients with an artificial airway, especially if neurologically impaired or pharmacologically sedated, are particularly susceptible to

environmental influences. In the critical care environment, these patients reside in a physical environment that is heavily contaminated with a diverse ecology of highly virulent microorganisms. Because these patients require frequent and usually hands-on care due to their critical illness, they are often brought into direct physical contact with these microorganisms.

Medications. Medications can increase the risk for infection in patients with artificial airways. The use of highly potent antimicrobial medications to treat infections elsewhere in the body can have important consequences in the pulmonary tract. First, broad-spectrum antibiotics can have bactericidal effects on normal non-pathogenic flora that would otherwise offer the host protection against the proliferation and migration of pathogenic flora. Second, inappropriate antimicrobial use can lead to antimicrobial resistance. Anti-inflammatory medications, including glucocorticoids and chemotherapeutic agents, suppress several immune mechanisms in the host. In patients with artificial airways, these immune mechanisms are among the only defenses available to prevent lower respiratory tract infections. When high doses of anti-inflammatory medications are given, the alveolar inflammatory response is blunted and pathogens are allowed to establish permanent colonies within the lung parenchyma. Guidelines have been published that facilitate appropriate use of antimicrobials and anti-inflammatories (Bassetti, Taramasso, Giacobbe, & Pelosi, 2012), but adherence to these guidelines has not been evaluated. Regardless, medications are an important part of the host's environment, particularly in the critical care unit, and clinicians must be cautious to avoid inappropriate medication use.

Mechanical Ventilation. The mechanical ventilator and its circuitry are important reservoirs of respiratory infection in the critical care unit. The ventilator must be properly maintained based on the number of hours of use. Condensate forming within the breathing circuit can also facilitate bacterial growth. The ventilator surfaces must be cleaned and the breathing circuit and endotracheal tube must be discarded or appropriately sterilized between patients. The breathing circuit and endotracheal tube are constructed of plastic and should be

sterilized or replaced in accordance with the manufacturer's recommendations. Mechanical ventilators may also contain humidifiers that must be cleaned and refilled with water from a suitable uncontaminated source. There is also a risk of trauma to the oral mucosa during intubation or alveolar distention during positive pressure ventilation, either of which could further compromise the host's natural defenses.

Staff. Nurses, physicians, and respiratory care practitioners are important within the mechanically ventilated host's environment. The nurse has frequent and prolonged direct contact with the host during bathing, repositioning, medication administration, and clinical procedures. The physician has less frequent or prolonged exposure to the host than nurses, but contributes significantly to the host's risk for respiratory tract infections through initial placement of the artificial airway, prescription of ventilator settings and medications, and ordering diagnostic studies to monitor for evidence of infection. The respiratory care practitioner also has frequent, though usually brief, direct contact with the host. However, physical contact between the respiratory care practitioner and host involves several opportunities to introduce potential pathogens into the ventilator circuit or other aspects of the host's environment.

Clinicians involved in the care of mechanically ventilated patients must be knowledgeable of the basic concepts of infectious disease epidemiology and proficient with their application to this population (Gange & Golub, 2014). Using an epidemiological perspective, in particular, the Epidemiological Triangle can be a useful strategy to frame quality improvement projects related to the prevention of VAE. Evidence-based interventions addressing all three aspects (i.e. agent, host, and environment) must be used to accomplish the goal of eradicating VAEs in the mechanically ventilated population.

Literature Search Strategy

A comprehensive literature search occurred electronically to find the best evidence-based research relevant to oral health and VAE prevention. The following electronic databases were searched: Cumulative Index to Nursing and Allied Health (CINAHL), Cochrane Database

of Systematic Reviews, ProQuest, Medline, PubMed, Joanna Briggs Institute, and the National Guideline Clearinghouse. The search was limited to scholarly articles, published in English, since 2000 to ensure inclusion of classic articles. Search terms used for the literature search included: *oral care and ventilator-associated pneumonia prevention, oral biofilm elimination, oral hygiene, oral assessment,* and *oral assessment tools.* Boolean phrases "*and*" and "*or*" were used between words to produce a larger volume of search results. The literature reviewed included peer-reviewed journal articles, evidence-based practice articles, systematic reviews, and meta-analyses. Additionally, the bibliographies for relevant research articles were consulted to expand the literature search. Articles that were not clearly related to this EBP project, editorials, expert opinions, and commentaries were excluded from the search.

Following the literature search, articles were reviewed for completeness and scope. Duplicate studies were eliminated and all remaining articles were appraised to evaluate their adequacy and transferability to this study. After thorough analysis, fifteen articles were selected for this project.

Sources Examined for Relevant Evidence

All studies that were chosen for inclusion addressed the standard of oral care, use of placebo or other products for oral care as control interventions and retained studies that reported rates of ventilator associated pneumonia as outcomes. In CINAHL, out of a total of 130 possible articles four studies were appropriate for inclusion. A PubMed via EBSCO search yielded nine articles. Out of those nine, three articles were appropriate to this study. The remaining articles were discarded due to their lack of specificity to the subject under investigation. In the Cochrane Database of Systematic Reviews, a search revealed 96 articles and of those, eight meta-analyses addressed the clinical question. ProQuest yielded 13 potential sources based on the key terms. Of those, only one research article addressed the clinical question. The remaining 12 articles did not meet inclusion criteria. Searches of the Joanna Briggs Institute database resulted in seven articles. Out of seven, two were selected for

inclusion into this study. Additionally, a search was done of the National Guideline Clearinghouse database and it resulted in 14 guidelines. Only one evidence-based guideline was appropriate for inclusion. The CONSORT Diagram in Figure 2.2 illustrates the flow of the process used to appraise the evidence in the literature.

Following the literature search, nineteen articles were reviewed for completeness and scope. Duplicate studies were eliminated and all remaining articles were critiqued. After thorough examination, fifteen articles were selected for this project. The articles considered for review included systematic reviews, meta-analyses, randomized control trials (RCTs), quasi-experimental studies, descriptive studies and a clinical practice guideline.

Critical Appraisal of Evidence

The Australian government's National Health and Medical Research Council (NHMRC) 2005 classification system was utilized to appraise the level and quality of evidence for each selected article. Out of the fourteen articles selected for inclusion, eight were meta-analyses of RCTs (Level I); two were RCTs (Level II); one was a quasi-experimental study (Level III-1); and four case studies with pre-test and post-test outcomes (Level IV). Ten of the articles were rated "A" for overall high quality, three articles were rated at "B" for good quality, one article was rated "C" for satisfactory quality, and none were rated "D" for poor quality. A summary of the articles and their individual appraisal is presented on Table 2.1, which provides a summary of the authors, date of publication, level of evidence rating, and key finding related to the proposed EBP project.

Table 2.1

Appraisal of Literature

Author(s) Date	Levels of Evidence	Key evidence and related findings
Alhazzani et al., (2013)	Level I	• Systematic review of six randomized control trials (RCT) comparing different tooth brushing modalities (electric with manual) and chlorhexidine (CHX) use to usual oral care. • In four trials, there was a trend toward lower VAP rates (risk ratio [RR], .77; 95% CI, .50 to 1.21; p = .26). The only trial with low risk of bias suggested that toothbrushing significantly reduced VAP (RR, .26; 95% CI, .10 to .67; p = .006). • Use of chlorhexidine antisepsis seems to attenuate the effect of toothbrushing on VAP (p= .02). • One trial comparing electric vs. manual toothbrushing showed no difference in ventilator-associated pneumonia rates (RR, .96; 95% CI, .47 1.96; p = .91). • Toothbrushing did not impact on length of ICU stay, or ICU or hospital mortality.
Ames et al., (2011)	Level IV	• Evidence summary to identify the best available tools, the modified Beck Oral Assessment Scale (BOAS) and the Mucosa-Plaque Score (MPS), for the oral assessment and evaluation of oral hygiene as a means of reducing oral

Author(s) Date	Levels of Evidence	Key evidence and related findings
		microflora that leads to the development of VAP.
CDC (2004)	Level I	• CDC offers (clinical practice guidelines) recommendations in the prevention and control of VAP.
Gastmeier & Geffers, 2007	Level I	• Systematic review of 15 RCTs that identified multi-module programs for reducing VAP rates. The data lead to the conclusion that topical use of CHX for oral care is beneficial and subglottic secretion drainage may lead to delayed onset of VAP.
Grap et al., (2011)	Level II	• This RCT tested an early intervention involving a single dose application of CHX by swab versus control (no swab) in an effort to reduce the incidence of VAP. • This study randomly assigned 145 trauma patients requiring endotracheal intubation to the intervention (5 mL CHX) or control group. VAP (Clinical Pulmonary Infection Score [CPIS] ≥ 6) was evaluated on study admission and at 48 and 72 hours after intubation. • A significant treatment effect was found on admission to 48 hours ($p = .020$) and to 72 hours ($p = .027$). • The study concluded that an early, single application of CHX to the oral cavity significantly reduces CPIS and thus VAP in trauma patients.

Author(s) Date	Levels of Evidence	Key evidence and related findings
Hutchins et al., (2009)	Level IV	• Descriptive study involving the implementation of an oral care intervention every four hours on mechanically ventilated adult patients. • The use of an oral care intervention led to an 89.7% reduction in the VAP rate in mechanically ventilated patients from 2004 to 2007. • The pre-implementation VAP rate in 2004 was 12.6 cases/1000 ventilator-days. After the implementation of the oral intervention the VAP rates decreased to 4.12 VAP cases/days of ventilation x 1000 ventilator-days for May to December 2005, to 3.57 for 2006, and to 1.3 for 2007. • The study concluded that the use of an oral care intervention led to a reduction in the VAP rate among mechanically ventilated patients in this study.
Hillier et al., (2013)	Level I	• This systematic review and meta-analysis of evidence comparing the effect of oral care practices, oral hygiene products and oral protocols on VAP incidence rates. • Review concluded that the implementation of an oral care protocol, ongoing nurse education, and evaluation were important in reducing the incidence of VAP.

Author(s) Date	Levels of Evidence	Key evidence and related findings
ICSI (2011)	Level I	• Institute for Clinical Systems Improvement (ICSI) published evidenced based VAP prevention guidelines in conjunction with the National Guidelines Clearinghouse- (Guideline Summary NGC-8966). This systematic review identifies the best available evidence for recommendations in the prevention of VAP. The aims for this protocol are to eliminate VAP and to increase the use of the VAP bundles and order sets in the management of mechanically ventilated adult patients residing in the intensive care setting.
Koeman et al., (2006)	Level II	• The objective of this randomized, double blind, placebo-controlled clinical trial was to determine the effect of oral decontamination with CHX or CHX/COL on VAP incidence and time to development of VAP. • This study enrolled 385 patients into three arms of the trial. Baseline characteristics were comparable. The daily risk of VAP was reduced in both treatment groups compared with placebo: 65% (hazard ratio [HR] = .352; 95% CI, .160, .791; p=.012) for CHX and 55% (HR=.454; 95% CI, .224, .925; p= .030) for CHX/COL. • The study concluded that oral decontamination with CHX or CHX/COL reduces

Author(s) Date	Levels of Evidence	Key evidence and related findings
		the incidence of VAP. CHX/COL provided significant reduction in oropharyngeal colonization with both gram-negative and gram-positive microorganisms, whereas CHX mostly affected gram-positive microorganisms.
Muscedere et al., (2011)	Level I	• Systematic review and meta-analysis of evidence comparing thirteen RCTs with a total of 2442 randomized patients. The RCT involved mechanically ventilated adults patients and compared standard endotracheal tube use with and without subglottic secretion drainage access and reported on the occurrence of VAP. • Of the 13 studies, 12 reported a reduction in VAP rates in the subglottic secretion drainage arm. • The overall VAP RR was .55 (95% CI, .46-.66; p < .00001) with no heterogeneity (I = 0%). The use of subglottic secretion drainage was associated with reduced intensive care unit length of stay (-1.52 days; 95% CI, -2.94 to -.11; p = .03); decreased duration of mechanically ventilated (-1.08 days; 95% confidence interval, -2.04 to -.12; p = .03), and increased time to first episode of ventilator-associated pneumonia (2.66 days; 95% CI, 1.06-4.26; p = .001). There was no effect on adverse events or on hospital or intensive care unit mortality.

