Ventilator Associated Pneumonia (VAP): Bundle Prevention Strategies in the Pediatric Intensive Care Unit

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Evidence-based protocols in the prevention of ventilator-associated pneumonia (VAP) in the intensive care setting have been well established in the adult population. Research studies using adult samples in intensive care have addressed the use of bundles, yet only a few have focused on children admitted to the pediatric intensive care unit (PICU). With issues concerning healthcare cost metrics and VAP being one of the hospital-acquired infections (HAI), preventative strategies must be equally placed for high-risk children and infants who are intubated and mechanically ventilated.

This paper aims to explore evidence on the use of VAP bundle in the PICU. A thorough review of literature synthesized through critical appraisal will be presented. Quality improvement endeavors, non-experimental and observational research articles are integrated to come up with the best available evidence. As a result, an EBP project, referred to as the ZAP VAP project, will be instituted in a 9-bed PICU located in a large community hospital. A comprehensive description, explanation, and implications of this EBP project will be highlighted in the rest of this paper.

Significance of the Problem to Nursing Practice

It is not uncommon for pediatric patients of any age to be electively or emergently intubated due to various multisystem issues. The use of mechanical ventilator after intubation places patients at risk for developing VAP (Bigham et al., 2009; Perugini, 2015; Rosethal et al., 2012). PICU nurses need to be vigilant in the care of pediatric patients placed on a mechanical ventilator. Nurses play a major role in the prevention of any nosocomial or hospital acquired infections, including VAP, as they coordinate care with other healthcare practitioners. Several

studies (Esteban et al., 2013; Kiernan & Hennessey, 2012; Muszynski et al., 2013; Richardson, Hines, Dixon, Highe, & Brierley, 2010) have presented the designation of nurse-led interventions in preventing hospital-acquired infections for catheter, central line, and ventilator related device use. These nurse-led nosocomial prevention quality improvement projects have been implemented in various facilities across the nation. Preventing VAP in particular, using a standardized, protocoled bundle, may help streamline the care provided, resulting in decreased length of PICU stay, cost containment and ultimately improved outcomes.

The following section presents the clinical question in a PICO format. This PICO question is a valuable guide to the acquisition of evidence from varied literature. Evidence were analyzed for quality and synthesized to formulate clinical recommendations appropriate for the VAP prevention EBP project.

PICO Clinical Question and EBP Project Background

An effectiveness of intervention type of PICO question is formulated for this particular EBP project. Asking the compelling question in a form of PICO (**P**atient interest, **I**ntervention, **C**omparison and **O**utcome) creates a structure to make the EBP process as concordant to goals as possible (Brown, 2014; Godshall, 2016). The PICO question for this VAP EBP project is—*Does the use of VAP bundle decrease the incidence of ventilator-associated pneumonia in pediatric patients ages 1 month to 18 years old admitted to the PICU?*

Project setting. The setting for the PICO question is the Pediatric Intensive Care Unit (PICU) at Huntington Hospital in Pasadena, CA. Huntington Hospital is a large community hospital that has the only PICU department in the San Gabriel Valley area. The PICU has a total of nine state of the art beds equipped with the latest medical technology, providing a high level of care to critically ill and severely injured pediatric patients (ages 1 month to 18 years old).

The Huntington Hospital PICU caters to a variety of patients requiring mechanical ventilator support. There were about 25 cases of patients placed on mechanical ventilators for the year 2015 with a documented 4 cases of confirmed VAP (Huntington Hospital PICU, 2015). While four seems a statistically insignificant number, the long-term burden involving high cost and a prolonged ICU stay can be detrimental not only to the physiologic and psychological health of the patients but also to the healthcare organization in general (Brilli et al., 2008).

The next section probes into various sources of literature and articles. It examines VAP conceptual background, epidemiology etiology, and risk factors. It will discuss search methods, appraisal, and synthesis of the evidence from research studies and quality improvement projects using bundle strategies as well.

Search Strategy

A comprehensive literature search was used in the development of the VAP EBP project. This section provides an overview of how the search was done. It has laid out inclusion and exclusion terminologies, year, language and the database sources.

Inclusion terms. The initial search was aimed to include the term *ventilator-associated pneumonia* in general with articles from the adult, pediatric and neonatal populations. The rationale behind this broad search was to gather an overview and conceptual background of VAP and its impact in other critical care settings or population. Some of the VAP theories and similar EBP articles from adult and neonatal populations are helpful in translating to the pediatric population, as studies involving pediatric patients (infants and children) are relatively sparse at this point.

Nevertheless, the inclusion terms that weighed heavily in this review of literature include: *pediatric VAP pneumonia prevention bundles, ICU bundles, nosocomial infections, hospital*

acquired infections (HAI), Pediatric Intensive Care (PICU) VAP preventions, and *pediatric VAP and VAP prevention in infants and children.*

Other search terms. The following terms, some of the components of a bundle, were used in the literature search: *head of bed positioning (30–45-degree angle), ventilator maintenance strategies-sterile closed suctioning, ventilator equipment change/replacement, draining of circuit condensation, hand hygiene-pre and post patient and equipment contact, oral care use of chlorhexidine and age appropriate mouth care, VAP bundle,* and *VAP bundle of care*.

Year of literature and language. The years 2008 to 2016 were used in the selection of articles and other types of literature. This strategy allowed for the comparison of trends and changes, if any, in research and evidence on VAP prevention strategies. As for language inclusion, any language that can be translated was considered. In the end, only one article was originally written in Spanish, and English version of this article was included. It would be indispensable to search other evidence from different countries and evaluate whether the interventions and resources are applicable in the US PICU settings.

Exclusion terms. Community-acquired, aspiration, bacterial, viral and fungal pneumonia were excluded from the search, as these are not generally caused by ventilator use. VAP measures and prevention strategies geared toward premature/low birth weight infants and geriatric ICU patients were excluded. The extremes of weight and age might affect the overall validity of evidence and may not apply to the PICU setting for the EBP project.

Sources and database. A variety of electronic and Internet-based search engines used in this project included; NNU library database, CINAHL, PubMed, EBSCO host and OVID. Organizational websites such as the Centers for Disease Control and Prevention (CDC), the Institute for Healthcare Improvement (IHI) and Association for Professional in Infection Control

and Epidemiology (APIC). These databases and websites contain peer reviewed articles and journals that have been rigorously screened before public dissemination. Reliable organizations such as the CDC, APIC, and IHI offer valuable clinical guidelines and up to date sources on VAP and prevention strategies.

Overall, 52 articles were found, 34 were excluded based on the criteria as mentioned previously, 18 were appraised for quality and applicability to the VAP EBP project. Eight research articles and one organizational, clinical guideline of good and high-quality evidence were used in the actual synthesis of evidence for the VAP prevention bundle EBP project. Refer to Appendix I for the complete table of evidence, level and ratings.

Review of Literature

The first half of this literature review provides a conceptual background of pediatric VAP—definitions, epidemiology, pathophysiology, clinical presentation, etiology, and risk factors. The second half will touch on the basics of a VAP bundle, followed by an expansive literature review from research articles and quality improvement projects employed in diverse PICUs which cater to ventilated infants, children, and adolescents. The last part of this literature review will briefly discuss one important non-research article from the Institute for Healthcare Improvement (IHI).

VAP Conceptual Background

VAP is one of the most common nosocomial or hospital-acquired infections defined as the development of pneumonia that evolved *at least 48 hours* after respiratory intubation and initiation of mechanical ventilation (Association for Professionals in Infection Control and Epidemiology [APICE], 2010; Centers for Disease Control and Prevention [CDC], 2016; Straumanis, 2009; Trimarchi, 2013). There is no minimum time that a patient has to be

mechanically ventilated to consider pneumonia a ventilator-associated one (APICE, 2010). However, for instances such as a patient being intubated at another facility before admission to the PICU, the 48-hour rule starts post-admission when categorizing VAP (APICE, 2010). It is important to note that a patient *must* be *both* intubated and mechanically ventilated within the 48-hour timeframe to meet the criteria of a VAP diagnosis (APICE, 2010).

