Office of Evidence Based Practice – Specific Care Question:

Should VAP Bundles, or Single Intervention Elements, be Used for Mitigating Ventilator-Associated Pneumonia (VAP) in the Intubated Pediatric Patient?
What is the best diagnostic approach (invasive methods using quantitative cultures versus non-invasive methods using qualitative cultures) in identifying VAP?

Specific Care Question:
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Question Originator:
CMH&C VAP Team

Plain Language Summary from The Office of Evidence Based Practice:
This summary is a compilation of data to answer the above specific care questions. Data was obtained from single studies, meta-analyses, the Institute for Healthcare Improvement, and the National Guideline Clearinghouse. There is some evidence to support the use of VAP bundles, the use of subglottic secretion drainage (SDD) devices, staff education, and silver coated endotracheal tubes. Evidence also supports that quantitative cultures of respiratory secretions are as effective as qualitative cultures of respiratory

Interventions mitigating VAP:
VAP Bundles:

In the found literature there was little data supporting the benefits of VAP bundles though it is believed that bundling effective interventions should lessen the risk of hospital acquired conditions in this case VAP. There are three bundles found in this analysis. Bigham et al (2009) is the only bundle that had data to support the use of bundles and the population of interest was pediatric in nature. The number needed to treat with this bundle to prevent one VAP infection is 38 (see page 6).

Single interventions:

Musceder et al's (2011) systematic review / meta-analysis (see page 9) provided evidence that the number needed to treat with the SDD to prevent one VAP is 30.

Within the six studies identified that answered the question, we were able to combine two studies, Marelich (2000) and Zack (2002), to analyze the effectiveness of education. This analysis identified that 135 staff would need to be educated to prevent one patient from acquiring VAP (see page 10). Of the four remaining studies only one (Afessa, 2010) showed difference in the incidence of VAP with the intervention of silver coated endotracheal tubes (37 patients would need to be treated to prevent one patient from acquiring VAP) (see page 11).

Quantitative versus qualitative cultures in diagnosing VAP.

Berton et al's (2012) (see page 7) provided evidence that the use of quantitative cultures of respiratory secretions is as effective as qualitative cultures of respiratory secretions results in reducing mortality, reducing time in the ICU or on mechanical ventilation, or changing the rates of antibiotic modification.

EBP Scholars reviewing and synthesizing the literature:
K. Collum, RN, A. Havlena, RN, T. Tobin, RRT; J. Menown, RN
EBP team member responsible for reviewing, synthesizing, and developing this analysis:
J. Bartlett, PhD, RN, EBP Program Manager

Search Strategy and Results:

PubMed search:

"Pneumonia, Ventilator-Associated"[Mesh] Filters: From 2009/01/01 to 2012/12/31, Humans, Consensus Development Conference, Consensus Development Conference, NIH, Guideline, Meta-Analysis, Practice Guideline, Multicenter Study, Controlled Clinical Trial, Randomized Controlled Trial, Systematic Reviews, Technical Report, Clinical Trial, Comparative Study, Scientific Integrity Review, English, Child: 0-18 years *(resulted in 159 studies; upon review of abstracts seven answered the questions, Bigham (2009) reported on the implementation of a VAP bundle (see page 6), studies reporting on the efficacy of individual interventions are: Hsieh (2010) ventilator circuit changes (see page 11), Jacomo (2011) oral hygiene with 0.12% chlorhexidine gluconate (see page 12), and Morrow (2012) closed system suction on VAP (see page 13). Two studies (Deng, 2011; Tang, 2009) could provide the team with background information (see page 14).*

Included studies:

Bigham, 2009
Deng, 2011—background information
Hsieh, 2010
Jacomo, 2011
Morrow, 2012
Tang, 2009—background information

Excluded studies: Abstract reviewer did not capture this information.

Additional data: TRIP Database was queried *(resulted in 24 documents [guidelines, SRs, and quality improvement studies] of those the following are included: two guidelines [see page 4-5], two SRs [see page 7-9] and three quality improvement single studies [Afessa, 2010, see page 11; Marelich, 2000, see page 10; Zack, 2002, see page 10)*.

Method Used for Appraisal and Synthesis:

The Cochrane Collaborative computer program, Review Manager (RevMan 5.1.7) was used to synthesize the three included studies. Two studies (Deng, 2011; Tang, 2009) were cohort studies and were not Critically Appraised Topic forms were used to synthesize two of the articles and subsequently reported in the CAT format.