Author(s) Date	Levels of Evidence	Key evidence and related findings
Nicolosi et al., (2014)	Level III-1	• Quasi-experimental study comparing the use instructor led oral hygiene (tooth brushing) and oral rinses with .12% chlorhexidine gluconate (Group 1) to a historical control group (Group 2) in the prevention of VAP among cardiovascular surgery patients. • Dentist provided instruction and supervised oral hygiene with tooth brushing and chlorhexidine oral rinses.72 hours prior to cardiovascular surgery. • There was a lower incidence of VAP (2.7% [95% CI .7-7.8] vs 8.7% [95% CI 4.9-14.7], P = .04) and a shorter hospital length of stay (9 ± 3 d [95% CI 8.5-9.5] vs 10 ± 4 d [95% CI 9.4-10.7], P = .01) observed in the intervention group. • The risk for developing pneumonia after surgery was 3-fold higher in control group (3.9, 95% CI 1.1-14.2). • The study concluded that supervised oral hygiene with chlorhexidine proved effective in reducing the incidence of VAP.
Prendergast et al (2013)	Level IV	• A descriptive study evaluated the effectiveness of implementing two oral assessment tools. The Bedside Oral Exam and the Barrow Oral Care Protocol were used to guide oral assessments guide oral care for intensive care unit

Author(s) Date	Levels of Evidence	Key evidence and related findings
		patients. • This study compared the incidence of VAP and the cost of oral care supplies before and after implementation. • The intervention resulted in a decrease in the incidence of VAP from 4.21 to 2.1 per 1000 ventilator days (p =.04). Additionally, a cost savings of 65% was noted on a monthly basis for oral hygiene supplies and nursing staff reported increased satisfaction in providing oral hygiene with a combination of oral care products. • The study concluded a significant reduction in the incidence of VAP with the Barrow Oral Care Protocol.
Richards (2013)	Level I	• Systematic review and meta-analysis of evidence assessed oral healthcare in four domains for the purpose of comparison in the development of VAP. The four domains were chlorhexidine (CHX mouth rinse or gel) versus placebo/usual care, tooth brushing versus no tooth brushing, powered versus manual tooth brushing and comparisons of oral care solutions • This systematic review included 35 RCTs (5374 participants) and classified the trials according to their risk for bias, quality of evidence, and outcomes

Author(s) Date	Levels of Evidence	Key evidence and related findings
		associated with a reduction in VAP. • Seventeen RCTs (2402 participants) provide moderate quality evidence that oral care utilizing CHX mouth rinse or gel, as compared to placebo or usual care is associated with a reduction in VAP (OR .60, 95% CI .47 to .77, P < .001, I(2) = 21%) A number needed to treat (NNT) of 15 (95% CI 10 to 34) was established. • There was no evidence of a difference between CHX and placebo/usual care in the outcomes of mortality, duration of mechanical ventilation or duration of ICU stay. • There was insufficient evidence to determine whether there was a difference between CHX and placebo/usual care in the outcomes of duration of use of systemic antibiotics, oral hygiene indices, microbiological cultures, caregivers' preferences or cost. • Only three studies reported any adverse effects, and these were mild with similar frequency in CHX and control groups. • Four RCTs (828 participants) compared oral hygiene without tooth brushing with and without CHX, and was no evidence of a difference in the VAP rate (OR .69,

Author(s) Date	Levels of Evidence	Key evidence and related findings
		95% CI .36 to 1.29, P = .24, I (2) = 64%). • This review concluded that effective oral care is important in reducing VAP among ventilated patients in intensive care units. Oral healthcare that includes either CHX mouthwash or gel is associated with a 40% reduction in the odds of developing VAP in critically ill adults.
Ross et al., (2007)	Level IV	• Implementation of an evidence based oral care program that focused on patient safety, quality improvement, and improved patient outcomes (VAP reduction). • Implementation of an oral health assessment guide. • Concluded that an oral health assessment guide decreased median oral assessment guide scores (pre-test: eleven, post-test: nine). • Analysis (t-test) revealed a statistically significant difference (p= .0002) • The frequency of oral care documentation improved.
Shi et al., (2013)	Level I	• Systematic review and meta-analysis of evidence comparing the effects of oral hygiene care in the form of mouthwashes, gel rinses, tooth brushing (or in combination), and aspiration of secretions on the incidence of VAP among critically ill mechanically ventilated patients from 1980 to January 2013.

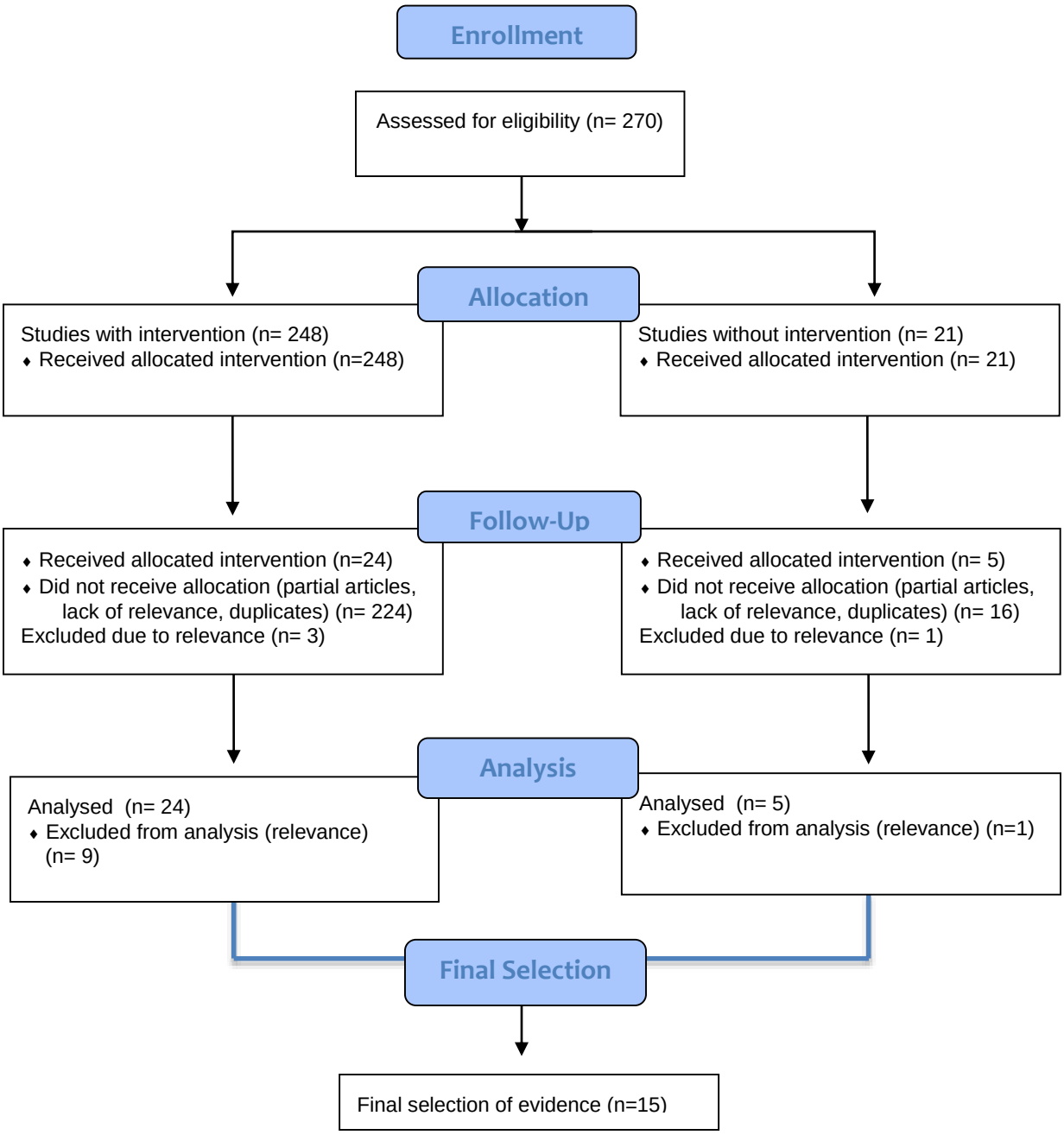
Author(s) Date	Levels of Evidence	Key evidence and related findings
		• Thirty-five RCTs (5374 participants) were included in this review and were classified according to their risk for bias, quality of evidence, and outcomes associated with VAP reduction. • There were four main comparisons domains: or care solutions such as CHX mouths rinse and CHX gel, versus placebo/usual care, tooth brushing versus no tooth brushing, powered versus manual tooth brushing and comparisons of oral care solutions such as saline, a weak povidone iodine solution, peroxide solution and tap water. • There is moderate quality evidence from 17 RCTs (2402 participants) that CHX mouth rinse or gel, when compared to usual care was associated with a reduction in VAP (OR .60, 95% (CI) .47 to .77, P < .001, I(2) = 21%). This is equivalent to a number needed to treat (NNT) of 15 (95% CI 10 to 34) indicating that for every 15 ventilated patients in intensive care receiving oral hygiene including chlorhexidine, one outcome of VAP will be prevented. • There is no evidence of a difference between CHX and placebo or usual care in the outcomes of mortality (OR 1.10, 95% CI .87 to 1.38, P = .44, I(2) = 2%, 15

Author(s) Date	Levels of Evidence	Key evidence and related findings
		RCTs, moderate quality evidence); duration of mechanical ventilation (MD .09, 95% CI -.84 to 1.01 days, P = .85, I(2) = 24%, six RCTs, moderate quality evidence); or duration of ICU LOS (MD -.21, 95% CI -1.48 to 1.89 days, P = .81, I(2) = 9%, six RCTs, moderate quality evidence). • One RCT compared use of a mechanical toothbrushing to manual toothbrushing. The study provided insufficient evidence to determine the effect of intervention on any of the measurable outcomes of this review. • A range of other oral care solutions were compared. There was weak evidence that povidone iodine mouth rinse is more effective than saline in reducing VAP (OR .35, 95% CI .19 to .65, P = .0009, I(2) = 53%) (two studies, 206 participants, high risk of bias). However, due to the variation in comparisons and outcomes among the trials, there is insufficient evidence concerning the effects of other oral care solutions on the outcomes of interest. • The authors concluded that the provision of oral hygiene that includes CHX mouth rinse is associated with a 40% reduction in the odds of developing VAP among critically ill adults residing in the intensive care unit. There was no

Author(s) Date	Levels of Evidence	Key evidence and related findings
		evidence of a difference in mortality, duration of mechanical ventilation or duration of ICU length of stay. • There was weak evidence to suggest that povidone iodine mouthrinse is more effective than saline in reducing VAP. There is insufficient evidence to determine whether powered toothbrushing or other oral care solutions are more effective in reducing VAP when compared to manual brushing with CHX.

Figure 2.2

CONSORT Flow Diagram



Theoretical Framework

This section will discuss the theoretical framework that was chosen to inform this evidence based practice change. A review of literature that represents an integrative review was conducted and will be discussed.