Epidemiology

VAP is the second most common cause of morbidity and mortality accounting for up to 20% of infections in the Pediatric Intensive Care Unit (Institute for Healthcare Improvement, 2015). According to CDC's integrated National Nosocomial Infections Surveillance System (NNIS), about 3 per 1,000 ventilator days of nosocomial pneumonia occur in mechanically ventilated children (Centers for Disease Control and Prevention [CDC], 2012). In the PICU alone, incidence varies from 4 to 44 per 1,000 mechanically ventilated children (CDC, 2016; IHI, 2015). Consequently, pediatric patients who develop VAP stay almost twice as long in the hospital as those who do not (IHI, 2015; Esteban, 2013).

Etiology and Risk Factors

Common risk factors of VAP include length of mechanical ventilation, use of sedatives and neuromuscular block agents, enteral nutrition, antibiotic therapy, endotracheal suctioning, reintubation, gastroesophageal reflux, and tracheal stenosis (Chang & Schibler, 2015; Cooper & Haut, 2013; Rosenthal et al., 2012). The most important risk factor that needs to be considered is the length of mechanical ventilation use. Studies have shown that the longer the time the patient is intubated and mechanically ventilated, the greater the risk of developing VAP (Chang & Schibler, 2015; Kusahara, Da Cruz Enz, Avelar, Peterlini, & Pedreira, 2014; Turton, 2008). Pediatric patients who are intubated are at higher risk than their adult counterparts due to poor

cough, decreased gag reflexes, use of uncuffed endotracheal tube, and teething. As for the onset, the first two weeks after intubation poses the greatest risk of developing VAP in children (Straumanis, 2009).

A basic understanding of the common risk factors for VAP in the pediatric population is critical in the development of EBP VAP prevention project. For example, instituting a protocol on minimal use of sedatives and neuromuscular agents might expedite weaning of mechanical ventilation. Another example is good oral care which can decrease bacterial colonization in the mouth attributed to the development of VAP. Understanding the cause can help prevent VAP's occurrence in one of the most vulnerable patient populations: children and infants. Prevention strategies with bundled care will be discussed in the expansive literature review section of this paper.

Pathophysiology

Microaspiration from contaminated or colonized oral-tracheobronchial and even gastric structure is thought to be the main pathogenesis of VAP (Chang & Schibler, 2015; Gurkis et al., 2009; Sebastian, Lodha, Kapil, & Kabra, 2012). Common microorganisms responsible in VAP are gram *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and other *Enterobacter* species that may enter the lung parenchyma anytime during intubation, suctioning or ventilator circuit disconnection (Chang & Schibler, 2015; O'Keefe-McCarthy, Santiago, & Lau, 2008). These organisms are present in subglottic secretions, biofilm, and orotracheal secretions (Sedwick, Lance-Smith, Reeder, & Nardi, 2012). If unabated, these organisms can create a cascade of pulmonary epithelial cell damage, leading to inflammatory body response with VAP as the end result (Straumanis, 2009; Trimarchi, 2013).

Diagnosis and Clinical Presentation

Although there is no diagnostic gold standard developed consensually by pediatric specialists, radiologic findings, tracheal aspirate culture, and identification of clinical signs might be helpful (Azab et al., 2015; CDC, 2012). This new pneumonia is mainly evidenced by a new, progressive (that is, worsening) infiltrate in radiological findings (Cooper & Haut, 2013). In patients 1-year-old or younger, VAP is characterized by pneumatoceles (an air-filled cavity seen in the lung parenchyma) in radiologic exams (CDC, 2016; Munaco, Dumas, & Edlund, 2014). This radiologic finding must be confirmed by another chest x-ray that must show a persistent appearance of infiltrate, cavitation or consolidation (Straumanis, 2009).

Clinical signs and symptoms are similar to classic pneumonia, which includes fever (or temperature instability in patients less than 1-year-old), leukopenia (WBC count < 4,000/mm^3 after ruling out other sources), tachypnea or apnea (dyspnea may be present in older children), retractions, adventitious breath sounds (wheezes, rales, or crackles), and new onset of purulent sputum, worsening cough, or increase work of breathing (APICE, 2010; CDC, 2012; Straumanis, 2009; Trimarchi, 2013). There should be at least three of these symptoms to consider the diagnosis of VAP in children (CDC, 2016; Straumanis, 2009).

Overview of the VAP Bundle

A bundle, also called a care bundle, is a set of about three to five care practices that, implemented together, will improve patient outcomes (IHI, 2015). Examples of VAP bundles that may apply to this EBP project include (but are not limited to) hand hygiene, oral care, clean suctioning, stress ulcer prophylaxis, sedation vacation, and ventilator circuit changes. When a bundle is performed collectively and reliably, patient outcomes are expected to improve (Institute for Healthcare Improvement, 2010; Lachman & Yuen, 2009).

Bundles are based on evidence-based practices from mostly randomized controlled trials (IHI, 2010). Bundle components have undergone testing, although changes in techniques and specific conditions for implementing them may change over time (Lachman & Yuen, 2009). For instance, some research suggests head of the bed elevation should be between 30–45 degrees (Perugini et al., 2015) while some research suggests 20–30 degrees is equally effective in prevention of VAP (Brierly, Highe, & Hines, 2012). Moreover, this head of bed elevation action should be combined with another bundle component such as oral care and ventilator circuit changes to produce better patient outcomes (Lachman & Yuen, 2009).

To simplify, a bundle is more than just a list; it involves “all or nothing” interventions (Lachman & Yuen, 2009). However, the focus should be on *how* to deliver the best care and not *what* the care should be for every single patient, every time (IHI, 2016). Bundles are not compulsory, and patient clinical condition must be evaluated prior to implementation (Lachman & Yuen, 2009). If bundles are adopted consistently in the PICU, teamwork is enhanced, and quality improvement goals (decreased VAP rates, increased compliance) can be achieved.

Critique/Rating Strategy and Expansive Review of Literature

This section examines the VAP prevention bundle-focused research studies, strategies, clinical guidelines and quality improvement projects. The articles presented in the expansive review of literature were leveled or rated anywhere from Level I to Level V using the Johns Hopkins Model. Quality was also examined and classified as high, good, or low. Refer to Appendix I.

The Johns Hopkins Evidence Rating

Level I articles are the experimental studies, randomized controlled trials, and meta-analysis (Newhouse, Dearholt, Poe, Pugh, & White, 2005). Level II are considered quasi-

experimental while level III are non-experimental, qualitative studies (Newhouse et al., 2005). Level IV are those clinical practice guidelines recommended by expert opinions based on research evidence or expert panel consensus (Newhouse et al., 2005). Finally, level V include articles based on non-research evidence, opinions, review of the literature, quality improvement, and financial data (Newhouse et al., 2005). Research articles, summative reviews and organizational studies that are well defined, consistent, and based on scientifically sound measures with definitive, valid and reliable conclusions are considered *high* quality (Newhouse et al., 2005). Those articles or literature with fairly credible, consistent conclusions and recommendations are rated as *good* quality (Newhouse et al., 2005). *Low*-quality articles were excluded from this review of literature. They present inconsistent and sparse scientific evidence generating vague or dubious conclusions (Newhouse et al., 2005). These low-quality articles will not be used on the final EBP project either.

Expansive Literature Review

Bigham et al. (2009) conducted a process improvement (PI) initiative in one of the largest Midwest PICUs using VAP bundle. This PI project was led by nursing and respiratory therapy department with a goal of revising ventilator strategies and at the same time, increasing awareness of VAP bundle through staff education. The authors highlighted the importance of changing ventilator circuits only when visibly soiled to prevent contamination from breaking the circuit unnecessarily (Bigham et al., 2009). After three years of implementation, there were a decreased number of ventilator days from 5.6 to 0.3 per 1,000 mechanical ventilator days (Bigham et al., 2009).