References:

Studies used in this analysis:

Afessa, B., Shorr, A.F., Anzueto, A.R., Craven, D.E., Schinner, R., & Kollef, M.H. (2010). Association between a silver-coated endotracheal tube and reduced mortality in patients with ventilator-associated pneumonia. *Chest*, 137(5), 1015-21.

Berton, D.C., Kalil, A.C., & Teixeira, P.J.Z. (2012). Quantitative versus qualitative cultures of respiratory secretions for clinical outcomes in patients with ventilator-associated pneumonia. *Cochrane Database of Systematic Reviews*, Issue 1. DOI: 10.1002/14651858.CD006482.pub3.

Bigham, M.T., Amato, R., Bondurrant, P., Fridriksson, J., Krawczeski, C. D., Raake, J., Ryckman, S., et al. (2009). Ventilator-associated pneumonia in the Pediatric Intensive Care Unit: Characterizing the problem and implementing a sustainable solution. *J Pediatr,* 154, 582-7.

Coffin, S.E., Klompas, M., Classen, D., Arias, K.M., Podgorny, K., Anderson, D.J., Burstin, H., et al. (2008). Strategies to prevent ventilator-associated pneumonia in acute care hospitals. *Infect Control Hosp Epidemiol,* 29 (Suppl 1), S31-40. PubMed

Hsieh, T.C., Hsia, S.H., Wu, C.T., Lin, T.Y., Chang, C.C., & Wong, K.S. (2010). Frequency of ventilator-associated pneumonia with 3-day versus 7-day ventilator circuit changes. *Pediatr Neonatol*, 51(1), 37-43.

Implement the IHI ventilator bundle. (2011, August 8). *Institute for Healthcare Improvement.* Retrieved from http://www.ihi.org/knowledge/Pages/Changes/ImplementtheVentilatorBundle.aspx

Jacomo, A.D.N., Carmona, F., Matsuno, A.K., Manso, P.H., & Carlotti, A.P.C.P. Effect of oral hygiene with 0.12% chlorhexidine gluconate on the incidence of nosocomial pneumonia in children undergoing cardiac surgery. Infection Control and Hospital Epidemiology 2011;32(6):591-596. [Other: ClinicalTrials.gov identifier: NCT00829842]

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

Morrow, B. M., Mowze, R., Pitcher, R., Argent, A. Investigation into the effect of closed-system suctioning on the frequency of pediatric ventilator-associated pneumonia in a developing country. Pediatric Critical Care Medicine 2012;13(1):e25-32. [DOI: 10.1097/PCC.0b013e31820ac0a2]

Musceder, J., Rewa, O., Mekechnie, K., Jiang, X., Laporta, D., Heyland, D.K. (2011). Subglottic secretion drainage for the prevention of ventilator-associated pneumonia: A systematic review and meta-analysis. *Crit Care Med*, 39, 1985–1991.

Zack, J.E., Garrison, T., Trovillion, E., Clinkscale, D., Coopersmith, C.M., Fraser, V.J., Kollef, M.H. (2002). Effect of an education program aimed at reducing the occurrence of ventilator-associated pneumonia. *Critical Care Medicine*,30(11), 2407-12.

Studies that may provide background information for the team:

Tang, C.W., Liu, P.Y., Huang, Y.F., Pan, J.Y., Lee, S.S.J., Hsieh, K.S., Liu, Y.C., Ger L.P. Ventilator-associated pneumonia after pediatric cardiac surgery in southern Taiwan. J Microbiol Immunol Infect 2009;42: 413-9.

Deng, C., Li, X., Zou, Y., Wang, J., Wang, J., Namba, F., Hiroyuki, Y., Yu, J., Yamauchi, Y., & Guo, C. (2011). Risk factors and pathogen profile of ventilator-associated pneumonia in a neonatal intensive care unit in china. Pediatrics International, 53, 332-337. doi: 10.1111/j.1442-200X.2011.03382.x

Updated: 8/31/12

Bundles identified:

Strategies to prevent ventilator-associated pneumonia in acute care hospitals (http://www.guideline.gov/content.aspx?id=13396)

Coffin, S.E., Klompas, M., Classen, D., Arias, K.M., Podgorny, K., Anderson, D.J., Burstin, H., et al. (2008). Strategies to prevent ventilator-associated pneumonia in acute care hospitals. *Infect Control Hosp Epidemiol,* 29 (Suppl 1), S31-40. PubMed

Education

1. Educate healthcare personnel who care for patients undergoing ventilation about VAP, including information about the following (**A-II**):
   - Local epidemiology
   - Risk factors
   - Patient outcomes
2. Educate clinicians who care for patients undergoing ventilation about noninvasive ventilatory strategies (**B-III**).