Diffusion of Innovation

The theoretical framework chosen for this EBP project is Rogers' Diffusion of Innovations (DOI). This well-established model, with more than 5000 publications associated with it since it was first published in 1962, is rooted in the works of Gabriel Tarde, a French sociologist, criminologist and social psychologist, who plotted the original S-shaped diffusion curve. DOI is of current importance because "most innovations have an S-shaped rate of adoption" (Rogers, 1995). Over the past decades, the Diffusion of Innovation paradigm has been implemented and validated by scholars from diverse disciplines and fields of study such as anthropology, sociology, education, public health, nursing, medicine, communications, and marketing, according to Rogers (2003).

Theory description

Nursing, like other allied health care fields, is a science-based profession. Research and technology continually evolve and it is expected that corresponding care and treatments evolve as well (Frantsve-Hawley & Meyer, 2008). New scientifically informed ideas, technologies, and methods can be successfully implemented and adopted for a variety of systems through the use of Rogers' Diffusion of Innovations Theory (DOI). This theory fits well with this EBP project because it provides a framework though which the adoption and use of innovation can effect social change.

Diffusion of Innovation typically refers to a process by which a system adopts a new practice. Rogers defines innovation as an ideal, or practice, that is perceived as new by a person, unit, or organization. Diffusion, according to Rogers (2003), is the process by which an innovation is communicated through certain channels over time among the members of a social

system or organization (Frantsve-Hawley & Meyer, 2008). Rogers' DOI (1995, 2003) proposes that adopters of any new innovation or idea can be categorized based on the number of standard deviations from the mean of the normal curve. It also proposes that each system's willingness and ability to adopt an innovation depends on their awareness, interest, evaluation, trial, and adoption. Adoption occurs through subjective evaluation and communication regarding the new innovation by those who have had success with the innovation (Frantsve-Hawley & Meyer, 2008; Rogers, 2003).

Diffusion occurs through a five–step decision-making process. Rogers' five stages include: knowledge, persuasion, decision, implementation, and confirmation. The first step, knowledge, is influenced by needs and desires of the decision making unit as well as the prior conditions such as traits and norms of the group (Rogers, 2003). Persuasion is determined by how adopters will perceive (a) the need for innovation and (b) the characteristics of the new practice (Frantsve-Hawley & Meyer, 2008; Simpson, 2011). If the innovation is of relative advantage or perceived to be significantly better than current practice, well suited to the goals and values of the organization (compatibility), easy to use and understand (simplicity), able to be tried out first (trialability), and demonstrably beneficial (observability) then it is more likely to be adopted. However, the decision stage takes into account the change and weighs the advantages and disadvantages for using the innovation and decides whether to adopt or reject it (Rogers, 2003). During the implementation phase, if the innovation is determined to be useful, it is put into practice. The last stage is confirmation and it involves the evaluation of outcomes related to the innovation and the reaffirmation that the implementation was the right decision.

The innovation must be widely adopted in order to be self-sustaining. The rate of adoption is variable and is measured by the length of time required for a percentage of individuals to adopt the innovation. The rate of adoption has to reach a critical mass, a point at which enough persons have adopted the innovation for it to continue. Rogers suggests a number of strategies that could be used to achieve the critical mass: (a) have a highly respected

individual within a social network adopt and promote the innovation, (b) create a desire for a specific innovation, (c) inject an innovation into a group of early adopters who would readily use it, and (d) provide positive feedback and benefits for early adopters (Rogers, 2003).

Diffusion signifies a group phenomenon, which suggests how an innovation spreads through the different adopter categories. The categories of adopters are: innovators, early adopters, early majority, late majority and laggards. Among those, there are certain characteristics of early adopters that should be noted. Rogers describes early adopters as having a higher social status, being more financially stable, well-educated, and more socially forward than late adopters (Rogers, 2003). Opinion leaders, Rogers suggest, derive predominately from the early adopter category and exert influence over the others. Opinion leaders are influential in spreading either positive or negative information about an innovation. They have greater exposure to the mass media, are in contact with change agents, have a higher social experience, better socioeconomic status, and are more personally innovative than others (Rogers, 2003).

There are consequences to innovation. Both positive and negative outcomes are possible when an individual or organization chooses to adopt or reject a particular innovation. Rogers lists three categories for consequences: desirable or undesirable, direct or indirect, and anticipated or unanticipated. The benefits of an innovation are the positive consequences, while the costs are the negative. Costs may be direct or indirect. Direct costs are usually related to financial burden while indirect costs are more difficult to identify. An example would be the need to ‘staff up’ in order to implement an innovative change. Indirect costs may also be social, such as social conflict caused by innovation (Rogers, 2003; Simpson, 2011).

Theoretical Framework Strengths and Limitations

The strengths of using Rogers’ DOI framework for this EBP project are readily apparent. The DOI model continues to be applied successfully to different specialties with varying problems and needs. The areas of application for these studies range from agriculture,

engineering, mathematics, and nursing (Rogers, 1995; Simpson, 2011). This is largely due to the model's generalizability and transferability to applied research (Greenhalgh, Robert, Macfarlane, Bate & Kyriakidou, 2004; Rogers, 2003).

Limitations of Rogers' DOI framework include pro-innovation bias and individual-blame bias (Rogers, 2003). Pro-innovation bias is the belief that an innovation should be adopted by a system without the need of its alteration. The innovation's change agent has such strong bias in favor of the innovation, that limitations remain inadvertently unnoticed. A second limitation is individual-blame bias. The individual-blame bias is a tendency to blame individuals for their non-adoption. Some persons are laggards simply because they do not like change and are slow to adapt to change. The responsible change agent must look beyond such individualistic explanations to fully understand the rationale for systematic non-adoption. Instead, the change agent should examine how the characteristics of the innovation might influence human behavior toward adoption or rejection of a change effort.

Application of the Theoretical Framework to EBP Project

Everett Rogers' ground-breaking framework has contributed to a greater understanding of innovative change, including the variation in rates of adoption of innovations, and it has held a broad scope of practical applications in the nursing and dental fields. Principles from the Rogers theoretical framework are incorporated into this EBP project. Key concepts of the framework are italicized in this section to highlight their application to the EBP project.

The *innovation* for this project is a standardized oral health assessment for orally intubated patients in the ICU, which is an innovation for the project sites since they have historically lacked a standardized oral health assessment. Two oral health assessment tools, the modified Beck Oral Assessment Scale (BOAS; Appendix A) and the Mucosa-Plaque Score (MPS; Appendix B) will be combined to form one standardized oral health assessment tool specific for patients with endotracheal tubes. These tools have been shown to identify early

evidence of oral biofilm development, which is an important early step in the development of VAC.

Gaining approval and support of *opinion leaders* is an essential step in Rogers' model. The opinion leaders for this project initially consisted of the unit manager and unit clinical nurse specialist (CNS) at one of the project sites, who embraced this project from the beginning. During the project planning stage, clinical directors, infection preventionists, unit managers, and CNS at all participating hospitals were contacted via email over a period of two months in order to acquire their support, answer their questions, and discuss any concerns regarding the benefits and value of the innovation for patient safety, cost reductions, and process improvement. Rogers' five steps of innovation diffusion are instrumental during these discussions. Careful attention to knowledge building and persuasion is necessary throughout project implementation and evaluation as adopters use the innovation alongside the myriad distractions that are prevalent in the clinical setting. Anticipating these challenges, particularly related to the ongoing need for persuasion, is essential for adoption. As advocates for patient autonomy, clinicians need validation that the innovation fits within the contract for ethical treatment of human research participants. As employees who report to hospital administrators, clinicians need validation that their supervisors support the innovation, as well as the overall project.

Clinicians and administrators alike must make the *decision* to adopt the innovation. For administrators, this decision is made when providing the initial approval of the project for use in the clinical department and each time they encounter difficulties in sustaining the innovation. Clinicians make the decision to adopt the innovation initially when they are given the directive to do so (either through education or institutional policy) and each time they are responsible for acting on the innovation. Supporting the decision to adopt an innovation requires ongoing education and persuasion, which can be accomplished through frequent interactions with clinicians and administrators.

Implementation of the innovation occurs as the adopter folds the innovation into their usual patterns of care. In this project, implementation occurred when the ICU nurses became more comfortable using the standardized oral health assessment scale using the correct technique and at the correct frequency. This step requires active commitment from the adopters, frequent contact with the project leader, and ongoing support from administrators. Implementation can be measured through process measures, such as staff compliance with the innovation. A downward trend in compliance may indicate the need for more knowledge about the innovation, additional persuasion, and reaffirming the decision to continue implementation.

During the *confirmation* stage, the adopters are able to sustain the innovation with decreasing levels of external support from the project leader or institutional supervisors. Process indicators, such as innovation compliance, as well as outcome indicators, such as the incidence rate of VAE, can be measured, statistically analyzed, and interpreted for significant changes during this stage.

Strengths and Limitations of Rogers' Framework in the context of the EBP project

The strengths of using Rogers' DOI model for this EBP project are apparent. The DOI model continues to be applied successfully to different specialties with varying problems and needs. The areas of application for these studies range from agriculture (hybrid seed corn), technology (modern math and engineering), and health care (antibiotic use, HIV/AIDS prevention, oral health promotion) [Rogers, 1995; Simpson, 2011]. This is largely due to the model's generalizability and transferability to applied research (Greenhalgh, Robert, Macfarlane, Bate & Kyriakidou, 2004; Rogers, 2003).

Everett Roger's DOI framework has contributed to a greater understanding of behavioral change, including the variation in rates of adoption of innovations, and it has held a broad scope of practical applications in the healthcare field. However, the investigator anticipated two major limitations of the diffusion approach in the context of this EBP project. The first such limitation was pro-innovation bias or the belief that everyone should unequivocally adopt the innovation as

it exists. The investigator, as change agent, planned to mitigate pro-innovation bias by inviting stakeholders to participate in giving feedback on the proposed innovation. This systematic approach gave stakeholders an opportunity to voice their concerns and to understand how the innovations would impact their workflow. A second anticipated limitation was individual-blame bias or the tendency to blame individuals for their non-adoption. The investigator planned to mitigate this bias by investigating how the characteristics of the innovation might affect laggards or those resistant to change. The study not only included in-services for all staff nurses at the four facilities regarding the rationale for and use of the innovation, but also reinforced the change effort by rounding on a bi-weekly basis. Within this EBP project, the investigator planned to mitigate potential limiting factors by inviting all stakeholders to explore the benefits and consequences of adopting a new approach. With the inclusion of these planned mitigation efforts, the DOI provided a framework that fit well with this EBP project.

The evidence suggests that the incidence of the various conditions that comprise VAE can be reduced through the use of interventions that address the agent, host and environmental characteristics of disease. A guiding framework is required in order to enhance the likelihood of successful implementation and evaluation. The diffusion of innovation framework has attributes that make it useful in guiding the selection and implementation of interventions to prevent ventilator associated events among mechanically ventilated adults within the critical care setting.

CHAPTER 3

METHOD

The purpose of this project was to determine if an evidence-based standardized oral health assessment, combined with a staff education program, would reduce the incidence of ventilator associated events (VAE) among mechanically ventilated adults admitted into the intensive care units at four Midwest community hospitals. The review of literature supported a multifaceted intervention including routine structured oral assessments and staff education to improve oral care techniques. This chapter describes the population of interest, setting, and methods used for outcomes measurement, data analysis, as well as the procedures for implementation of the Evidence-Based Practice (EBP) project. Data management and protection of human subjects is also addressed.

Participants and Setting

The sites for this EBP project were four community hospitals in the Midwest, which are part of a multi-hospital not-for-profit organization. The settings of implementation include four medical-surgical intensive care units at these facilities and these units served as the units of analysis. These ICU areas admit critically ill patients at least 18 years of age, and approximately one-half receive mechanical ventilation via endotracheal tube. Because intervention and outcome data were not collected at the patient-level, demographic variables were not measured. However, ventilator-days (defined as the number of patients receiving mechanical ventilation at midnight census) during the study period were collected from an administrative database.