Brierly, Highe, & Hines (2012) also used a quality improvement process to gauge the effectiveness of a VAP bundle. One unique VAP bundle component in this project was the

inclusion of gastric ulcer prophylaxis to increase gastric pH. In theory, increasing gastric pH can be cytoprotective against bacterial contamination, reducing the risk of VAP. However, other literature sources have inconclusive views on the effectiveness of H2 blockers (such as Zantac) versus sucralfate in the prevention of VAP (Cooper & Haut, 2013; Kusahara et al., 2014; Muszynski et al., 2013). There is no difference in the incidence of VAP between children treated with H2 blockers and children who were treated with sucralfate (Foglia et al., 2007 as cited in Cooper & Haut, 2013). In the end, Brierly et al. (2012) project resulted with zero VAP rates over a 12-month period after implementation of a VAP bundle.

One noteworthy VAP bundle prevention study by Brilli et al. (2008) in a renowned children's teaching hospital measured the financial impact of VAP rates associated with hospital PICU length of stay (LOS). VAP rates after the implementation of VAP bundle prevention strategies decreased from 7.8 to 0.5 cases per 1,000 ventilator days (Brilli et al., 2008). This resulted in an unreimbursed cost reduction by $442,789 and a total hospital cost reduction by $2,353,222. These financial advantages were attributed to the decreased hospital LOS of 400 in a two calendar year period (Brilli et al., 2008).

Another VAP bundle quality improvement project was steered by Esteban et al. (2013) in a university hospital with a 14-bed PICU. Esteban et al. (2013) evaluated the long-term outcomes (period of 12-month post implementation) of a VAP bundle prevention project. With the concurrent use of other bundle components such as head of bed elevation, oral care, and closed system suctioning, the authors also emphasized the use of cuffed ET that can prevent subglottic microaspiration and subsequent leakage of tracheal secretions into the lower airways (Esteban et al., 2013). VAP rates have decreased from 28.3 to 10.6 and has sustained after 12 months with further VAP rate reduction down to 9 per 1,000 ventilator days (Esteban et al., 2013).

Gurkis et al. (2009) examined the outcomes of a VAP bundle after instituting a multimodal strategy to reduce nosocomial infections in a Lithuanian hospital. In addition to the usual bundle components like hand hygiene, ventilator circuit change PRN, staff education was highlighted as one of their strategies. VAP rates decreased from 5.6 to 1.9 per 100 patients at the end of their 2-year surveillance study. Similarly, Perugini et al. (2015) recommended strengthening staff education to increase adherence to bundle use, especially the head of bed elevation, hand hygiene, standard precautions (gown and gloves) and vigilant removal of ventilator condensates components. There was 64.8% reduction in VAP rates after implementation of VAP bundle coupled with multidisciplinary staff education (Perugini et al., 2015).

On the other hand, Kiernan and Hennessey (2012) piloted a VAP bundle protocol for their PICU and trended outcomes over five years. What is unique about their bundle is the incorporation of “sedation vacation.” Sedation vacation is defined as the intermittent, structured, planned interruption of narcotics, sedatives and paralyzing agents with the goal of weaning the patient off from the ventilator (Kiernan & Hennessey, 2012). The faster and more efficient the patient is weaned off from the ventilator, the lower the risk of developing VAP. This pilot unit-based project also supported the value of hand hygiene, making this particular component/evidence stronger in the context of VAP prevention. VAP rates decreased from 3.9 to 1.5 cases per 1,000 ventilator days and had sustained at 0.46 per 1,000 ventilator days for three years post bundle implementation (Kiernan & Hennessey, 2012).

The most intensive study amongst the rest as far as geographical setting is concerned was a multicenter study completed by Rosenthal et al. (2012). The study was conducted in several countries (Columbia, Philippines, India, El Salvador, and Turkey) with an emphasis on

multidimensional approach. Some of the multidimensional elements being implemented together with VAP bundle include staff education, feedback and surveillance (Rosenthal et al., 2012). Surveillance was the key element in this study's VAP bundle implementation. Surveillance in this study was focused on monitoring, recording, and trending compliance with measurable outcomes such as health care worker adherence to strict hand hygiene, head of bed elevation, oral care and sedation vacation (Rosenthal et al., 2012). Overall VAP rate was reduced from was 11.7 cases per 1,000 ventilator days to 8.1 cases per ventilator days (Rosenthal et al., 2012).

Lastly, the Institute for Health Care Improvement (IHI), a leading not-for-profit international organization with a mission to improve healthcare systems, recommended several interventions for the bundle prevention of VAP in children. These included head of bed elevation, daily sedation vacation or assessment of extubation readiness, peptic or stress ulcer prophylaxis and deep vein thrombosis if age appropriate (IHI, 2015). Deep vein thrombosis is a part of preventing pulmonary embolism, thought to be one of the sequelae of VAP in adults. However, a direct correlation in the prevention of VAP in the children has yet to be established (CDC, 2016; IHI, 2015; Morinec, Iacaboni, & McNett, 2012).

Please refer to Appendix II for the table summary of bundle components as recommended from each of the reviewed articles above.

Synthesis and Recommendations

After assessing the quality of articles, the next step was to extract the common themes and the best evidence. This process required meticulous analyses involving evaluation of study results for validity, reliability, applicability, and feasibility to the setting and population intended. This section synthesizes the preceding review of literature and integrates some of the recommendations crucial in the development of the PICU VAP prevention bundle project.

There were eight peer-reviewed and published articles to be considered in this VAP EBP project. Additionally, one organizational, clinical guideline from IHI was considered as it fits the VAP bundle.

The three articles (Bigham et al., 2009; Brierly et al., 2012; Kiernan & Hennessey, 2012) were written after instituting performance improvement projects in the PICU. These three projects incorporated bundle of care in the prevention and reduction of VAP rates in the PICU. Bigham et al. (2009) had included six bundle components, including hand hygiene, head of bed elevation, oral care, ventilator circuit change, draining of ventilator condensate and maintenance of appropriate cuff pressure based on age. Brierly et al. (2012) also included head of bed elevation and oral care in their project with the addition of stress ulcer prophylaxis and clean suctioning techniques. Kiernan & Hennessey (2012) also implemented hand hygiene, head of bed elevation, oral care, clean suctioning, and sedation vacation as an additional bundle component.

Esteban et al. (2013) and Gurkis et al. (2009) both described the effectiveness of a bundled VAP prevention by designing a prospective, cohort, and interventional study. Both articles were based on an organizational quality improvement geared toward the reduction of VAP rates. Gurkis et al. (2009) emphasized standard precautions through the use of gowns and gloves when anticipating respiratory contamination during pulmonary procedures such as suctioning, bronchial lavage, and bronchoscopy. Hand hygiene and head of bed elevation are the two bundle components mentioned in Brilli et al. (2008), Perugini et al., 2015 and Rosenthal et al. (2012) studies while the IHI 2015 collectively integrated the various strategies into total of eight pediatric VAP prevention clinical guideline (see Appendix II).

Putting it All Together

Based on the evidence presented in the review of literature, five common bundle components emerged—hand hygiene, oral care, head of bed elevation, ventilator care, and clean suctioning technique. A description of the bundle components, brief rationale for each, and recommendations are discussed here.

Hand hygiene. Adherence to meticulous hand hygiene remains the primary measure for the prevention of any hospital-acquired infection including VAP (Chang & Schibler, 2015; CDC, 2012; IHI, 2015). The key is constant awareness when rendering patient and equipment care. Attention to strict hand washing or use of hospital-approved sanitizers before and after contact with patient, equipment, environment, and surface is imperative to avoid nosocomial infection (Chang & Schibler, 2015; Gurkis et al., 2009; Perugini et al., 2015).

Oral care. Proper rendition of oral care in the prevention of pediatric VAP depends on patient's age, dentition, and general oral condition. For infants with no teeth, moistening and cleaning of the oral cavity can be done by soaking oral cleaning swabs with normal saline or sterile water as needed (Gurkis et al., 2009; Rosenthal et al., 2012). For children less than 6 years old with teeth, a small soft toothbrush can be used BID on top of PRN oral moistening or cleaning same as infants with no teeth (Gurkis et al., 2009; Kiernan & Hennessey, 2012 Perugini et al., 2015). For all ages 6 and older, oral swabs soaked in 1% chlorhexidine can be used in oral care, at least, every 4 hours and PRN (Bigham et al., 2009; Gurkis et al., 2009). Thorough oral hygiene is essential in reducing mucosal biofilms and dental plaque containing microorganisms which may contribute to the development of VAP (Cooper & Haut, 2013; Dosher et al., 2014).