Surveillance of VAP

1. Perform direct observation of compliance with VAP-specific process measures (**B-III**).
   - VAP-specific process measures include hand hygiene, bed position, daily sedation interruption and assessment of readiness to wean, and regular oral care.
   - Use structured observation tools at regularly scheduled intervals.
2. Conduct active surveillance for VAP and associated process measures in units that care for patients undergoing ventilation who are known or suspected to be at high risk for VAP on the basis of risk assessment (**A-II**).
   - Collect data that will support the identification of patients with VAP and calculation of VAP rates (i.e., the number of VAP cases and number of ventilator-days for all patients who are undergoing ventilation and in the population being monitored).

Practice

1. Implement policies and practices for disinfection, sterilization, and maintenance of respiratory equipment that are aligned with evidence-based standards (e.g., guidelines from the Centers for Disease Control and Prevention and professional organizations) (**A-II**) (Tablan et al., 2004).
2. Ensure that all patients (except those with medical contraindications) are maintained in a semirecumbent position (**B-II**).
3. Perform regular antiseptic oral care in accordance with product guidelines (**A-I**).
4. Provide easy access to noninvasive ventilation equipment and institute protocols to promote the use of noninvasive ventilation (**B-III**).

Special Approaches for the Prevention of VAP

Perform a VAP risk assessment. These special approaches are recommended for use in locations and/or populations within the hospital that have unacceptably high VAP rates despite implementation of the basic VAP prevention procedures listed above.

1. Use an endotracheal tube with in-line and subglottic suctioning for all eligible patients (**B-II**).
2. Ensure that all intensive care unit (ICU) beds used for patients undergoing ventilation have a built-in tool to provide continuous monitoring of the angle of incline (**B-III**).

Approaches That Should Not Be Considered a Routine Part of VAP Prevention

1. Do not routinely administer intravenous immunoglobulin (Tablan et al., 2004), white-cell–stimulating factors (filgrastim or sargramostim) (Tablan et al., 2004), enteral glutamine (Tablan et al., 2004), or chest physiotherapy (Tablan et al., 2004; Ntoumenopoulos et al., 2002). (**A-III**)
2. Do not routinely use rotational therapy with kinetic or continuous lateral rotational therapy beds (**B-II**) (Tablan et al., 2004; Goldhill et al., 2007).
3. Do not routinely administer prophylactic aerosolized or systemic antimicrobials (**B-III**) (Richards et al., 2000; Tablan et al., 2004; Hoth et al., 2003).

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Unresolved Issues

1. Avoidance of H2 antagonist or proton pump inhibitors for patients who are not at high risk for developing gastrointestinal bleeding (Collard, Saint, & Matthay, 2003; Cook, 1995; Cook et al., 1996; Cook et al., 1998; Khan, Doctor, & Rubenfeld, 2006; Kantorova et al., 2004; Yildizdas, Yapicioglu, & Yilmaz, 2002; Levy et al., 1997).
2. Selective digestive tract decontamination for all patients undergoing ventilation (Liberati et al., 2004; van Nieuwenhoven et al.,2001; Bonten, 2006; de Jonge et al., 2003; Krueger et al., 2002; Silvestri et al., 2007).
3. Use of antiseptic-impregnated endotracheal tubes (Pacheco-Fowler et al., 2004; Berra et al., 2004).
4. Intensive glycemic control (Collier et al., 2005; van den Berghe et al., 2001; Toschlog et al., 2007; Brunkhorst et al., 2008).

Quality of Evidence*

I. Evidence from ≥1 properly randomized, controlled trial.
II. Evidence from ≥1 well-designed clinical trial without randomization, from cohort or case-controlled analytic studies (preferably from >1 center), from multiple time-series studies, or from dramatic results of uncontrolled experiments.
III. Evidence from opinions of respected authorities based on clinical experience, descriptive studies, or reports of expert committees.

Strength of Recommendation*

A. Good evidence to support a recommendation for use.
B. Moderate evidence to support a recommendation for use.
C. Poor evidence to support a recommendation.

**Adapted from the Canadian Task Force on the Periodic Health Examination.*

Outcomes measured

This report did not include measurement data.