Design and Outcome Variables

This EBP project utilized a single-group pretest-posttest design in which all project sites began using the intervention simultaneously. The monthly VAE incidence

rate on each ICU was reported for a total of 13 months (nine months before implementation, four months after implementation). Standardized surveillance definitions for VAE were utilized for measurement of VAE incidence (Table 3.1). Briefly, incidence was calculated as the number of VAE cases per unit per month divided by the number of ventilator-days per unit per month, then standardized to a scale of 1,000 ventilator-days (# cases / # ventilator-days * 1,000 ventilator-days), which is consistent with the scale used in VAP prevention literature. The infection preventionist at each study site provided aggregated data at the unit level for the outcome variables listed in Figure 3.1.

Table 3.1

Outcome variables: National Healthcare Safety Network (NHSN) surveillance definitions

Variable	**Operational Definition**
Time	Defined in calendar months pre and post- implementation.
Patient-Days	Number of patients reported on the midnight census each day.
Ventilator-Days	Number of patients on a ventilator reported on the midnight census each day.
Ventilator Device	A device to assist or control respiration, inclusive of the weaning period, through a tracheostomy or by endotracheal intubation.
Ventilator Device Utilization Rate	Ventilator Device Utilization Ratio measures the proportion of total patient-days in which ventilators were used on a given unit during a specified time period. It is calculated by dividing the number of ventilator days by the number of patient days.
VAE Count	Number of VAE cases of patients on invasive mechanical ventilation; utilized standardized surveillance definitions for VAE
VAE Rate	Total number of ventilator-associated events derived from a specific standard population during a specified time period.
VAC Rate	Total number of observed healthcare-associated VACs among critically ill adult patients in the ICU

Variable	Operational Definition
IVAC Rate	Total number of observed healthcare-associated IVACs among critically ill adult patients in the ICU
Possible and Probable VAP rate	Total number of observed possible and probable VAP cases (with manifestations of purulent respiratory secretions or positive respiratory cultures) among critically ill adult patients in the ICU.

Intervention

Staff members that received the educational intervention were unit-based or float pool staff registered nurses (RN) assigned to work in one of the study settings. The intervention had two main components: (a) a standardized oral assessment and (b) an educational in-service for staff registered nurses at the study units that focused on the objectives listed in Table 3.3. Implementation of the intervention occurred at all sites over a 1-month period of time (October 2014), after which, post-intervention outcomes data collection commenced on a pre-determined date at all sites.

The standardized oral assessment was comprised of two non-invasive oral assessment tools: the Beck Oral Assessment Scale (BOAS) (Table 3.1) and the Mucosa-Plaque Score (MPS) (Table 3.2). As described in Chapter 2 of this EBP report, both of these tools have good internal consistency when used together. The BOAS and the MPS were incorporated into a standardized oral assessment data collection form (Figure 3.0) to increase the accuracy of the measured variables.

Additionally, the combined tool has excellent internal consistency as evidenced of a Cronbach's alpha of greater than .7.

The standardized oral assessment was to be performed every shift (defined for this project as every 12 hours). All nurses received the same educational content, and time was provided at the end of the in-service to answer questions.

Table 3.2

Beck Oral Assessment Scale (BOAS), modified

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

Note: Modified from Beck, S. (1979). Impact of a systematic oral care protocol on stomatitis after chemotherapy. *Caner Nursing, 2*, 185-199.

Table 3.3
Mucosa-Plaque Score (MPS)

Criteria
Mucosa
Normal appearance of gingiva and oral mucosa……..……**1**
Mild inflammation = slight redness and or hypertrophy/hyperplasia Slight redness in some areas of the palatal mucosa; red spots indicating inflamed salivary duct orifices……**2**
Moderate inflammation = marked redness and hypertrophy/hyperplasia of the gingiva, which bleeds easily when pressure is applied and/or any of the following: • Marked redness in large areas (≥2/3) of palate • Marked inflammatory redness of the oral mucosa in sites other than the palate • Presence of ulcerations • Red and inflamed fibroepithelial hyperplasia …..……**3**
Severe inflammation = severe redness and hypertrophy/hyperplasia of the gingiva • Spontaneous gingival bleeding • Marked palatal granulations • Inflamed oral mucosal areas that “break” easily and bleed under pressure…..……**4**
Plaque
No easily visible plaque ……**1**
Small amounts of hardly visible plaque……**2**
Moderate amounts of plaque……**3**
Abundant amounts of confluent plaque……**4**
Score Greater than 5 reflects marked lack or oral integrity

Note: Based on data in Henriksen, B. M., Ambjornsen, E., & Axell, T. E. (1999). Evaluation of a mucosal-plaque index (MPS) designed to assess oral care in groups of elderly. *Special Care in Dentistry, 19*, 154-157. Silness, P., & Löe, H. (1964). Periodontal disease in pregnancy, II: Correlation between oral hygiene and periodontal condition. *Acta Odontologica Scandinavica, 22(*1), 121-135. Reprinted with permission from the American Dental Association; American Association of Hospital Dentists; Academy of Dentistry for the Handicapped; American Society for Geriatric Dentistry. Copyright Clearance Center Confirmation Number: 11265179.

Figure 3.1 *Oral Health Assessment Tool*

ORAL HEALTH ASSESSMENT TOOL

FOR MECHANICALLY VENTILATED ADULTS IN ICU

BECK ORAL ASSESSMENT SCALE (BOAS)

Date:																					
Shift *N=11p-7a; D=7a-3p; E=3p-11p*	N	D	E	N	D	E	N	D	E	N	D	E	N	D	E	N	D	E	N	D	E
Lips																					
Gingiva/Mucosa																					
Tongue																					
Teeth																					
Saliva																					
Total Score																					

	BOAS Score Legend			
	1	2	3	4
Lips	Smooth, pink, moist, intact	Slightly dry, red	Dry, swollen isolated blisters	Edematous, inflamed blisters
Gingiva & Oral Mucosa	Smooth, pink, moist, intact	Pale, dry, isolated lesions	Swollen, red	Edematous, inflamed blisters
Tongue	Smooth, pink, moist, intact	Dry, prominent papillae	Dry, swollen, tip and papillae are red with lesions	Very dry, edematous, engorged coating
Teeth	Clean, no debris	Minimal debris	Moderate debris	Covered with debris
Saliva	Thin, watery, plentiful	Increase in amount	Scanty and somewhat thicker	Thick and ropy, viscid or mucid
Total Score: Dysfunction	5: None	6-10: Mild	11-15: Moderate	16-20: Severe
Intervention Frequency	>= Every 12 h	>= Every 8-12 h	>= Every 8 h	>= Every 4 h

MUCOSAL-PLAQUE SCORE (MPS)

Date:																					
Shift *N=11p-7a; D=7a-3p; E=3p-11p*	N	D	E	N	D	E	N	D	E	N	D	E	N	D	E	N	D	E	N	D	E
Mucosa																					
Plaque																					
Total Score																					

	MPS Score Legend			
	1	2	3	4
Mucosa	Normal appearance of gingiva and oral mucosa	Mild inflammation: slight redness and or hypertrophy/hyperplasia. Slight redness in some areas of the palatal mucosa; red spots indicating inflamed salivary duct orifices	Moderate inflammation: marked redness and hypertrophy/hyperplasia of the gingiva, which bleeds easily when pressure is applied and/or any of the following: • Marked redness in large areas (≥2/3) of palate • Marked inflammatory redness of the oral mucosa in sites other than the palate • Presence of ulcerations • Red and inflamed fibroepithelial hyperplasia	Severe inflammation: severe redness and hypertrophy/ hyperplasia of the gingiva: • Spontaneous gingival bleeding • Marked palatal granulations • Inflamed oral mucosal areas that “break” easily and bleed under pressure
Plaque	No easily visible plaque	Small amounts of hardly visible plaque	Moderate amounts of plaque	Abundant amounts of confluent plaque
Interpretation	A total score greater than 5 reflects a significant lack of oral integrity.			

Implementation Plan

Everett Rogers' DOI framework served as a useful map for planning this EBP project. Table 3.3 provides detailed descriptions of how each of these stages influenced innovation adoption in this EBP project.

Knowledge of the local problem with VAE had already been established by the clinical directors, unit managers, IP, and CNS, but there was a knowledge gap regarding the solution to this problem. Therefore, the first step in this project was to explore with the clinical stakeholders what the barriers were to achieving their goal of having no VAE in their facilities. One such barrier was a lack of standardized oral health assessment practices, and another was poor compliance to evidence-based procedures for oral care of patients with mechanical ventilation. While the clinical stakeholders perceived both of these barriers to be important, they agreed that the emphasis for this project was to develop, implement, and evaluate a standardized oral health assessment procedure. Clinical stakeholders decided to facilitate this project with the expectation that any staff education would also include a review of the approved standards of care for oral hygiene.

After agreeing to the project aims, timeline, and responsibilities of the clinical sites and EBP project leader, the project was planned with substantial input from the clinical stakeholders and the EBP project advisor. After achieving consensus on project methods, approval to conduct human subjects research was obtained from the institutional review board (IRB) at both the academic institution at which the EBP project leader was enrolled as a student and at the clinical sites. Obtaining these approvals before approaching clinical staff about the project was vital to the successful adoption of the project because it demonstrated to the clinical staff a commitment to protect the autonomy of each ICU patient, even though they were not individually required to provide informed consent to participate in the project. A plan was also developed to establish on-site and on-call availability of the project leader throughout the decision and implementation phases.

The EBP project leader arranged times at each site to deliver intervention training to the nursing staff. Upon completion of the program, nursing staff were expected to: (a) explain the significance of oral health assessment in patients with mechanical ventilation, (b) perform a standardized oral health assessment for patients with mechanical ventilation, and (c) perform site-approved oral hygiene for patients with mechanical ventilation. The educational program consisted of a brief oral presentation during a regularly scheduled unit staff meeting, a handout that provided further details about the intervention, a project binder with additional information about VAE prevention, a one-page flyer that explained how to complete the standardized oral health assessment procedure, and a printed poster describing various VAE prevention strategies.

Unit-based leaders at each project site, including nurse managers, charge nurses, and clinical nurse specialists, were recruited as change champions to facilitate and motivate staff nurses to utilize the standardized oral health assessment tools. These unit leaders also implemented “train-the-trainer” sessions at each project site. The nurse manager and CNS at each facility identified a site-specific plan to distribute data collection forms, display the educational poster, and store completed data collection forms until they could be retrieved for data entry. Staff training occurred from October 1st, 2014 through October 31st, 2014. The unit leaders, IP, and clinical nursing director agreed to implement the project on November 2nd, 2014.

Oral assessment methodology

Nurses will receive initial training on the use of the oral assessment tools during a unit-based educational session. Although routine oral care was being performed on mechanically ventilated patients, staff had not consistently assessed for evidence of biofilm growth within the mouth of mechanically ventilated patients. The innovation was conceptually embraced by the nurse manager, the regional education manager, and the regional chief nursing officer (CNO). The investigator proposed an in-service in which she would discuss each facility's VAE/VAC

prevention protocol with the addition of teaching nurses a systematic way to assess the intubated patient's oral health status. The initiative was implemented at four Midwestern hospitals.

On, November 2nd, 2014, follow-up phone calls, reiterating the importance of the EBP project, were made to unit managers, unit team leaders, or charge nurses as a reminder of the implementation date on the following day. The EBP project leader began bi-weekly site visits to reinforce or provide additional training, as needed, to promote intervention adherence among unit staff. These site visits were performed on all shifts for several weeks and then were performed exclusively on the day (7:00 A.M. to 7:00 P.M.) shift to ensure availability to the nurse managers and CNS, who primarily worked on this shift. The decision to change the schedule for site visits was made based on feedback from the nurse manager and CNS at these sites.