Head of bed elevation. Current recommendations for head of bed elevation vary and may depend on the PICU bed mechanical function available as well as patient age and medical

condition. For small infants and full-term neonates on warmers and cribs, at least 15-degree elevation is desired (Kiernan & Hennessey, 2012). Most of the PICU beds nowadays have elevation markers that go more than 15 degrees, so the elevation of at least 30 degrees is recommended (Brierly et al., 2012). Patients maintained in semi-recumbent position reduce the risk of aspiration caused by microaspiration of contaminated gastric contents (Bigham et al., 2009; Brierly et al., 2012; IHI, 2015; Sedwick et al., 2012).

Ventilator care. Draining ventilator condensate and changing circuit only if necessary are the two main focal points in this bundle component. Both respiratory therapy and nursing should ensure that any water from the ventilator circuit is being emptied away from the patient especially during position changes. A routine or scheduled circuit assessment and condensate removal of at least every two to four hours is recommended (Bigham et al., 2009; Gurkis et al., 2009; Perugini et al., 2015). Ventilator circuit changes must be kept minimal and limited only when visible soiling is observed (Bigham et al., 2009; Gurkis et al., 2009; IHI, 2015).

Clean suctioning technique. It has been highly suggested to use gloves and gown if anticipating contact with respiratory secretions during suctioning or any tracheobronchial manipulation (Gurkis et al., 2009). On the other hand, an in-line catheter is also recommended to minimize contamination when the ventilator is being disconnected from the patient when suctioning (Kiernan & Hennessey, 2012). An astute assessment of respiratory status is important to avoid unnecessary, even harmful suctioning. If suctioning is clinically required (such as if there are coarse breath sounds, visible secretions, or desaturation) instilling normal saline should be avoided as much as possible. Research shows that this practice not only predisposes the airways to bacterial contamination, it also generates negative effects on oxygenation, work of

breathing, heart rate, and blood pressure (Aelami, Lotfi, & Zingg, 2014; APICE, 2010; Hsieh et al., 2010; Lachman & Yuen, 2009).

In a nutshell, a bundle is a specific tool based on parameters derived from research evidence. For the VAP bundle, each component is critically important. The theory is if all of the components are implemented together (not just individually), it will result in decreased incidence of VAP in the PICU setting. The recommended bundle components are hand hygiene, oral care, head of bed elevation, ventilator care, and clean suctioning. A bundle is not something set in stone or a rigorous recipe to follow, but ensuring consistency and adherence will help create long-term positive outcomes.

The PICU Zap VAP Evidence-Based Practice Project

The purpose of this EBP project is to explore the strategic use of a care bundle in the prevention of pediatric VAP. Specific goals of this project are to identify pathophysiologic basis and risk factors for VAP and to appraise and synthesize EBP evidence which were already detailed out in the previous sections. A VAP prevention protocol, guideline, and checklist for all mechanically ventilated pediatric patients will be constructed as well. Ongoing multidisciplinary education, monitoring compliance, and evaluating outcomes are all integral parts of this EBP project.

Theoretical Framework/Model

Translating evidence from research studies to clinical practice require a framework that will serve as a guide in developing an EBP. The foundation of EBP relies on a theoretical framework suitable to the population, setting, personnel and resources impacted by a clinical need identified. The classic EBP model meshed with the Colorado model best mold the process involved in this Zap VAP project. Refer to Appendix III for illustration.

The EBP model. The triad of EBP is best evidence, clinical expertise, and patient values. The first piece, best evidence, refers to the systematic, methodological, scientifically researched information on the efficacy, accuracy, strength and quality of nursing interventions beneficial to patients (Brown, 2014; Godshall, 2016). The extensive literature search, appraisal, and synthesis completed in the first part of this paper is reflective of this EBP component. Next is clinical expertise, the healthcare practitioners or clinicians' cumulative knowledge, skills and attitude gained from their extensive platform of education, experience, and practice. The success of this Zap VAP project depends on the contribution of ideas and collaboration by the different members of the interdisciplinary health care team. The third piece, patient values, is the core reason an EBP project is being advanced in the first place. Although it is challenging to incorporate patient values in the PICU setting, family values are equally imperative, as some of the adjunct interventions of the VAP prevention project may involve participation from parents. For example, parents should be included in planning care when weaning a patient from the ventilator or switching sedation medications to allow spontaneous breathing with minimal pharmacologic interference. All of these describe components applicable to the Zap VAP EBP project.

The Colorado model. This model builds on leadership, mentorship, facilitation, and organizational support, with the patient (and his/her family) as the main center (Goode, Fink, Krugman, Oman, & Traditi, 2011). Like Dosher et al. (2014), the VAP project showcases the contribution of interdisciplinary team members consisting of managers, educators, respiratory therapists, doctors, and infection control personnel in the reduction of VAP rates. This interdisciplinary approach will facilitate EBP planning, implementation and evaluation with ample support from the organization. Leadership and mentorship are exemplified in all phases as each team member contributes ideas, teaches others and keeps one another focused on the goal.

Along the same lines, the Colorado model speaks of the main principle of pediatric nursing – achieving outcomes through the provision of patient/family-centered care. Involving the patient and especially the family in daily rounds or simply teaching the importance of hand hygiene is paramount in this EBP project. Conversely, the Colorado model engenders some interdisciplinary challenges. These challenges include intra- and interdepartmental resistance to change, communication gaps, lack of budget, and coordination setbacks concerning time and unresolved departmental issues (Newhouse & Spring, 2010).

Implementing the Zap VAP Project

This section explains the EBP design based on the identified model, participants, specific interventions and evaluation plan to be applied in this Zap VAP. A comprehensive list of interventions and action plan are outlined in Appendix IV.

Design of the project. The Zap VAP EBP project design will be a crossover between quality improvement (QI) and clinical protocol with a common goal of refining patient safety, efficiency, effectiveness, and accessibility of resources. QI projects are data-driven and monitor outcomes of implemented care processes (Brown, 2014) while a clinical protocol pertains to a standardized care set, a bundle, or a pathway that aims to simplify decision making by guiding the staff to the action that applies to a given scenario (Brown, 2014). This EBP project requires a VAP bundle protocol for all admitted PICU patients. Also, a bundle checklist will aid staff remembering the bundle components (see Appendix VI). Baseline data pre- and post-implementation will be collected and analyzed as a part of quality improvement outcomes evaluation.

Implementation/Interventions and Participants

Evidence collection from an expansive literature search has already been accomplished. Results will be discussed and convened with the project participants referred to as the PICU VAP Bundle Champions. The Zap VAP champion committee is being led by Raulin Feria, a graduating MSN Student of NNU. Staff nurses who vowed commitment in this project include one dayshift RN and one nightshift RN. The respiratory therapy department, medical director, managers, unit educators, an EBP committee representative, and infection control personnel will be involved. Implementation will start in May and will presumably complete by the end of July 2016. See Appendix IV for table, timelines and specific details.

The patient's families can be indirectly involved in the EBP implementation. For example, reiterating the importance of handwashing before and after visiting/touching the patient or encouraging a parent to participate when doing oral care. Such patient care participation provides the parents sense of control over their child during their stay in the PICU.

Meanwhile, support from leadership and management is crucial especially if new products are needed to be purchased such as oral care kit swabs and commercial suction kits that are evidence-based and efficacious. Currently, several products from different manufacturers are being tested by Huntington Hospital PICU staff. Open communication via email, EBP monthly meetings, and daily multidisciplinary rounds will enhance dissemination of information and updates.

Staff education promotes cooperation during the implementation process of VAP prevention bundle. This entails considerable participation and help from other disciplines such as respiratory therapy and infection control department. A computer-based learning module will be created and loaded to the hospital intranet for staff to peruse and complete. VAP champion members will also be available for in-service education and consultation. The success of VAP

EBP project will depend on the level of commitment, robust information dissemination, and steadfastness in achieving the goal of zero VAP in the PICU. Continuous evaluation is also crucial in the long run. Evaluation strategies will be discussed in the following section.