IHI bundle (http://www.ihi.org/knowledge/Pages/Changes/ImplementtheVentilatorBundle.aspx**):**

- Elevation of the Head of the Bed-- 30 to 45 degrees (It is unclear if raising the HOB prevents VAP by minimizing the risk of aspirating gastric contents or oral and nasopharyngeal secretions. Clinicians need to be aware that by elevating the HOB could promote the incidence of pressure ulcers.)
- Daily "Sedation Vacations" and Assessment of Readiness to Extubate (Kress et al [2000] conducted a randomized controlled trial in 128 adult patients on mechanical ventilation, randomized to daily interruption of sedation irrespective of clinical state or interruption at the clinician's discretion. Daily interruption resulted in a marked and highly significant reduction in time on mechanical ventilation. The duration of mechanical ventilation decreased from 7.3 days to 4.9 days [p=0.004]).
- Peptic Ulcer Disease Prophylaxis (While it is unclear if there is any association with decreasing rates of ventilator acquired pneumonia, when applied as a package of interventions for ventilator care, the rate of pneumonia decreases precipitously. The intervention remains excellent practice in the general care of ventilated patients.)
- Deep Venous Thrombosis Prophylaxis (While it is unclear if there is any association with decreasing rates of ventilator acquired pneumonia, our experience is that when applied as a package of interventions for ventilator care, the rate of pneumonia decreases precipitously. The intervention remains excellent practice in the general care of ventilated patients.
- Daily Oral Care with Chlorhexidine (In a meta-analysis published in 2007 by Chan and colleagues in the *British Medical Journal,* eleven studies were evaluated for effect of oral decontamination on the incidence of ventilator-associated pneumonia and mortality in mechanically ventilated adults. Results of that analysis concluded that oral decontamination of mechanically ventilated adults using chlorhexidine is associated with a lower risk of ventilator-associated pneumonia.)

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Outcomes measured
This report did not include measurement data.

Ventilator-associated pneumonia in the Pediatric Intensive Care Unit: Characterizing the problem and implementing a sustainable solution

Bigham, M.T., Amato, R., Bondurrant, P., Fridriksson, J., Krawczeski, C. D., Raake, J., Ryckman, S., et al. (2009). Ventilator-associated pneumonia in the Pediatric Intensive Care Unit: Characterizing the problem and implementing a sustainable solution. *J Pediatr,* 154, 582-7.

Prevention of bacterial colonization of oropharynx, stomach, & sinuses

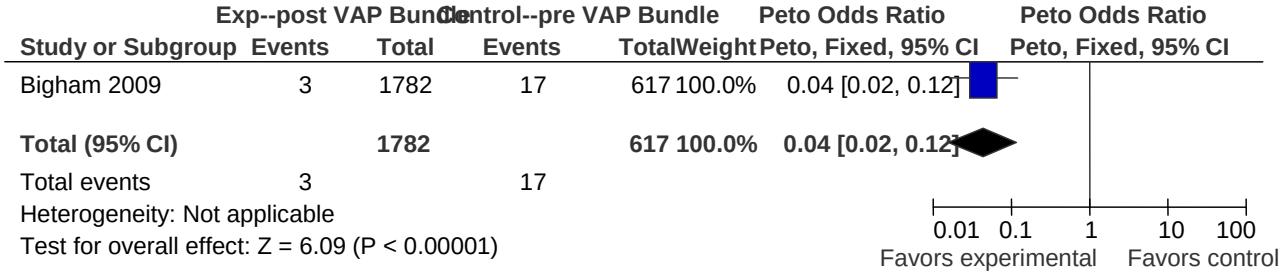
- Change ventilator circuits and in-line suction catheters only when visibly soiled
- Drain condensate from ventilator circuit at least every 2-4 hours (use heated wire circuits to reduce rainout)
- Store oral suction devices (when not in use) in non-sealed plastic bag at the bedside; Rinse after use
- Hand hygiene before and after contact with ventilator circuit
- When soiling from respiratory secretions is anticipated, wear gown before providing care to patient
- Follow Unit Mouth Care Policy – every 2 – 4 hours

Prevention of aspiration of contaminated secretions

- Elevate HOB 30 – 45 degrees, unless contraindicated and by written order
- Always drain ventilator circuit before repositioning patient
  When possible, for children > 12 years old, use endotracheal tube with dorsal lumen above endotracheal cuff to help suction secretions above the cuff.

This study is the only bundle found in the pediatric literature. The data presented in Bingham et al (2009) indicates that the odds of not acquiring VAP when the VAP bundle is used are 0.04 (see Figure 1). Another way to think about this is reflected in the number needed to treat statistic. Thirty eight patients would need to be treated with the VAP bundle to prevent one VAP infection.

Figure 1. Forest plot of comparison: Implementation of VAP Bundle, Outcome: Incidence of VAP



Systematic reviews (SR) and/or Meta-analyses identified:

Berton DC, Kalil AC, Teixeira PJZ. (2012). Quantitative versus qualitative cultures of respiratory secretions for clinical outcomes in patients with ventilator-associated pneumonia. *Cochrane Database of Systematic Reviews*, Issue 1. DOI: 10.1002/14651858.CD006482.pub3.