During the implementation of the study, when the patient arrived to the critical or intermediate care areas, the staff nurses assessed the oropharyngeal and mucus membranes, teeth, and artificial airway for risk factors and signs and symptoms of deterioration or infection. The BOAS and MPS were quantified either upon patient intubation or arrival to the critical care unit, whichever came first. Patients at low risk for developing VAE received preventive measures, including mechanical tooth brushing and chlorhexidine application at least every 12 hours. Those patients who were revealed to have mild to severe oropharyngeal and mucus membrane dysfunction had mechanical oral care more frequently, per institutional policy. Additionally, primary care providers were instructed regarding the potential severity of the of oropharyngeal and mucus membrane dysfunction in order to facilitate a more collaborative treatment approach for critically ill patients at high risk for VAE development.

Table 3.4
Application of Rogers Diffusion of Innovation

Rogers Stage of Change	EBP Project Action Step
Acquisition of Knowledge	• Change in NHSN surveillance definitions of VAE/VAC/VAP • Study site acknowledgement of inconsistent oral care in patients with endotracheal tubes • Email sent to regional director of critical care and infection prevention at study setting explaining the proposed EBP project focusing on prevention of VAP • Meeting with site leaders to explain the project purpose, scope, and proposed methods
Persuasion	• Obtained strong support of leaders at study sites • Identified change champions at each study site
Decision-Making	• Administration authorized the practice change at all study sites • Change champions were educated on the study purpose and methods • Feedback sought from change champions for ways to maximize study procedure adherence among staff
Implementation	• EBP project leader attended departmental staff meetings to explain the study purpose, how to perform the standardized oral assessment, reinforcement of facility VAP prevention protocol, and how to submit the completed oral assessment tool to the EBP project leader • Bi-weekly project leader site visits to support implementation • Meetings with site leaders and change champions as needed to clarify project goals and methods
Confirmation	• Standardized oral assessment will be included in the next revision of regional VAP prevention protocol

Data Analysis Plan

Ventilator-associated events were counted each month at all project sites and standardized across sites using ventilator-days. The incidence rate of VAE per month was calculated for each site, along with the incidence rate of all VAE subtypes (i.e. VAC, IVAC, possible VAP, and probable VAP). To test the null hypothesis that there was no statistically significant difference between VAE incidence from pre-intervention to post-intervention, a 2x2 contingency table was constructed for each site using data from all four project sites with VAE (present or absent) on one axis and implementation phase (pre-implementation or post-implementation) on the other axis. From this table, a chi-square test of independence was performed and a *p*-value calculated using $\alpha = .05$ as the level of significance. A pooled VAE incidence rate for all sites, which accounted for variations in ventilator-days between sites, was also calculated for pre-intervention to post-intervention, and the process for hypothesis testing repeated as it was performed for each individual site.

To analyze the second aim, staff compliance with the standardized oral assessment was determined by utilizing the oral assessment form as a proxy for compliance. To determine the strength of the association between staff compliance with the intervention and the change in VAE incidence rate from pre-intervention to post-intervention, a Spearman's ρ correlation coefficient and a *p*-value calculated using $\alpha = .05$ as the level of significance. Data were analyzed using IBM's Statistical Package for the Social Sciences (SPSS) software (SPSS, 2015).

Table 3.5
Data Analysis Plan

Question to be Answered	Measures	Statistical Test
Did the incidence rate of VAE decrease after implementation of a standardized oral assessment for adult patients on mechanical ventilation?	VAE incidence rate VAC incidence rate IVAC incidence rate PossVAP incidence rate PrVAP incidence rate	Chi-square test for independence
Was compliance with the standardized oral assessment associated with the incidence rate of VAE in this population?	Incidence rates at each site, as above % of vent-days with at least two completed oral assessments on data collection form	Spearman's ρ

Human Subjects Protection

Institutional Review Board (IRB) approval was obtained from both the study site and Valparaiso University prior to project implementation. Because this project utilized aggregated system-level data instead of individual patient-level data, the project did not require the acquisition of informed consent from individuals. Furthermore, since there was minimal risk beyond that involved with receiving routine clinical care, and the informed consent document would have been the only way to identify individual participants, this project was granted "exempt" status from both IRBs. Facility infection preventionists, who served as the sources for data on study outcomes, de-identified and aggregated outcomes data at the unit level prior to these data being sent to the EBP project leader. All outcomes data were sent electronically directly from the infection preventionist to the PI via e-mail communication. Each study site assigned a specific place for staff nurses to submit the standardized oral assessment data collection forms, which were kept in an opaque envelope or folder. The PI collected these forms bi-weekly and transported them to a locked filing cabinet using a closeable binder.

CHAPTER 4

FINDINGS

The purpose of this EBP project was to determine if an evidence-based oral care assessment combined a with staff education program reduced the incidence of ventilator associated events (VAE) among mechanically ventilated (whether via oral endotracheal intubation, nasal endotracheal intubation, or tracheostomy) adults admitted into the intensive care units at four Midwestern community hospitals over a four-month period, compared to routine oral care practices over a prior nine-month period. This chapter will provide results from the data analyses of the study.

In order to determine the effectiveness of the EBP project protocol, pre-intervention and post-intervention VAE incidence rates and facility EBP protocol documentation compliance were monitored on a monthly basis. Analyses of all variables are listed on Tables 4.1, 4.2, 4.3 and 4.4. The data from all four participating facilities were then pooled for the purpose of statistical analysis using SPSS version 22 software.

Patient-Days and Ventilator-Days

This project utilized an administrative data set that included patient-days and ventilator-days at each facility. Pre and post-intervention data were collected over a pre-determined date range at all participating sites. The pre-intervention period began January 1, 2014 and ended on September 30, 2014. A one-month implementation phase was scheduled during October 2014. Post-intervention data collection began on November 1, 2014 and continued until February 28, 2015.

Patient-days were calculated as the total number of patients in each intensive care unit at midnight every day over each one-month period. Ventilator-days were calculated as the total number of patients using mechanical ventilation in each intensive care unit at midnight every day over each one-month period.

Patient-days. A total of 13,050 patient-days were examined in this study (9,149 pre-intervention patient-days; 3,892 post-intervention patient-days). Table 4.1 provides details of the distribution of patient-days at the 4 facilities.

Ventilator-days. Of the 13,050 patient-days, there were 4,892 ventilator-days (3,304 pre-intervention ventilator-days; 1,588 post-intervention ventilator-days). Table 4.1 provides details of the distribution of ventilator-days at the 4 facilities.

Staff Compliance with Evidence-Based Practice

Daily completion of the Oral Health Assessment Tool was used as an indicator of staff compliance with the standardized oral health assessment practice. Staff compliance was calculated as the percentage of ventilator-days during the post-implementation phase with at least two documented oral health assessments per day. Of 1,588 ventilator-days in the post-implementation phase, 399 had at least two documented oral health assessments (25.1%). The staff compliance between facilities ranged from 2% to 70% (Table 4.2).

Table 4.1

Patient-days and ventilator-days at study facilities

Facility	Patient-Days (%)			Ventilator-Days (%)		
	Pre-Implementation	Post-Implementation	Total	Pre-Implementation	Post-Implementation	Total
A	2356 (26)	824 (21)	*3180*	694 (21)	275 (17)	*969*
B	2166 (24)	1065 (27)	*3231*	582 (17)	343 (22)	*925*
C	1848 (20)	741 (19)	*2589*	650 (20)	271 (17)	*921*
D	2779 (30)	1271 (33)	*4050*	1378 (42)	699 (44)	*2077*
Pooled	9149 (100)	3901 (100)	*13050*	3304 (100)	1588 (100)	*4892*

Note: Administrative data set.

Table 4.2

Staff compliance with evidence-based oral health assessment protocol

Facility	Correct Documentation	Ventilator-Days	Staff Compliance %
A	28	275	10.2
B	240	343	70
C	6	271	2.2
D	125	699	17.9
Total	*399*	*1588*	*25.1*

Criteria: At least two documented oral health assessments per day.

Instrument Reliability

Two standardized, non-invasive, oral assessment tools (i.e., the Beck Oral Assessment Scale [BOAS] and the Mucosa-Plaque Score [MPS]) were combined for this EBP into the Oral Health Assessment Tool (Figure 1). Although the need to evaluate the psychometric properties of the BOAS and the MPS have been discussed elsewhere (Beck, 1979; Henriksen, Ambjornsen, & Axell, 1999; Silness, & Löe, 1964), no published results were found in the literature search. Inter-rater reliability coefficients for the BOAS, MPS, and the Oral Health Assessment Tool were calculated for the sample in this EBP project as .742, .592, and .824, respectively (Table 4.3). This demonstrated that the reliability of the instrument combining the MPS and BOAS was greater than the use of either scale alone. Validity of these scales was not calculated as part of this EBP project.

Table 4.3

Internal consistency of instruments

Instrument	Number of Items	Cronbach's α
Beck Oral Assessment Scale (BOAS)	5	.742
Mucosa-Plaque Score (MPS)	2	.592
Oral Health Assessment Tool	7	.824

Outcome Variables

VAE Incidence Rates. The PICOT question guiding this analysis asked, "Among mechanically ventilated patients, how does the implementation of a standardized oral care assessment guideline combined with a mandatory staff education program affect the incidence of VAE when compared to standard care over a four month period?" VAE incidence rates varied at all participating facilities (Table 4.4). However, during the pre-implementation phase, VAE incidence rates at three participating facilities were less than 8.7 per 1,000 ventilator days. Facility A exceeded that rate at 17.3 per 1,000 ventilator days. For comparison purposes, the

pooled VAE rate for all sites was calculated. During the pre-implementation phase, the pooled mean incidence rate for VAE across the four facilities was 9.99 per 1,000 ventilator-days (Table 4.4). During the post-implementation phase, VAE incidence rates continued to vary among the four facilities (Table 4.4). The pooled mean incidence rate of VAE at all sites decreased to 8.2 per 1,000 ventilator-days in the post-implementation phase. However, this change was not statistically significant.

Ventilator-associated pneumonia (VAP) was a relatively rare type of VAE in this sample, which is consistent with the literature (CDC, 2014). There were no cases of confirmed VAP during either the pre-implementation or the post-implementation phase. There were only four cases of probable VAP during pre-implementation (all occurring at the same facility) and no cases of probable VAP during post-implementation. Because the incidence of confirmed and probable VAP was extremely low, statistical analysis of the VAP outcome variable was not performed.