Evaluation

Evaluating the outcomes of the PICU VAP bundle EBP project will comprise of three elements: staff knowledge/skills, staff compliance, and VAP rates.

As previously mentioned, a computer-based learning module will be created with the assistance of PICU unit educator, information technology department and various input from the PICU VAP champions. A pre-test will be administered to gauge baseline staff knowledge of VAP. Learning gaps will be identified from analyzing the results of the pre-test and will help the unit educator strategize teaching methods. After successfully completing the computer-based module, a post-test will have to be fulfilled. At the moment, items to be included and the format of the pre- and post-test have not been developed yet. Test format and items to be included will be discussed with the unit educator and other members of the VAP champion team.

On the other hand, a skills checklist has already been constructed, although it is still in the process of approval from the unit educator and other members of the VAP team. It will be incorporated into staff annual skills competency evaluation and to be administered to new PICU hires as well. It also evaluates staff skills necessary to practice safe and efficient care for intubated patients. See Appendix VII.

Evaluating staff compliance is vital in sustaining the success of the VAP project. Audits will be administered following education and implementation of the VAP bundle. A designated VAP auditor will be determined for dayshift and nightshift. The unit shift auditor is responsible for observing, recording and tracking compliance of the VAP bundle. This will include a

thorough review of documentation from electronic chart—oral care at least every four hours, head of bed elevation (degrees as appropriate for patient age and bed type), draining of ventilator condensate, and suctioning PRN. Observation of hand hygiene pre and post patient handling will be recorded in a separate audit sheet since this bundle component is not existent in the current electronic charting system. The goal is at least 90% compliance in the first quarter. Any fall-outs will be reviewed and correlated with VAP rates quarterly and annually. Re-education is warranted if compliance goals are not being achieved or if VAP occurs during a specific time frame.

The last evaluation plan is surveillance, a data-driven strategy that ensures VAP rates are kept minimal (as compared to pre-intervention phase) to zero. Continuous surveillance is a collaboration between PICU management and Infection Control Department. Huntington Hospital's Infection Control department is responsible for analyzing the raw data gathered by both nursing and respiratory departments. The nursing side analyzes documentation of standard precautions and VAP bundle application and extracts correlation to VAP rates. On the respiratory side, the lead RT (or manager) is responsible for collecting ventilator device days. Quarterly written report of the pooled data is then submitted to infection control department for final epidemiological and statistical analysis. Evaluation results, outcomes, and further action plans will be discussed in PI and VAP champion meeting.

Concluding Remarks on the Zap VAP Project

Using the concepts of EBP and assimilating the steps into a theoretical framework, provides an organized, streamlined and goal-directed project. Identification of committed staff members from different disciplines is crucial in the early phase of the Zap VAP project. The development of protocols and guidelines is a multidisciplinary work, and ongoing education is

indispensable to encourage staff compliance. Surveillance and auditing are central in attaining long-term outcomes and ultimately achieving zero VAP rate in the PICU.

Implications for Nursing Practice

The identification of VAP's pathophysiology and accompanying risk factors such as the duration of ventilator use, sedation status and age of the child offers cues for early implementation of preventative strategies. Staff nurses and other healthcare team members should be cognizant of the risk factors to mitigate VAP in the PICU. PICU nurses deal with intubated and mechanically ventilated infants and children all the time. Hence, if nurses are actively involved in preventing occurrence of VAP, medical cost is reduced, length of stay is decreased, and patient/family psychological burden is alleviated. The implementation of a VAP bundle in the PICU ensures guidelines are followed, and uniformity of care is achieved.

Nursing is at the forefront of quality health care improvement using the best evidence-based practice (EBP) available. Our constant advocacy for patients and curious minds in "making things better" have led us to become initiators and coordinators of EBP. Implementing, sustaining, and evaluating results of EBP requires adept leadership and efficient interdisciplinary collaboration. Education is also paramount for the sustenance of an EBP program. That said, nursing has the biggest opportunity to participate in clinical scholarship and clinical education aimed at achieving optimal patient outcomes.

Limitations and Future Research

Individual bundle pieces were not comprehensively discussed in this EBP paper. Future research, evidence critique, appraisal, and literature review is needed that will critically appraise each of the bundle components, and various implementation strategies. Other areas that may be interesting to be included in future evidence project include establishing sedation vacation

protocols, use of cuffed versus uncuffed tubes, sedation vacation, gastrointestinal prophylaxis, and ventilator weaning protocols prior to extubation.

Summary

Despite the heterogeneity of bundle components from the appraised articles, five elements yielded substantial evidence in the prevention of VAP in the PICU setting. These components include hand hygiene, oral care, head of bed elevation, ventilator care, and clean suctioning. Efficacy is enhanced when care bundle elements are implemented as a single unit rather than independently.

Considering those concepts, an evidence-based project is instituted in the PICU of a large community hospital with a focus on multidisciplinary staff education, compliance auditing, and post-implementation data surveillance. PICU VAP prevention bundle protocol, guidelines, and visual checklist were created in the hopes of creating uniformity and consistency of care among PICU staff. Continuous evaluation is essential to sustain positive outcomes and ultimately *Zap VAP* away from vulnerable infants and children, for good.

Reflection of Program Outcomes

This last section depicts my personal reflection from the evidence-based course outcomes set by NNU. There are four outcomes, and each has its value and meaning to me.

Assume clinical and/or educational leadership in diverse healthcare settings. Leading this EBP on VAP prevention myself represents clinical leadership in the acute care setting. This concerted effort requires unwavering commitment and proficient coordination with other members of our PICU team. Leadership skills such as collaboration, professionalism, and ability to influence change are paramount to the success of this EBP project.

Model ethical behavior; demonstrate integrity and honesty in the role of leader and educator. This EBP project also features the function of a clinical educator with the focus of disseminating evidence and information to other staff members. Integrity and honesty are exemplified from reviewing the literature to educating the staff with precise information as possible, while respecting other staff ideas and input along the way. The principle of beneficence is also validated as such EBP is profoundly directed toward the improvement of patient outcomes and enrichment of family satisfaction.

Advocate for diverse populations and demonstrate social responsibility in healthcare delivery. The PICU setting itself is an environment where diversity is evident. Our PICU provides the utmost care to all pediatric patients regardless of race, gender, culture, family dynamics, or ability to pay. Including the families and other interdisciplinary team members in daily rounds and informing them of the plan of care is reflective of social responsibility in the delivery of family/patient care centered care.

Demonstrate scholarly activity in research, evidence-based practice and adapting theoretical frameworks to clinical practice. The scrupulous process involved in the selection, appraisal, and synthesis of evidence required for this course is a manifestation of scholarly work. Adapting the EBP concepts and customizing the model intended for the project requires hours of meticulous deliberation. Lastly, translating the evidence from the book to the bedside requires forward thinking and innovative strategies. These strategies were the learned theories from our professors and shared expertise from cohort mates as well. NNU has equipped me with tremendous knowledge and skill and a positive attitude– moving me forward to continue such scholarly activity even after graduation.