This SR included five studies with minimal risk of bias, inconsistency in data extraction, or imprecision in data analysis. One concern is that the largest study in the SR (CCCTG, 2006, *N* =739) excluded patients with infected or colonized pseudomonas species and methicillin-resistant Staphylococcus aureus (S. aureus). This SR provided no evidence that the use of quantitative cultures of respiratory secretions results in reduced mortality (see Figure 2), reduced time in ICU (see Figure 3) and on mechanical ventilation (see Figure 4), or higher rates of antibiotic change (see Figure 5) when compared to qualitative cultures in patients with VAP. No heterogeneity was identified between studies in the mortality, reduced time in ICU or the mechanical ventilation analyses however significant heterogeneity was identified in antibiotic change analysis (I^2 = 81%).

Figure 2. Forest plot of comparison: Quantitative versus qualitative culture, Outcome: Mortality.

	Quantitative culture		Qualitative culture			Risk Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Fixed, 95% CI**
CCCTG 2006	69	365	69	374	43.3%	1.02 [0.76, 1.38]
Fagon 2000	63	204	81	209	50.8%	0.80 [0.61, 1.04]
Solé Violán 2000	10	45	9	43	5.8%	1.06 [0.48, 2.36]
Total (95% CI)		**614**		**626**	**100.0%**	**0.91 [0.75, 1.11]**
Total events	142		159			

Heterogeneity: Chi² = 1.70, df = 2 (P = 0.43); I² = 0%

Test for overall effect: Z = 0.94 (P = 0.35)

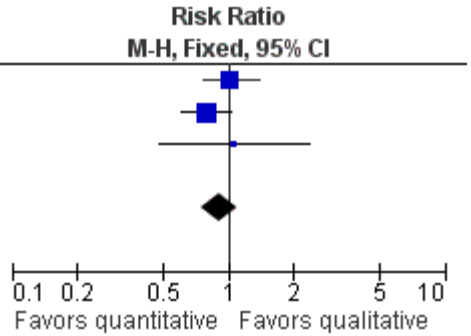


Figure 3. Forest plot of comparison: Quantitative versus qualitative culture, Outcome: ICU stay (days).

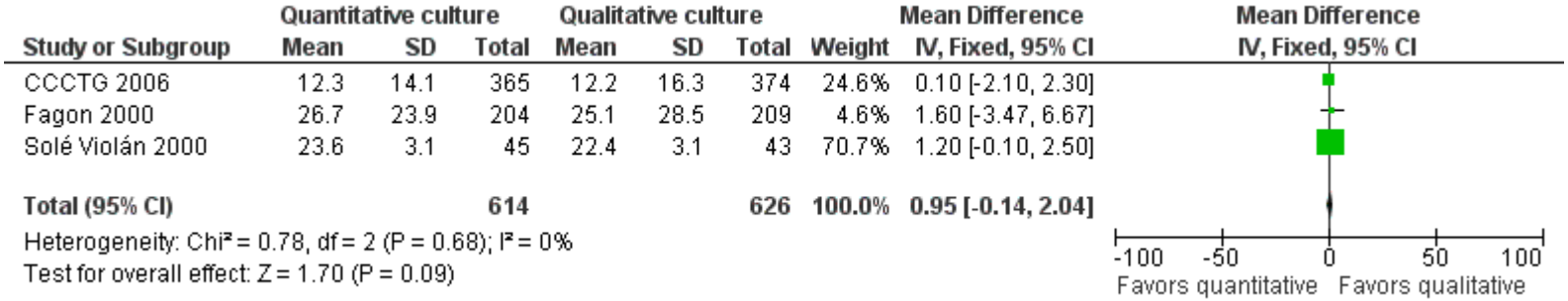


Figure 4. Forest plot of comparison: Quantitative versus qualitative culture, Outcome: Duration on mechanical ventilations (days).