Figure 4.1

Pre and Post Changes in VAE Rates

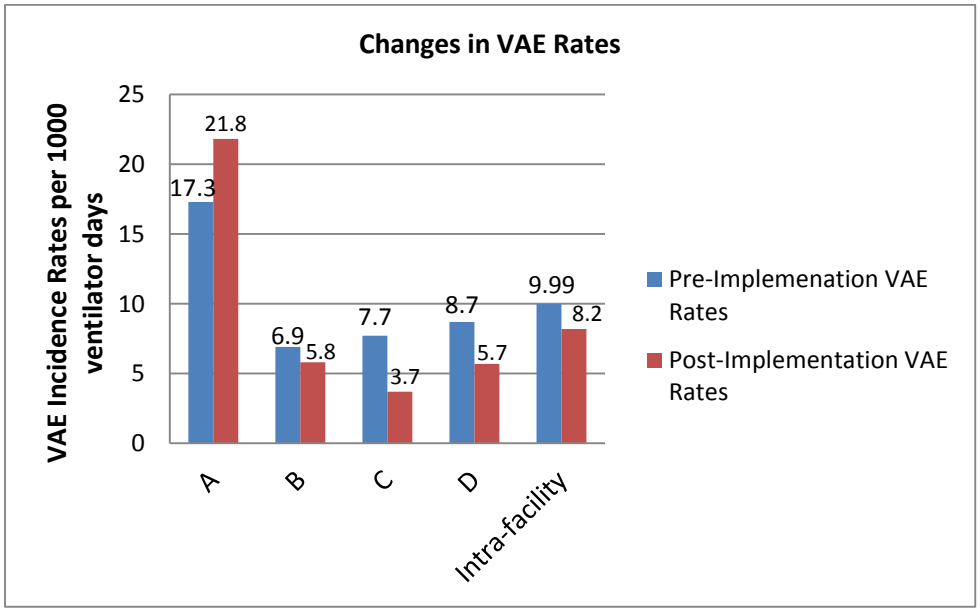


Table 4.4

Changes in VAE incidence rates

Facility	Pre-Implementation			Post-Implementation				
	VAE Frequency (%)	*Ventilator-Days (%)*	*VAE Incidence (per 1,000 ventilator-days)*	*VAE Frequency (%)*	*Ventilator-Days (%)*	*VAE Incidence (per 1,000 ventilator-days)*	*Change in VAE Incidence rate*	*p-value*
A	12 (36)	694 (21)	17.3	6 (46)	275 (17)	21.8	4.5	.73
B	4 (12)	582 (17)	6.9	2 (15)	343 (22)	5.8	-1.1	.85
C	5 (15)	650 (20)	7.7	1 (8)	271 (17)	3.7	-4	.49
D	12 (36)	1378 (42)	8.7	4 (31)	699 (44)	5.7	-3	.46
Inter-facility	*33 (100)*	*3304(100)*	*9.99*	*13 (100)*	*1588(10)*	*8.2*	*-1.8*	*.54*

Significance of facility-specific VAE incidence rate changes. Changes in VAE incidence rate were also analyzed within each facility (Table 4.4). Although reductions in VAE incidence were observed at three of these facilities, and an increase in VAE incidence was observed at one facility, these differences were not statistically significant.

Compliance with EBP intervention and post-implementation VAE incidence rate. A post hoc analysis that determined the relationship between compliance with documentation of the evidence-based oral health assessment protocol and changes in VAE incidence was performed. Spearman's rank correlation coefficient was calculated to assess this relationship. Staff compliance with the oral health assessment protocol was positively correlated, but this relationship was not statistically significant (r = .4, n = 4, p > .1).

Table 4.5

Significance of change in VAE rate and compliance rate, by facility

Facility	Staff Compliance rate % (X Value)	Change in VAE Incidence Rate (Y Value)
A	10.2	4.5
B	70	-1.1
C	2.2	-4
D	17.9	-3
Inter-facility	25.1	-1.8

The overall pooled results across all four study sites showed a moderate but observable decrease in VAE incidence rate from the pre-intervention period to the post-intervention period. This result was apparent in the site-specific results at all but one study location, Site A, where the incidence rate increased. Notably, despite having had by far the highest compliance with study documentation, Site B had the second least favorable change in VAE rate. This suggests that any correlation between documentation compliance and the outcome of the intervention

was weak. It may be instructive, in subsequent research, to investigate the relationship between compliance and individual patient outcomes.

Chapter 5

Discussion

The purpose of this EBP project was to answer the PICOT question: Among mechanically ventilated patients, how does the implementation of an oral care assessment guideline when combined with a staff education program, affect the incidence of ventilator-associated events when compared to standard care over a four month period? This chapter will discuss the findings presented in Chapter 4. This chapter will also discuss essential elements of the Epidemiological Triangle of Infectious Disease and Everett Rogers' Diffusion of Innovation (DOI) framework (Rogers, 2005) that were used to integrate an evidence-based strategy to decrease VAE rates among mechanically ventilated adults in the ICU setting. The applicability and fit of the theoretical and EBP framework, strengths and weakness of the EBP projected and implications for the future will also be addressed.

Explanation of Findings

It was important to determine the clinical feasibility and effectiveness of this EBP project's protocol. Therefore, descriptive statistics were used to assess facility specific, as well as organizational pooled mean VAE rates and protocol adherence rates. The statistical software SPSS version 22 was used was used to assess ordinal variables by utilizing the Chi Square test to measure the strength of association between pre- implementation VAE rate and the post-implementation VAE rate.

This single-group pretest-posttest study utilized aggregate data that was collected in accordance with NHSN guidelines by facility specific infection preventionist at four community hospitals in the Midwest. De-identified data was reported to the principal investigator for statistical analysis. The variables included: (a) patient days; (b) VAE count; (c) ventilator days; (d) VAE rate; (e) ventilator device utilization (DU); (f) Ventilator-Associated Condition count (VAC); (g) Infection-related Ventilator-Associated Complication (IVAC) count; and (h) Possible/Probable ventilator associated pneumonia (P-VAP) count.

Pre-implementation VAE data for this project were collected using a retrospective approach by facility specific infection preventionists for the period from January 1, 2014 to September 30, 2014. Post-intervention VAE data were collected on a monthly basis by facility specific infection preventionists from November 1, 2014 until February 28, 2015. Descriptive statistics were used to assess and compare facility specific, as well as cumulative pooled mean data for all four sites. Comparisons of pre- and post-intervention VAE counts, VAE rates, patient ventilator days, and changes in VAE incidence rates were discussed in Chapter 4 (Table 4.4).

As shown in Table 4.5, the pooled mean VAE incidence rate for the four facilities declined by 1.8 cases per 100 ventilator-days in the post-implementation phase. However, this drop was not statistically significant, X^2 (1, N = 4,846) = .37, p = .54. Although most facilities experienced decreased VAE rates, facility A experienced an increase in VAE rate of 4.5, which was also not statistically significant, X^2 (1, N = 951) = .22, p = .64. The study anticipated that low staff engagement, as evidenced by lower documentation compliance would correspond to higher VAE rates. Therefore, additional statistical analysis was performed by utilizing Spearman's rank correlation coefficient to determine if staff compliance with documentation of the EBP intervention would be correlated with decreased VAE rates. Ultimately, the increased VAE rate at Facility A proved unrelated to documentation compliance. Although the study did not track staffing metrics, the author's impression is that increased nurse turnover and use of contingent labor at Facility A may have contributed to its outlier result. Whereas data does not exist to draw firm conclusions about this outlier, evidence does exist to draw conclusions about the lack of statistical significance of the results.

Post-implementation VAE rate changes may have been found not to be statistically significant due to a variety of factors. First, there was a relatively small difference between the pre-intervention and post-intervention VAE rates at the study sites. The VAE incidence rates at most participating facilities were low to begin with and declined by 1.8 post-implementation. The low rates decrease the detectability of changes. However, the findings are consistent with the

published evidence (Dudeck et al., 2013a; 2013b; 2013c; Klompas et al., 2014; Klompas, Kleinman, & Murphy, 2014; Lilly et al., 2014). Published evidence suggests that VAE incidence rates have decreased as compared to previous VAP rates due to the specificity of the new surveillance definition as proposed by the NHSN in 2013. Second, seasonal variability in the VAE rates may have existed at all the participating sites. Seasonal staffing issues and seasonal changes in the incidence of disease processes that contribute to the exacerbation of co-morbid conditions may have contributed to the temporal variability. According to Lilly et al., (2014), the new VAE surveillance definitions are less sensitive, are more resistant to manipulation, and do not adequately account for temporality. Lastly, the aggregated data utilized in this study was relatively small (*n*=4), when compared to larger, more comprehensive studies that include high-risk patient populations in academic medical centers and trauma centers. Larger, more robust multi-facility studies that include teaching and specialty critical care units tend to have more variability in VAE incidence rate changes (Dudeck et al., 2015; Herndon, 2012). Dudeck and colleagues conducted a study in coordination with the NHSN that included critically ill patients from over 3,000 hospitals of varying sizes that actively participate in the NHSN's HAI surveillance program. Critical care units, at larger teaching institutions, that care for high risk patients with severely compromised bronchial-pulmonary air exchange, such as trauma and burn critical care units, experience both an increased incidence and statistically significant change in VAE rates (including VAP) when compared to the smaller critical care units, such as the four enrolled in this study (Dudeck et al., 2015; Klompas et al., 2014; & Klompas et al., 2015).

Compliance and Adherence to EBP intervention.

Compliance with the EBP intervention was tracked at all four facilities individually and cumulatively (Table 4.2). Facility B had a 70% compliance rate and had the lowest pre-intervention VAE incidence rate among the four facilities (6.9 per 1000 ventilator days), suggesting that nurses at facility B were already effective at preventing VAE before the project.

On the other hand, facility A appeared to have the greatest challenge with VAE rates in the pre-implementation period and was the only site to experience an increase in VAE rate in the post-implementation period. Possible contributing factors included high patient census, benefit and staffing changes which may have impacted employee satisfaction leading to high turnover and use of contingent staffing. Although the study did not include collection of staffing metrics, the quality of care delivered to critically ill patients is understood to be sensitive to experience of the nursing staff. At facility A, the investigator perceived a greater presence of contingent nurses and nurses with limited critical care experience. However, these factors do not, on their own, fully account for the lack of statistical significance in the results.

Whereas, facilities B, C, and D experienced decreases in VAE rates, the level of analysis selected may have played the greatest role in hindering a finding of statistical significance. Since results were aggregated for each facility over two periods, it was not possible to control for patient specific risks or stratify data to reveal hidden trends. Future research may benefit from performing analysis at the individual patient level with access to the full range of data elements in the electronic medical record.

Furthermore, the use of aggregate data analysis effectively reduced the study's sample size from thousands of ventilator days to four sites. That small sample size reduced the ability of the analysis to find statistical significance in the results. Nonetheless, various statistical techniques were employed in the effort to draw meaningful conclusions from the study's results.

Statistical analysis was performed using Spearman's ρ in order to determine if compliance with the intervention's documentation was correlated with a change in VAE rate. Spearman's ρ was applied to two variables: facility compliance with documentation of the evidence based intervention, and; changes in VAE rate following the intervention (Table 4.5). Based on the results of the study, there was a moderate direct correlation between intervention documentation compliance and differences in VAE rates, r (4)= .4, p< .05, but this correlation was not statistically significant (p = .5). Therefore, these findings provide preliminary evidence of

a trend towards reduced VAE rates using a staff education program to promote evidence-based oral assessments for mechanically ventilated patients residing in intensive care units.

Applicability of the Theoretical Framework

Rogers' Diffusion of Innovation (DOI) was selected as the guiding theoretical framework for this EBP project. This well-established change model has been used in over 5,000 research studies since it was first introduced in 1962 (Rogers, 2003), and it proved to be similarly useful for this EBP project as well.

Fit of the EBP framework

Rogers' Innovation Process in Organizations (2003, p. 421) consists of five stages within two broader categories known as the initiation and implementation phases. The initiation phase consists of the agenda-setting and matching stages where information gathering, conceptualization, and pre planning occurs in order to define the organization's problem and facilitate the perceived need for an innovation or solution. During the initiation phase, the principal investigator identified a clinical practice problem and assessed internal and external factors in order to develop a solution to best fit the organization's agenda. Issues of importance to the organization such as priority, intended purpose and outcomes were ascertained from key stakeholders. The PICOT format was utilized to initiate a literature search for all relevant evidence. The search affirmed the need for incorporating standard oral assessments as part of an evidence-based oral hygiene protocol for patients on mechanical ventilation to prevent VAEs within the organization. Although current evidence outlined oral assessment mitigation strategies to reduce or eliminate VAE, the organization had not been following those recommendations.