Appendix I: Evidence Table for Pediatric Ventilator-Associated Pneumonia (VAP)

Author(s)/Year	Questions, objectives, purpose	Design, sample, setting	Bundle Elements/components included/Interventions	Results/Findings/Measures Outcomes/Conclusions	Level/Quality of Evidence *
Aelami et al., 2008	To review current ventilator associated pneumonia (VAP) incident rates epidemiology, risk factors, surveillance and prevention	Review of literature (ROL) Neonates, infants and children	• Hand hygiene (HH) • Glove and gown with endotracheal (ET) suctioning • Head of bed (HOB) elevation • Oral care with chlorhexidine • Stress ulcer prophylaxis • Cuff pressure maintenance	Multimodal strategies when carried out using multidisciplinary teams can prevent VAP in neonates, infants and children	Level V-B (ROL, Good quality)
Azab et al., 2015	To assess the efficacy of VAP bundle in neonatal intensive care (NICU)	Prospective before and after study at a university hospital (NICU) 143 mechanically ventilated neonates	• HOB elevation 30-45 degrees • HH • Sterile ET suctioning • Intubation/reintubatio n hospital protocol • Ventilator circuit changes • Timed mouth care with normal saline (NS) and oropharyngeal suctioning (OPS) • Extubation readiness daily evaluation	VAP rates reduced from 36.4 episodes per 1000 mechanical ventilator (MV) days to 23 episodes/1000 MV days No statistical significance in NICU length of stay (LOS) days	Level III-A (Non experimental, high quality)

			• Sedation vacation		
Author(s)/Year	**Questions, objectives, purpose**	**Design, sample, setting**	**Bundle Elements/components included/Interventions**	**Results/Findings/Measures Outcomes/Conclusions**	**Level/Quality of Evidence***
Bigham et al., 2009	To implement preventative strategies to reduce VAP rates	Process Improvement initiative All Pediatric Intensive Care Unit (PICU) patients who were mechanically ventilated Free standing academic children's hospital in the Midwest	• Ventilator circuit change ONLY when visibly soiled • Drain MV condensate every 2-4 hours • Proper oral care equipment storage • HH • Mouth care • HOB 20-45 degrees • Patients >12, use ET dorsal lumen above ET cuff to suction	VAP rate reduction from 5.6 to 0.3 per 1000 MV days after bundle implementation	Level V-A (Organizational, high quality)
Brierly et al., 2012	Instituting care bundles to reduce VAP rates	Quality improvement methodology All PICU patients on MV 2008-2009 Tertiary PICU in the UK	• HOB elevation 20-30 degrees minimum; 45-degree maximum • Mouth care using chlorhexidine or tooth brushing • Clean suctioning practice • Ranitidine use when patient not on full feeds • Documentation every 4 hours	Zero VAP rates over period of 12 months	Level V-B (Organizational, Good quality)

Author(s)/Year	**Questions, objectives, purpose**	**Design, sample, setting**	**Bundle Elements/components included/Interventions**	**Results/Findings/Measures Outcomes/Conclusions**	**Level/Quality of Evidence***
Brilli et al., 2008	To implement prevention bundle to reduce VAP LOS and decrease costs associated with VAP	Retrospective matched (1:1) case-control study PICU patients with VAP (13 patients were matched to 13 control patients) Cincinnati Children's Hospital	There was a mention of hand hygiene and HOB elevation but there was no explicit discussion of each bundle	VAP rates decreased from 7.8 cases per 1000 MV days to 0.5 cases. Total hospital LOS reduction-400 days Cost reduction by $ 442,789 (unreimbursed care combined in for fiscal years 2006 and 2007) Cost reduction by $2,353,222 in 2 years (2006 and 2007 combined)	Level III-B (Non-experimental, good quality)
Chang & Shibler, 2015	To explore ventilator strategies in addition to other bundle components in the prevention of VAP	Review of Literature PICU patients	• HH • Mouth care • HOB elevation 30-45 degrees • Changing MV circuit only if necessary • Draining MV condensate • Sedation holidays • Weaning protocol	Recommendations from the review of literature (refer to bundle element column)	Level V-B (ROL, good quality)
Author(s)/Year	**Questions, objectives, purpose**	**Design, sample, setting**	**Bundle Elements/components included/Interventions**	**Results/Findings/Measures Outcomes/Conclusions**	**Level/Quality of Evidence***

Cooper & Haut, 2013	To present the definition, etiology, risk factors, diagnosis and prevention strategies based on background evidence.	Review of Literature Infants and children who are mechanically ventilated in the PICU	• Oral care based on dentition (highlight of this article) • Ventilator circuit change • Draining MV condensate every 2-4 hours • Cleaning and storage of suction devices • HH • Barrier precautions when soiling from respiratory secretion is expected • HOB elevation 30-45 degrees • ET dorsal lumen use above the cuff for children >12 years' old	Proposal of VAP prevention bundle with emphasis on oral care: • Neonates/infants with no teeth: every 2 hours with saline swabs • <6 yrs. of age with teeth: brush every 12 hours • Children >6 years with teeth: Brush teeth every 12 hours; Chlorhexidine 1% swab every 12 hours and PRN	Level V-A (ROL, high quality)
Author(s)/Year	**Questions, objectives, purpose**	**Design, sample, setting**	**Bundle Elements/components included/Interventions**	**Results/Findings/Measures Outcomes/Conclusions**	**Level/Quality of Evidence***
Esteban et al., 2013	To evaluate the effectiveness of quality improvement (QI) intervention to reduce nosocomial rates (including VAP)	Prospective interventional cohort study 851 patients (preintervention period), 822 (intervention period	• HOB 30 degrees • Oral care with 2% chlorhexidine every 8 hours • Closed suctioning • Use of cuffed ETs unless contraindicated	VAP rate decreased from 28.3 to 10.6 per 1000 ventilator days (p=0.005) Long term outcomes (period of 12 months after the QI intervention): VAP rated decreased to 9.1/1000	Level V-A (Organizational, high quality)

		and 940 (in long term follow up period) 14 bed PICU bed in a university children hospital		ventilator days	
Author(s)/Year	**Questions, objectives, purpose**	**Design, sample, setting**	**Bundle Elements/components included/Interventions**	**Results/Findings/Measures Outcomes/Conclusions**	**Level/Quality of Evidence***
Gurkis et al., 2009	To evaluate outcomes after instituting multimodal interventions to reduce nosocomial infections (VAP included)	Prospective surveillance study 755 children (ages 1-18 years) PICU in a university hospital in Lithuania	• HH • Ventilator circuit changes only when visible soiled • Drain condensate PRN • Wear gloves when handling fluids • Clear secretions before deflating ET cuff when extubating • Staff education	VAP rates decreased from 5.6 to 1.9 per 100 patients	Level V-A (Organizational, high quality)
Hsieh et al., 2010	To examine the risk factors and incidence associated with VAP when changing MV circuit within 3 days versus 7 days	Cohort observational study N=46 (3-day group) N= 50 (7-day group)	No other bundle components mentioned in the study	Weekly circuit change does not increase the incidence of VAP No statistical difference noted (13% vs. 16% p=0.68)	Level III-B (Non-experimental, good quality)
Institute for Healthcare improvement (IHI), 2015	Presents a summary of pediatric VAP prevention strategies as modified from adult ventilator bundle	Clinical guideline	• HOB elevation • Use 15-30 degrees for neonates; 30-45 degrees for infants and above • HH	Root cause analysis based on Cincinnati children's hospital tool (not explicitly presented)	Level IV-B (Clinical practice guidelines, good quality)

			• Sedation vacation • Peptic ulcer disease prophylaxis • DVT prophylaxis • Comprehensive mouth care every 2 hours • Vent circuit draining every 2-4 hours • Inline suction change only when soiled • Place oral suction equipment in a non-sealed plastic bag when not in use		
Author(s)/Year	**Questions, objectives, purpose**	**Design, sample, setting**	**Bundle Elements/components included/Interventions**	**Results/Findings/Measures Outcomes/Conclusions**	**Level/Quality of Evidence***
Kiernan & Hennessey, 2012	To evaluate a 5-year multidisciplinary intervention after implementing VAP prevention bundle	Long term quality improvement project PICU, NICU and Pediatric Cardiac ICU in a tertiary hospital	• HH • Barrier use when suctioning • HOB elevation • Oral hygiene • Sedation evaluation • Clean/closed suctioning	Zero VAP rates (based on 90th percentile of performance) for 56 months	Level V-B (Organizational, Good quality)
Lachman & Yuen, 2009	To search for evidence and context of VAP prevention bundle in children	Review of literature NICU and PICU specific	• HH • Oral care • HOB elevation • Avoidance of over-sedation • Ventilator circuit changes	Care bundles can be potentially effective if introduced as a part of safety culture in a unit.	Level V-B (ROL, good quality)
Author(s)/Year	**Questions, objectives,**	**Design, sample,**	**Bundle**	**Results/Findings/Measures**	**Level/Quality**