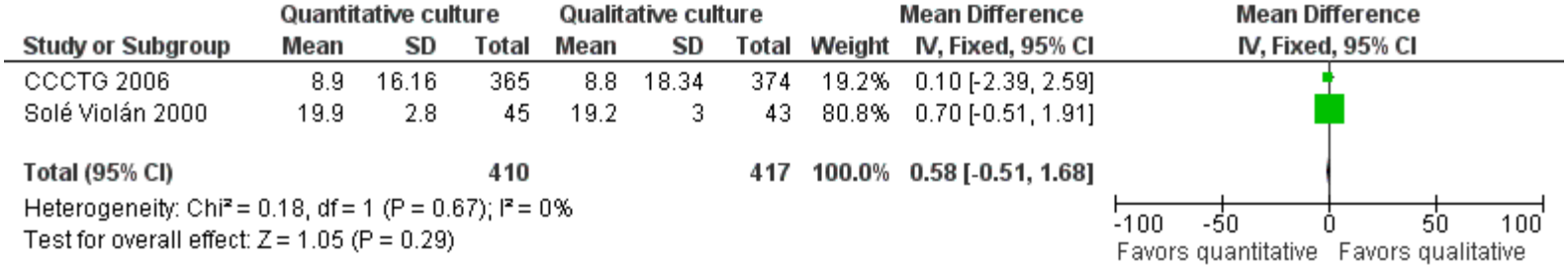
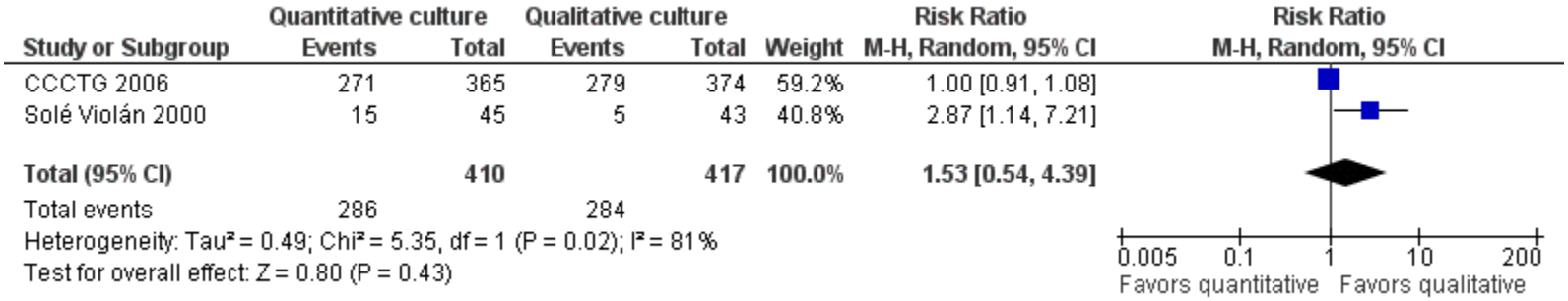


Figure 5. Forest plot of comparison: Quantitative versus qualitative culture, Outcome: Antibiotic change.



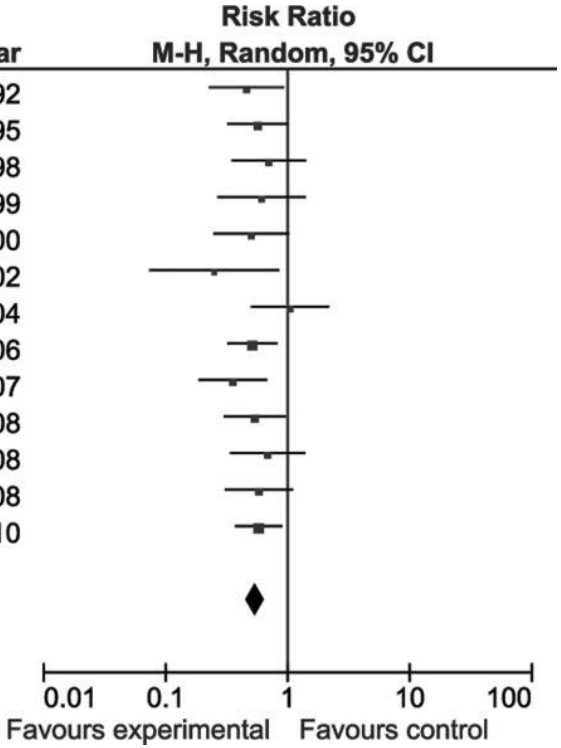
Musceder, J., Rewa, O., Mekechnie, K., Jiang, X., Laporta, D., Heyland, D.K. (2011). Subglottic secretion drainage for the prevention of ventilator-associated pneumonia: A systematic review and meta-analysis. *Crit Care Med*, 39, 1985–1991.

This SR included thirteen studies with minimal risk of bias, inconsistency in data extraction indirectness in the study's methodologies, imprecision in data analysis. It had a large effect size reported as the Relative Risk = 0.55. Intention to treat analysis occurred in nine out of 13 studies. The supplemental data provided the author's methodology scoring criteria and the characteristics of the individual studies. There was no heterogeneity identified (I^2 = 0%) between studies. This SR / MA provided evidence that the use of endotracheal tubes with subglottic secretion drainage (SSD) devices is effective in VAP prevention (see Figure 6). The number needed to treat with the SSD to prevent one VAP is 30.