The implementation phase consists of the redefining/ restructuring, clarifying and routinizing stages. These three stages consist of all events, actions, and decisions involved in getting an innovation adopted. Initially, during the redefining/ restructuring stage, the innovation is incorporated into the organization. As implementation begins to occur, stakeholders become

more comfortable with the new initiative and accommodation begins to occur as changes are required and as barriers are identified. Adjustment may occur with both the organization and the innovation. However, there is a narrow window of opportunity to make appropriate modifications; thereafter, the innovation will be rapidly routinized and embedded within the organization (Rogers, 2003, p. 424).

During the clarifying stage, the innovation becomes widespread across the entire organization. Implementation processes should be monitored to ensure continued support and stakeholder buy-in. In the case of this EBP project, changes had to be made to accommodate the organizational agenda, stakeholder needs, and environmental functionality. Social reconstruction often results during this stage. During this EBP project, key stakeholders had to be reassured that the principle investigator would continue to monitor progress and clarify staff concerns.

The routinizing stage occurs when the innovation becomes ingrained within the organization's regular activities. The successful adoption of an innovation signifies the end of the innovation process. Sustainability of an innovation, also known as "institutionalization", is dependent on perceived need and on stakeholder participation in creating and implementing the innovation (Goodman & Steckler, 1989; Rogers, 2003). Incremental change results, most often, when innovation adoption occurs as a result of an authoritative decision. However, transformational change occurs when collective innovation-decisions are made, due to wider participation (Rogers, 2003, pg. 429).

Applying the theoretical framework. Rogers' DOI framework is applicable to this EBP project as it elucidates how adopters perceive new characteristics of a practice change or innovation. Rogers' (2003) framework guided the principle investigator in communicating and prioritizing the innovation. The innovation for this EBP project was the implementation of a standardized oral care assessment guideline in the critical care setting at four facilities. During the knowledge stage of this EBP project, the principle investigator met with and spoke to facility

stakeholders, unit leaders, and key opinion leaders within each unit at the participating facilities. Key leaders included the regional director, department managers, and influential stakeholders (i.e. clinical nurse specialists, IRB director, infection preventionists). Gaining early acceptance and support from opinion leaders was crucial to the success of this study. Once formal approval was garnered, the project leader was then able to embark upon communicating the innovation within the organization's social system.

The diffusion process was transmitted to critical care and intermediate care nursing staff through the use of educational programs offered during the day and evening hours in order to accommodate both the day and night shift staff. The educational presentation was also uploaded onto YouTube and communicated to staff member via posters. Educational posters and notebooks were strategically placed in all participating units. The educational programs allowed for an open dialogue between the principle investigator and the nursing staff. Interchanges of ideas, thoughts, and opinions were verbalized. Nonverbal forms of communication were noted allowing both the investigator and staff to probe for a deeper understanding of the problem, incidence of VAE, and the critical care unit culture. The investigator controlled staff uncertainty by listening, educating, brainstorming, and sharing ideas at each encounter. Ultimately, successful adoption of an innovation is reliant on how potential adopters perceive the innovation (Rogers, 2003).

The DOI framework places adopters into five categories depending on how readily they accept and incorporate innovative change initiatives. During the first two weeks of implementation, the principle investigator attended morning and evening staff meetings to explain the purpose of the EBP project and to underline the importance of the intervention to patient outcomes. Targeting innovators and early adopters during the early stages of a change effort is crucial to triggering the critical mass necessary to catalyze a change (Rogers, 2003). Initiation of the innovation process was accomplished by familiarizing adopters with the knowledge necessary to understand the purpose and function of the innovation.

The innovative diffusion curve depicts late majority and laggards at the opposite end of the spectrum from early adopters. Late majority individual are skeptical about innovation and require peer pressure prior to initiating a change. Typically, late majority individuals adopt the innovation after the majority of the adopters incorporate the practice change (Rogers, 2003). Laggards are often deeply traditional, cautious, and suspicious of change according to Rogers (2003). During the EBP implementation period, the investigator targeted educational resources, through exchange of ideas, at these two groups comprised of highly experienced registered nurses with longevity at their respective facilities.

During the persuasion stage, potential adopters must develop a positive outlook and should view the innovation as beneficial. Five influential factors that are crucial to the successful acceptance of an innovative process change include: relative advantage, compatibility, complexity, trialability, and observability. Rogers (2003) contended that these characteristics positively correlated with the rate of innovation adoption.

Relative advantage. Rogers' DOI framework facilitates the adoption of the innovation by conveying the relative advantage of the innovation (Rogers, 2003, p. 225). The framework accounts for the healthcare setting as the unit of adoption and it facilitates the adoption of the innovation by conveying potential benefits as improved outcomes relevant to the setting and project goals (Rogers, 2003, p. 225). Past investigations have reported a positive relationship between relative advantage and the rate of adoption (Rogers, 2003). As a result, the principal investigator rounded at the four facilities on a biweekly bases and monitored documentation as an indicator of project compliance to ensure the project's momentum. The principal investigator continued to educate, motivate, and remind staff that the EBP project was being implemented. Phone calls were made to the day and night shift charge nurses, at all participating facilities, on a twice weekly schedule.

In late November 2014, all four facilities implemented new pulmonary and ventilator documentation profiles in the electronic medical record. All four facilities were implementing a

pneumonia prevention initiative that paralleled this EBP project. As a result, when that initiative began, staff was initially unsure if they had to continue documenting their oral health assessments as outlined in this study. This required the EBP principal investigator to re-inform facility staff members to continue with the implementation process.

Compatibility. Innovations must be compatible with the values, past experiences, and needs of the adopter (Rogers, 2003). The innovation was compatible with the organization's mission to provide safe, cost effective, quality healthcare to promote good healthcare outcomes. This EBP project was consistent with the organization's goals, needs and workflow. Adopters were comfortable with the innovation since it incorporated existing indigenous knowledge systems. As a result this was not regarded as unnecessary or foreign. The staff nurses perceived the innovation to be consistent with current practice and beneficial to the patients in the form of improved oral health, infection control, and quality healthcare outcomes. Critical care unit leadership was supportive of this project as it addressed current goals to reduce VAE rates and variability. Therefore, this EBP project aligned well with the organization's stewardship initiative to reduce hospital acquired infections, particularly pneumonia, regionally.

Complexity. Complexity is described as "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers, 2003, p. 15). Innovations are easier to adopt when they do not pose barriers to existing workflow processes (AHRQ, 2008, p. 2-222). Registered nurses found the EBP intervention, as outlined by the BOAS and MPS, to be intuitive and practical to their practice. Documentation, at all participating sites, was done via electronic medical record. Consequently, the end-users (i.e. registered nurses), reported the projects paper documentation method to be inconsistent with their workflow. The EBP investigator alleviated concerns by consulting with end-users, project champions, and clinical leadership regarding workflow optimization for this project. Staff nurses, project champions, charge nurses, clinical nurse specialists and unit managers were instrumental in advising the

EBP investigator regarding their workflow practices in order to reduce complexity and facilitate adoption.

Complexity encompasses organizational barriers to change. One month post-implementation, a consulting group working at the corporate level of the organization, implemented three quality improvement initiatives. One focused on VAP reduction. Since the measures were synergistic with the EBP project, their workflow aligned well with the existing documentation infrastructure. However, staff reported difficulty understanding project distinctions and documentation requirements. Professional communication and team collaboration presented synergistic opportunities for enhanced patient safety (AHRQ, 2008). The principle investigator alleviated participant concerns through frequent communication.

Trialability. According to Rogers (2003), “trialability”, is the degree to which an innovation may be experimented with on a limited basis” (p. 16). Trialability positively correlated with the rate of adoption, especially among early adopters. As part of the implementation methodology, the principle investigator allowed nursing staff to use and familiarize themselves with the BOAS and MPS oral assessment tools. The tools were distributed to nursing staff on colored stationary in an easy to read font. Documentation forms were also distributed and staff was encouraged to practice documenting and familiarize themselves with the format prior to implementation. The principle investigator noted that the site with the highest documentation compliance institutionalized the Oral Health Assessment as part of everyday practice.

Observability. The last characteristic in DOI framework is observability. Rogers (2003) defines observability as “the degree to which the results of an innovation are visible to others” (p. 16). Role modeling and peer-to peer observation are two examples of how adopters can motivate each other to adopt new innovations. This EBP intervention yielded observable results immediately upon completion. Staff visualized the decrease in oral plaque within the patients’ oral cavity. Despite, the objective evidence in oral plaque removal, staff did not consistently document the provision of oral care. However, VAE changes, unlike physical plaque removal,

are not readily apparent to staff. The results of this study suggest that compliance with timely oral care, when coupled with oral care assessments, may correlate with a decrease in VAE incidence rates.

Decision, implementation, and confirmation make up the final three stages of Rogers Innovation-Decision Process. During the decision stage, potential adopters determine either to adopt or reject the implementation of a proposed innovation. As previously stated, this EBP project was implemented at four intensive care units at four healthcare facilities that are owned and operated by a larger health care organization. The decision to implement facility changes, at the participating study sites, was at the discretion of two key organizational leaders. The two leaders stated an interest in addressing a pressing issue, that being increases in VAE rates. As a result, the principal investigator for this EBP project, gained support from organizational stakeholders. Formal meetings were conducted with individuals in the following roles: (a) regional director for critical care and infection control services at all four participating facilities; (b) nursing unit managers, responsible for daily unit management; (c) clinical nurse specialists, responsible for nursing education and unit support services; and (d) infection preventionists, responsible for infection control and monitoring of infection related quality measures at specific sites. IRB approval, to implement the EBP project, was granted after garnering support from key opinion leaders.

The implementation stage initiates the innovation diffusion process within the clinical environment. This was accomplished by developing a standardized oral care guideline that incorporated existing oral care protocols, oral care procedures, and a standardized oral care assessment tool. In essence, facility specific oral care practices and VAP bundle use were incorporated into the innovation. Secondly, the provision for staff education concerning evidence based oral care practices, oral care assessment, and the role of oral biofilm in the development of VAEs, was discussed from an epidemiological perspective. The education program was delivered to intensive care and intermediate care nursing staff on the day, evening, and night

shifts. Presentation and related educational materials were made available in a variety of formats to maximize the spread of the innovation. The presentation was delivered orally, via PowerPoint presentation, and via abbreviated YouTube address and QR code displayed on a poster. A project binder that included the purpose of the study, project outline, standardized oral care guideline, BOAS and MPS tools, PowerPoint slides, and references, was delivered to each participating intensive care unit.

Prior to implementation, discussions with opinion leaders revealed that there was VAE variability across participating facilities. Support from unit leaders was eventually obtained. This support was necessary to ensure project compliance within individual critical care units. Innovation diffusion within an organization requires change management to facilitate and encourage people to adopt initiatives. Corporate opinion leaders ensured that unit leaders were implementing the oral care guideline at the study sites and documenting oral care practices on the Oral Health Assessment Tool (Figure 4.2). Despite the additional oversight, documentation compliance did not increase. This may be due to the implementation of a parallel VAP quality improvement project by a consulting firm working with the organization. The consulting firm integrated documentation changes within the EMR; thus, increasing adoption and documentation compliance for their initiative. Workflow optimization was critical to encouraging and sustaining innovation adoption within the clinical setting.

Strengths and weaknesses of the theoretical framework. Rogers' Diffusion of Innovations framework was adequate in guiding this EBP project. The DOI framework provides effective strategies for implementing change and guiding the organizational adoption process. Rogers' framework assisted the principle investigator to identify influential leaders that would facilitate access and acceptance of the practice change. For example, it was important to attain support from key opinion leaders prior to initiating the implementation process. Influential leaders within a hierarchical organization wield influence over subordinates; their support was necessary for the success of this EBP project.