	purpose	setting	Elements/components included/Interventions	Outcomes/Conclusions	of Evidence*
Pergunini et al., 2015	To examine the effects of VAP bundle in pediatric VAP rates	Pre and post intervention study 135 opportunities of patient care were evaluated PICU in a hospital in Brazil	• HH • Use of gown and gloves • HOB 30-45 degrees • Condensate removal • Staff education on VAP bundle	VAP rates post intervention decreased to 17.5 % compared to 49.6% pre-intervention (64.8% reduction in VAP rate overall)	Level V-B (Organizational, good quality)
Richardson et al., 2010	To describe the establishment of a nurse led VAP program in the reduction of PICU VAP rates	Nurse-led surveillance program project Data from 100 eligible intubated PICU patients (intubated >24 hours)	VAP surveillance program Bundle components were not described in this article	To facilitate data collection pertaining to VAP, a flow diagram and teaching program were implemented. Nurses can take a part of this surveillance program. However, increase in nursing workload was the main identified challenge. VAP bundles were planned to be implemented next.	Level V-B (Organizational, good quality)
Rosenthal et al., 2012	To assess the effectiveness of VAP prevention bundle in 5 developing countries using a multidimensional approach	Before and after study 8 PICUs in 5 developing countries: Colombia, El Salvador, India, Philippines, Turkey	• HH • HOB elevation 30-40 degrees • Weaning protocols • Regular oral care • Use of non-invasive ventilation • Multidimensional approach: education, outcomes surveillance,	31% reduction in VAP rate (from 11.7/1000 MV days to 8.1 during the intervention period, p=0.02)	Level III-A (Non-experimental, high quality)

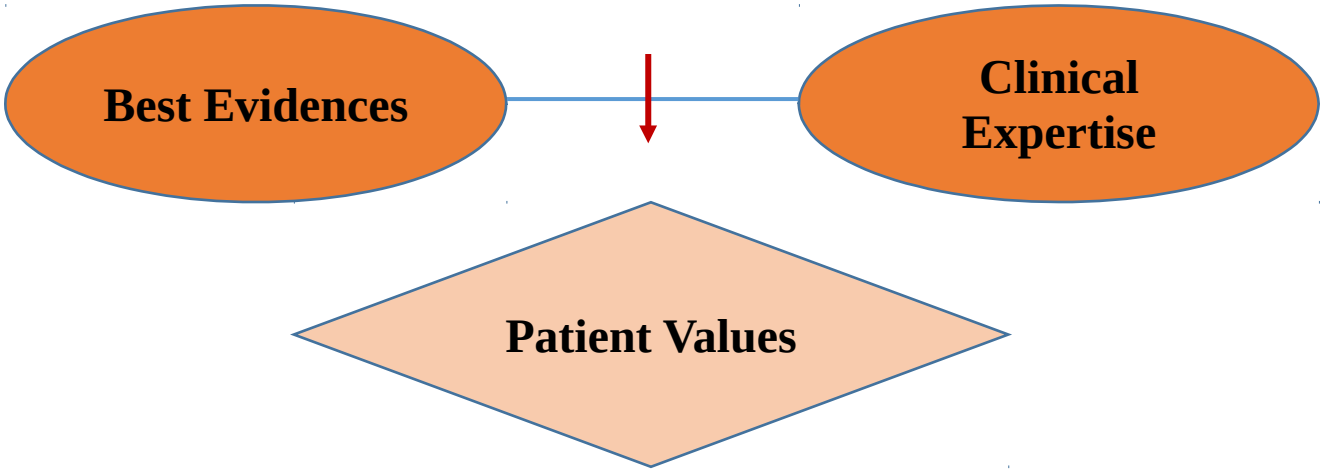
			feedback on VAP rates and performance feedback on infection control practices		
Author(s)/Year	**Questions, objectives, purpose**	**Design, sample, setting**	**Bundle Elements/components included/Interventions**	**Results/Findings/Measures Outcomes/Conclusions**	**Level/Quality of Evidence***
Smulders et al., 2013	Are bundles effective in reducing VAP in neonates and children?	Review of Literature Neonate and children admitted in the PICU	3 studies were reviewed: Refer to Bigham (2009), Brierly (2012) and Brilli (2008) for the bundle elements	Bundle care for VAP prevention in pediatric population is not as robust in adults. The focus should be geared toward compliance of VAP prevention strategies due to heterogeneity in bundle components from the literature reviewed	Level V-A (ROL, high quality)
Turton, 2008	To explore pediatric VAP concepts and prevention strategies	Review of Literature	HH Oral care HOB elevation	Low cost measures to reduce VAP in pediatric population can be successfully implemented. These measures include hand hygiene compliance and adherence to oral care standards	Level V-B (ROL, good quality)

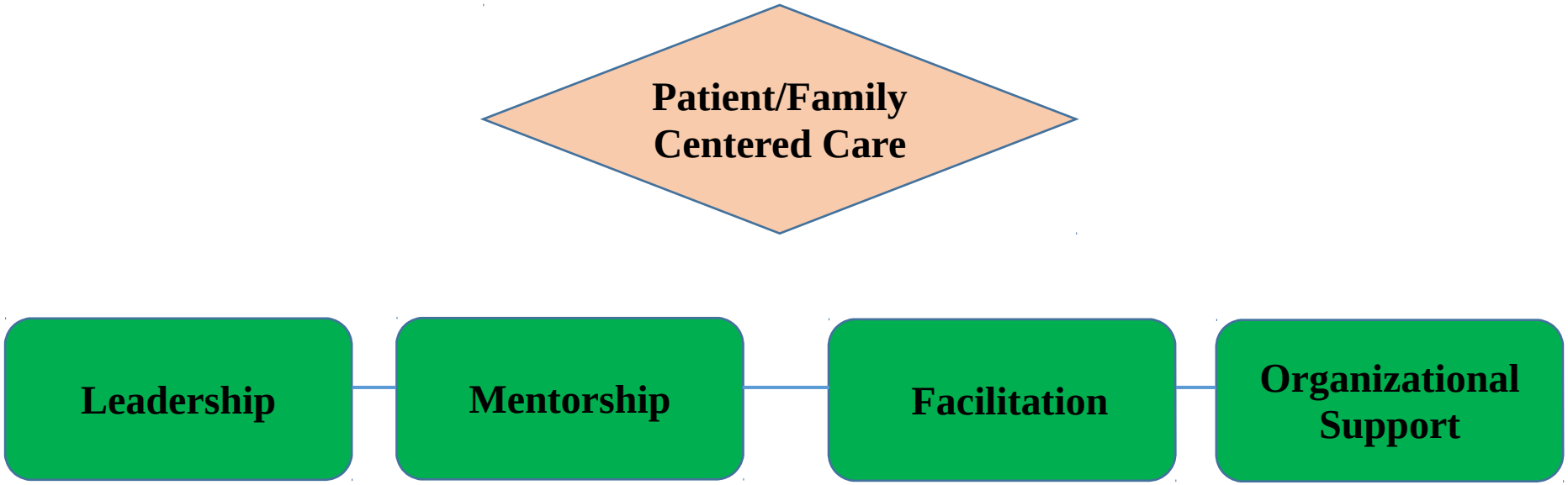
Appendix II. Summary of Bundled Components Used in the Studies/Articles Appraised

Interventions (Bundle components)	**Bigham et al. (2009)**	**Brierly et al. (2012)**	**Brilli et al. (2008)**	**Esteban Et al. (2013)**	**Gurkis Et al. (2009)**	**Kiernan & Hennessey (2012)**	**Pergunini et al. (2015)**	**Rosenthal et al. (2012)**	**IHI Guideline (2015)**

Hand hygiene	✓		✓		✓	✓	✓	✓	✓
Head of bed elevation	✓	✓	✓	✓		✓	✓	✓	✓
Oral care	✓	✓		✓		✓		✓	✓
Stress ulcer prophylaxis		✓							✓
DVT prophylaxis									✓
Sedation vacation						✓		✓	✓
Gloves and gown					✓	✓	✓		
Ventilator circuit change	✓				✓				✓
Draining of condensate	✓				✓		✓		
Cuff pressure maintenance	✓			✓					
Clean suctioning techniques		✓		✓		✓			✓
Staff education					✓		✓		
Multidimensional approach including surveillance and feedback								✓	
TOTAL COMPONENTS	**6**	**4**	**2**	**4**	**5**	**6**	**5**	**5**	**8**

Appendix III. EBP and the Colorado Model (Modified) Theoretical Framework for the ZAP VAP Project