Figure 6. Forest plot of comparison: SSD versus control, Outcome: VAP.

	SSD		Control			Risk Ratio	
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	Year
Mahul 1992	9	70	21	75	6.2%	0.46 [0.23, 0.93]	1992
Valles 1995	14	76	25	77	9.5%	0.57 [0.32, 1.01]	1995
Metz 1998	5	10	10	14	6.3%	0.70 [0.35, 1.41]	1998
Kollef 1999	8	160	15	183	4.5%	0.61 [0.27, 1.40]	1999
Bo 2000	8	35	15	33	6.1%	0.50 [0.25, 1.03]	2000
Smulders 2002	3	75	12	75	2.1%	0.25 [0.07, 0.85]	2002
Girou 2004	5	8	6	10	5.7%	1.04 [0.50, 2.18]	2004
Liu 2006	14	41	30	45	13.9%	0.51 [0.32, 0.82]	2006
Lorente 2007	11	140	31	140	7.4%	0.35 [0.19, 0.68]	2007
Yang 2008	12	48	20	43	9.1%	0.54 [0.30, 0.97]	2008
Bouza 2008	12	331	19	359	6.2%	0.69 [0.34, 1.39]	2008
Zheng 2008	9	30	16	31	7.5%	0.58 [0.31, 1.11]	2008
Lacherade 2010	25	169	42	164	15.6%	0.58 [0.37, 0.90]	2010
Total (95% CI)		**1193**		**1249**	**100.0%**	**0.55 [0.46, 0.66]**	
Total events	135		262				

Heterogeneity: Tau² = 0.00; Chi² = 7.78, df = 12 (P = 0.80); I² = 0%
Test for overall effect: Z = 6.57 (P < 0.00001)



Single studies identified:

Two of the studies (Marelich, 2000; Zack 2002) report the affect staff education has on VAP and was analyzed together. The other studies will be reported separately as the research studies area of interest differed: (a) silver-coated endotracheal tubes Afessa (2010), frequency of ventilator-associated pneumonia Hsieh (2010), 0.12% chlorhexidine gluconate (Jacomo, 2011), and closed-system suctioning devices (Morrow, 2012). Figure 7 provides for the reader a summary of the risk of bias found in the 6 single studies analyzed.

Figure 7. Risk of bias summary for each included study.

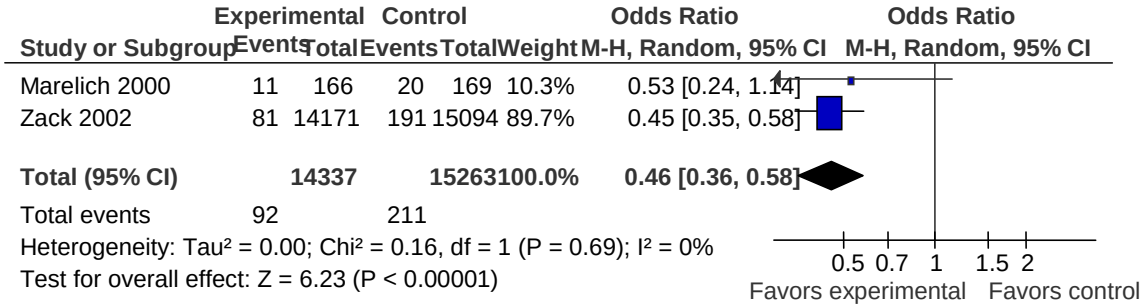
Staff Education

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

Zack, J.E., Garrison, T., Trovillion, E., Clinkscale, D., Coopersmith, C.M., Fraser, V.J., Kollef, M.H. (2002). Effect of an education program aimed at reducing the occurrence of ventilator-associated pneumonia. *Critical Care Medicine*,30(11), 2407-12.

The education objectives differed between the two studies; Marelich (2000) studied the implementation of a standing order ventilator weaning protocol lead by nurses and respiratory while Zack (2002) focused on correct care practices for ventilated patients. In combining the study data, the effect size was moderate, OR = 0.46. The NNT = 135; meaning 135 staff would need to be educated to prevent one patient from acquiring VAP. There was no heterogeneity identified (I^2 = 0%) between studies. These studies provide some evidence that the use of staff education can decrease VAP (see Figure 8).