A second strength of the DOI framework was identifying and understanding existing workflow processes in place at each participating facility. Understanding and incorporating workflow at each specific study site was essential to system participation and practice adoption. Only then would participants appreciate the relative advantage of the new practice, as supported by the literature, relative to standard practice. The evidence based practice change was developed to be easy to understand, incorporating participants' foundational knowledge to streamline documentation efforts. The innovation was compatible with existing organizational mission and values of providing an environment where innovation, technology, compassion and knowledge converge to provide safe, quality healthcare services to all patients. Lastly, the change was observable. Staff and patient family members provided positive feedback regarding their perceptions of changes in the patient's oral health status.

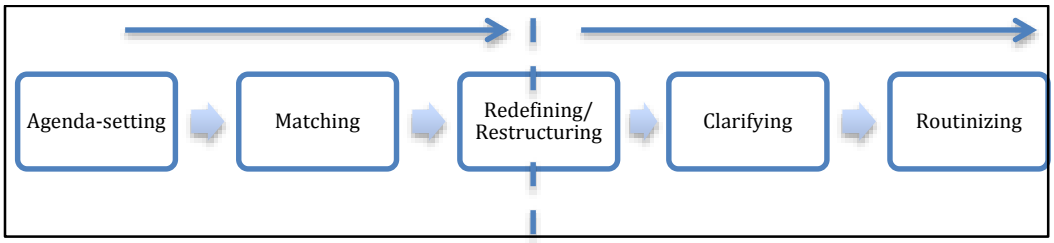
There were several limitations to using Rogers' framework. While opinion leaders encouraged and motivated staff members to utilize the change initiative, it was difficult to determine whether individuals were actively embracing the change. The DOI framework does not provide an adequately process for engaging late adopters and laggards. Continued education, staff engagement and clinical support will encourage staff to learn about the inherent benefit of maintaining this EBP initiative. Therefore, the principal investigator will reinforce engagement by providing staff and the IRB with this EBP study's results.

A limitation of Rogers' Innovation-Decision Process is that it depicts a linear pathway. However, the principal investigator iterated between the different stages throughout the study. In particular, the stages of persuasion, implementation, and confirmation required iteration. For example, the principal investigator continued to attend staff meetings, routinely rounded at all study sites, and continued to provide educational reminders, educational in-services and provided support for all staff nurses including new hires and temporary staff.

Applicability of the EBP framework

Rogers' Diffusion of Innovations-Decision Process (2003) guided the design and implementation of this EBP project. The framework's Innovation-Decision Process consists of five phases that are designed to guide integration of research into practice.

Figure 5.1
Diffusion of Innovation Stages



Strengths and weakness of the EBP framework. Rogers' Innovation Process (2003) was a good fit for this EBP project, as it was rigorous enough to ensure the successful implementation of the project. The EBP framework provided a five-stage guide that resulted in the design and implementation of an EBP initiative. The principle investigator developed a PICOT question, appraised the relevant literature, developed a practice guideline and developed a nursing staff education program. Another strength of the EBP framework was that it facilitated adaptive changes during the redefining and clarifying stages of the process. Rogers' Innovation Process was the cornerstone of the entire project.

Limitations. A weakness of Rogers' Innovation Process is that it does not adequately address pro-innovation bias (Rogers, 2003). Such bias was evident at Facility B, where the sense of urgency to adopt this change effort was pre-existing. This site was the first to commit to the study, had the lowest pre-implementation VAE rate and extremely high documentation compliance. In order to mitigate pro-innovation bias, the investigator invited participating stakeholders to develop, critique, and provide feedback regarding the proposed innovation. Another limitation is individual stakeholder blame bias for non-adoption. However, the

investigator continued to support, educate, and reinforce the purpose of the change initiative in an effort to mitigate potential limiting factors by individual stakeholders.

Rogers' Innovation Process does not allow for the adequate evaluation of the innovation. While the innovation's process provides a mechanism for disseminating an innovation, it lacks systematic criteria by which to evaluate contextual outcomes for the purpose of comparison. Essentially, the innovation process fails to appraise the circumstances related to adoption or non-adoption, as well as the consequences and rationales associated with incomplete or failed adoptions (Meyer, 2004). However, it does provide some benchmarks for innovation diffusion within a larger system.

Strengths and Limitations of the EBP project

Strengths. The study succeeded in several respects. First, the research and data collected support the use of an evidence based oral health assessment during the provision of oral care. Although results were not statistically significant, there is preliminary evidence that adherence to oral care guidelines decreased VAE counts (including VAP). A second area of strength was the use of the APN skill set. The APN provides value to the organization by effectively using diverse skill sets to improve patient outcomes and healthcare quality, minimize costs, and increase patient safety. This additional data contributes to the current evidence by adding new knowledge regarding the utility of APN-led infection control practice changes (Goss & Bryant, 2014). Lastly, the implementation of the innovative change benefited nursing staff and the organization. The nursing staff in the critical care units expressed satisfaction with the educational program as it enabled them to be more cognizant, not only of oral care practices, but also, of the existence of microorganisms within the clinical environment. The staff's increased awareness empowered them to adopt the innovation and change their practices, thus contributing to lower VAE rates.

This EBP project demonstrated that advanced practice nurses are in an ideal position to coordinate evidence-based system-level interventions to reduce VAE. Furthermore, registered

nurses and patients' family members expressed satisfaction with this project. Nurse led interventions are more likely to overcome adoption challenges due to nurses' familiarity with the organization's culture, environment, clinical expertise, and access to key stakeholders.

Limitations. This EBP project utilized aggregate data from four distinct facilities with different workflow processes and levels of staff engagement. Aggregated data is the consolidation of data relating to multiple patients. This data is not patient specific, and therefore cannot be traced back to a specific patient. The results of this study cannot be generalized at the patient level. Aggregate data results are primarily utilized by organizations for process improvement as quality indicators and for strategic planning.

Workflow processes at the multiple study sites impacted this study. Therefore, results and compliance differed significantly. This, coupled with aggregated statistics and a sample size of four facilities (n=4), was likely to have contributed to non-statistically significant findings despite improved VAE frequencies.

Lastly, it was difficult to assess and maintain staff engagement given that all four participating sites experienced varied confounding factors that affected their compliance and the efficacy of this study. In order to maintain the engagement of some participants, it was necessary to elicit repeated reaffirmations of support from senior leaders. Furthermore, other initiatives within the organization had the potential to introduce confusion regarding study methods. This was apparent when staff notified the principal investigator that the standardized oral health assessment form had been uploaded into the EMR. Subsequent inquiry revealed that the organization had made revisions to its VAP prevention documentation in the electronic medical record. These revisions were unrelated to this study and utilized different data elements. In future rounding sessions, the need to continue use of the Oral Health Assessment Tool was reinforced. However, since the Oral Health Assessment Tool was not mandatory, compliance rates dropped at a site that had not yet institutionalized the change. Due to nurses' use of their organization's patient specific documentation method, that data was not available

for analysis. Only results documented on the paper based standardized oral assessment form were included in this study. This may have limited the power of the assessment tool to detect compliance with the overall intervention.

Implications for the Future

Practice. Evidence based practice changes integrate research and clinical expertise with the primary goal of improving patient and healthcare outcomes. The advanced practice nurses' multifaceted skill set and clinical expertise lay the foundation for an increased role within healthcare organizations. As clinical educators, consultants and providers, APNs can use their strong leadership abilities to enable transformational change. APNs are in a prime position to promote and implement EBP recommendation into clinical practice and can play a pivotal role in the adoption and uptake of new innovative practices. Future research may involve developing a systems level approach to increase oral care documentation rates. Given ongoing and impending national healthcare reforms, advanced practice nurses could help healthcare organizations adapt by developing and guiding change management initiatives.

Theory. The epidemiologic triangle and Rogers' DOI Framework and Innovation Process were useful in guiding the development and implementation of this EBP project. However, Rogers' Innovation Process was of limited utility when evaluating the project outcomes. Future theory development should explore why the translation of research to practice is lagging, especially in the area of VAE prevention, and develop strategies to improve compliance with EBP recommendations. Additionally, future theory development needs to address needs from the family's perspective. Theory that integrates the family unit provides context to the problem and may even serve to encourage practice change and adoption.

Research. A review of the literature revealed thousands of research articles describing the implications of VAE development. However, relatively few articles evaluated barriers to implementation such as standards and procedures related to the provision of oral care and VAE prevention, staff compliance, and staff feedback regarding change initiatives. Research that

focuses on increasing individual, group, and system adoption of innovation needs to be undertaken. Future research should focus on developing strategies for the successful adoption of and compliance with, the provision of evidence based oral care and oral health assessment documentation. Additionally, future research could incorporate patient level data as well as the patient's or family's perspective. In so doing, researchers could access the richer context that may provide greater depth and understanding of change initiatives and their adoption within the critical care setting.

Education. After an innovation is adopted, practice changes are affirmed and become routinized into everyday practice. VAE prevention requires commitment and continued staff education at all levels. Therefore a multidisciplinary approach and transparency should be encouraged within organizations. Educating new personnel during orientation and providing yearly skills training is imperative to sustaining a long lasting practice change. Additionally, an intra-organizational team based approach should be used to foster organizational cohesiveness. Multidisciplinary approaches can alleviate facility specific barriers that interfere with the adoption of current EBP guidelines.

Conclusion

This EBP project provided useful information for critical care nurses, advanced practice nurses, nursing managers, and other healthcare providers regarding the strength of the evidence published in the literature. Based on the evidence presented, practice guidelines can be utilized to implement meaningful change within the ICU setting. The effects of oral hygiene care on the incidence of hospital-acquired infections, including VAE, among critically ill patients are important. Timely oral assessments, mechanical brushing, use of CHG solutions, maintaining appropriate infection control measure during the provision of care, and staff educations, will reduce the incidence of ventilator associated conditions (Koemam et al., 2006; ICSI, 2011; Shi et al., 2013).

Although statistical significance was not found, this study provided preliminary evidence that routine oral assessment and timely intervention in mechanically ventilated patients are useful components of comprehensive oral care practices to prevent or reduce the incidence of VAE.

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BIOGRAPHICAL STATEMENT

Ms. Williams earned her Bachelor of Science in Nursing from the University of Iowa in 2000. She has focused her career on critical care nursing and has 15 years of clinical experience in critical care settings including medical, surgical, neurological intensive care and emergency medicine units. Ms. Williams is a certified ACLS, and PALS instructor and a preceptor for undergraduate nurses during clinical rotations. In 2011, Ms. Williams decided to pursue training in advanced practice nursing and enrolled at Valparaiso University. She is currently an adjunct instructor at the College of Nursing and Health Professions at Valparaiso University. In addition to her work in healthcare and academia, Ms. Williams' research interests include the intersection of performance improvement and reimbursement. Her current doctoral research is concentrated on the reduction of ventilator-associated conditions through performance management. She is a member of the Zeta Epsilon Chapter of the Honor Society of Nursing, Sigma Theta Tau International and a member of the American Association of Nurse Practitioners.

ACRONYM LIST

BOAS: Beck Oral Assessment Scale

CDC: Centers for Disease Control

CNS: Clinical Nurse Specialist

DOI: Diffusion of Innovation

EBP: Evidence Based Practice

HAI: Hospital Acquired Infection

ICU: Intensive Care Unit

IRB: Institutional Review Board

IVAC: Infection-Related Ventilator-Acquired Condition

LOS: Length of Stay

MPS: Mucosa-Plaque Score

MV: Mechanically Ventilated

NHSN: National Healthcare Safety Network

PEEP: Positive End-Expiratory Pressure

PICOT: Population/ Patient Problem; Intervention; Comparison; Outcome; Time

RN: Registered Nurse

VAC: Ventilator-Associated Condition

VAE: Ventilator-Associated Event

VAP: Ventilator-Associated Pneumonia