Appendix IV EBP Action Plan

Steps/Actions*	What (Specific actions)	When	Who	Where	Remarks
1. Respond to Identified Need	There's a need to address cases of VAP in the PICU	January 2016	Identified primarily by MSN Student Raulin Feria Data verified with manager Jean Maines	Huntington Hospital (HH) PICU	Done
2. Form a project work group	Form and lead the PICU Zap VAP champion team	March 2016	Lead RN: Raulin Feria, MSN Student, RN	HH PICU	VAP champion members

Steps/Actions*	What (Specific actions)	When	Who	Where	Remarks
	Multidisciplinary coordination		AM shift lead/VAP champions: Connie Galang, RN, Catherine Thomas, RN and Les Parent, RRT Night shift lead/VAP champions RN: Erol Gurel, RN and Cindy Huang, RRT Coordinate with HH's Infection Control and Children's Services Department HH PICU Medical Director: Dr. Stephen Treiman		aware
3. Search for relevant research evidence	Search for broad literature pertaining to VAP and prevention strategies	February 2016	Raulin Feria, RN, MSN Student	NNU library database and other electronic database Use of HH library resources Web-based sources	Done
4. Extract information	Narrow down VAP literature search to pediatric population specific Seek help from HH and NNU librarians Collaborate with HH PICU's EBP	February to March 2016	Raulin Feria, RN, MSN Student Connie Galang, RN (EBP unit committee member) Jo Gold Mc Carthy, RN, MSN (unit educator)	HH PICU HH Library	Done

Steps/Actions*	What (Specific actions)	When	Who	Where	Remarks
	committee representative and unit educator				
5. Eliminate poor quality evidence	Obtain high quality evidences from the literature Critically appraise articles, studies and Quality improvement projects found from the literature search Solicit help from other members of the VAP team (review and critique evidences and come up with a consensus)	February to March 2016	Raulin Feria, MSN Student Connie Galang, RN, EBP chair Jo McCarthy (unit educator) Dr. Stephen Treiman Cindy Huang, RT	HH PICU VAP collaborative team meeting to be included in Performance Improvement meeting every 2nd Thursday/month (West Tower Room 2)	Will present results of ROL to
6. Design a clinical protocol	Design the PICU VAP bundle protocol/checklist for all mechanically ventilated patients Draft protocols from the evidences gathered Present in Performance improvement meetings Encourage input from other members of the VAP team as well as input from staff RNs and RTs	March to April 2016	All VAP team members (RN, RT, MD, EBP, education and infection control department)	HH meeting rooms Education lab	First draft done and will be presented in this paper (see Appendix V and VI)
7. Plan implementation of	Assess PICU staff baseline	May to July	Raulin Feria, MSN Student	HH PICU	To follow

Steps/Actions*	What (Specific actions)	When	Who	Where	Remarks
protocol	knowledge of VAP (pre-test) Create VAP education computer based learning module Be available for in service for AM and night shift staff	2016	Jo Gold-McCarthy, MSN (unit educator) AM and Night shift VAP champions Education and IT personnel to help with computer based design		
8. Evaluate the impact	Compliance audits Ventilator days and VAP rate data gathering Analyze pre and post implementation data Post-test: use of skills checklist for staff. This may be incorporated in annual competency evaluation and for new hires as well.	1 and 3-months post implementation Quarterly audits Yearly audits to evaluate VAP rates July 2016 Include as an annual competency skills check	Raulin Feria, Connie Galang Jean Maines, RN and Les Parent RRT Infection Control Department	HH PICU	To follow See VAP skills checklist on Appendix VII
9. Revisit and Revise if necessary	Continuous quality improvement, surveillance and re-education of	Continuous, ongoing	Quality improvement personnel	HH PICU	To follow

Steps/Actions*	What (Specific actions)	When	Who	Where	Remarks
	staff (and new staff) as necessary.	process	Infection control Department PICU Medical Team Dr Stephen Treiman HH PICU Department Manager Jean Maines, RN		

*Based on Brown (2014) EBP Project Sequence of Actions

Appendix V. Proposed Pediatric VAP Guidelines and Protocol

General Protocol

1. All patients intubated and mechanically ventilated in the PICU will be placed on VAP bundle prevention protocol. Consider patient's age and dentition when providing oral hygiene (See oral care guidelines).

2. Coordinate with Respiratory therapy when providing respiratory and mechanical ventilator care.

3. Daily rounds will include discussion of ventilator days, necessity, weaning plans and sedation management.

4. Apply VAP bundle guidelines consistently, and discuss with other staff if modification is warranted.

5. Document VAP prevention strategies and interventions in CERNER.

VAP Bundle Guidelines

I. Prevent Bacterial Colonization

- Hand washing before and after patient, equipment or surface/environment handling
- Standard precautions: Gown, gloves or goggles if anticipating respiratory contamination
- Change ventilator circuit only if visibly soiled or malfunctioning
- Use In-line suction device, avoid instilling normal saline down the ETT (only use saline bombs when clearing ETT away from the patient.
- Suction the mouth before the ETT or prior to repositioning patient
- Suction only if clinically indicated (visible secretions, crackles, desaturation)

II. Prevent Aspiration

- Elevate Head of Bed

  For infants in warmers: at least 15-20 degrees
  Children in cribs and PICU beds: at least 30 degrees

- Drain ventilator condensate away from the patient before repositioning patient

III. Provide Standardized Oral Care

For full term neonates and infants with no teeth

- Clean and moisten mouth using swabs soaked in sterile water or normal saline at least every 4 hours

Infants and children less than 6 years of age

- Clean and moisten mouth using swabs soaked in sterile water or normal saline at least every 4 hours
- Brush teeth with small, soft toothbrush with fluoride toothpaste BID

For patients 6 years of age and older

- Clean and moisten mouth using swabs soaked in sterile water or normal saline at least every 4 hours
- Brush teeth with small, soft toothbrush with fluoride toothpaste BID
- Swab mouth with 0.1% chlorhexidine BID (at least 30 minutes after brushing, DO NOT RINSE)
- May use petroleum jelly to moisturize lips

IV. Other Consideration to Discuss with the health care team

- Sedation vacation (daily interruption of sedatives, neuromuscular blockers)
- Tailored weaning parameters
- Stress ulcer prophylaxis

Appendix VII Example of Evaluation Tool for Staff Knowledge/Skills on VAP bundle

VAP Prevention and Management Strategies	Observed/ *verbalized	Not Observed/ Not verbalized	N/A
1. Perform hand hygiene before and after patient or ventilator contact			
2. Use of appropriate isolation/standard precautions			
3. Elevate head of the bed 15-30 degrees unless contraindicated			
4. Oral care using oral care kit appropriate for patient age • Less than 2 years of age: swab dabbed in NS or sterile water • Over 2 years of age: Chlorhexidine 1% solution			
5. Suction patient only when there is clear indication (e.g. increased/visible secretions, unexplained desaturation, coarse breath sounds)			
6. Suction the mouth BEFORE the endotracheal tube.			
7. Use closed system/in-line when suctioning ETT			
8. Avoid instilling saline directly into the ETT when suctioning			
9. Rinse oral suction line with sterile water after each use			
10. Rinse in-line catheter with single use NS ampule			
11. Use of manufactured device or plastic bag to cover suction end when not in use			
12. Communicate with the respiratory therapist about ventilator management • Settings (weaning, adjustments etc.) • Condensation shall be drained away from the patient (drain BEFORE patient position change) • Ventilator circuit changes every 7 days			
13. Change suction equipment every 24 hours and if contaminated • Separate suction equipment for oral and ETT • Labels suction tubings and canister appropriately with date and time changed			
14. GI prophylaxis and avoidance of abdominal distention			
15. Checks CXR order as indicated			
16. Perform patient family education about infection control and ventilator therapy basics			
TOTAL POINTS			

PASS: score 14 (87%) and above skill/competency
FAIL: score less than 14 out of 16: Needs Retraining: YES / NO

Verbalized: Means the learner must be able to state the rationale behind such VAP prevention strategy if appropriate

Ventilator Associated Pneumonia (VAP) Prevention/Management Skills Observation Checklist

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