Figure 8. Forest plot of comparison: Education versus no education, Outcome: VAP.

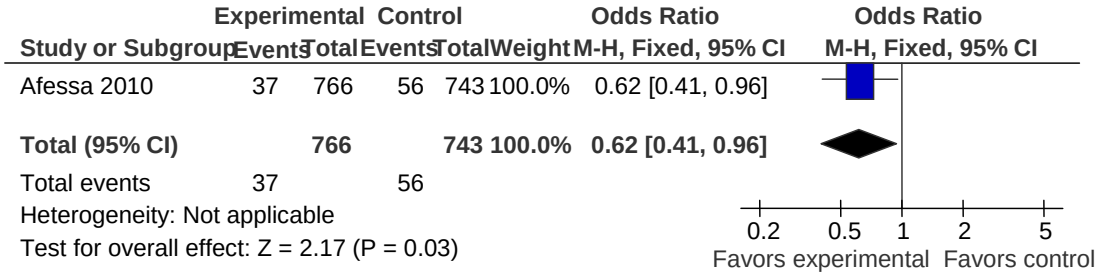


Silver coated endotracheal tube

Afessa, B., Shorr, A.F., Anzueto, A.R., Craven, D.E., Schinner, R., & Kollef, M.H. (2010). Association between a silver-coated endotracheal tube and reduced mortality in patients with ventilator-associated pneumonia. *Chest*, 137(5), 1015-21.

This study is a secondary data analysis of the NASCENT group. This study is strong due to the methodological approach. The study had a large effect size, OR = 0.62 (see Figure 9). The NNT = 37; meaning 37 would need to be treated to prevent one patient from acquiring VAP.

Figure 9. Forest plot of comparison: Silver coated ETT vs. regular ETT, Outcome: VAP.

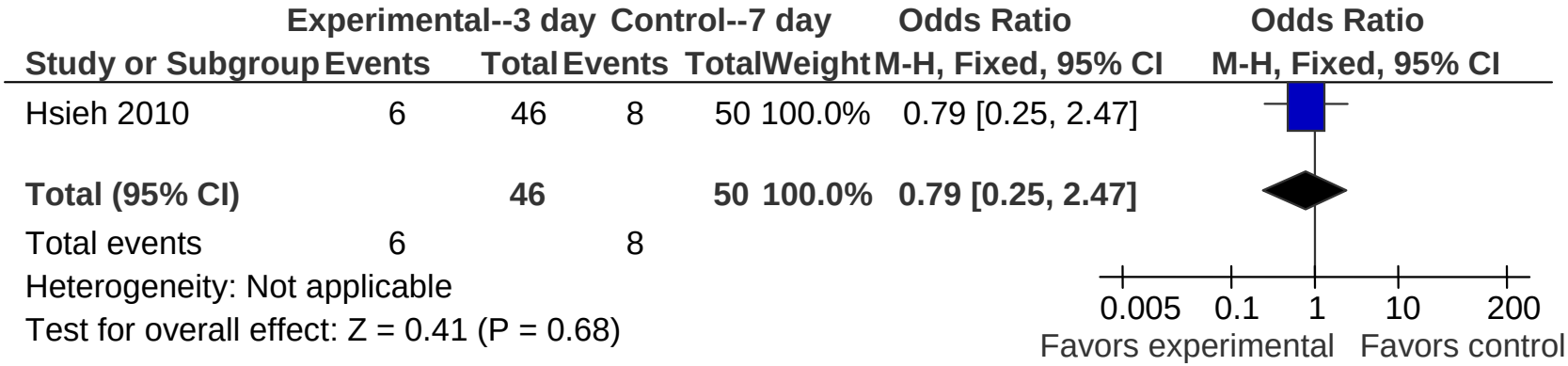


Ventilator circuit changes

Hsieh, T.C., Hsia, S.H., Wu, C.T., Lin, T.Y., Chang, C.C., & Wong, K.S. (2010). Frequency of ventilator-associated pneumonia with 3-day versus 7-day ventilator circuit changes. *Pediatr Neonatol*, 51(1), 37-43.

This study is the first of three pediatric studies in this analysis. There are several flaws to the methodological approach as it was an observational cohort study. The authors do not provide when ventilator circuits only that the circuits were changed at the discretion of the physician or respiratory therapist, the reader is left to assume it was changed on the appropriate day. There is no mention on any training pertaining to the study that the intervention staff attended. Blinding was not used. There was no difference in VAP incidence if ventilator circuits were changed at 3-day or 7-day intervals (see Figure 10).

Figure 10--Circuit changes, Outcome: Incidence of VAP

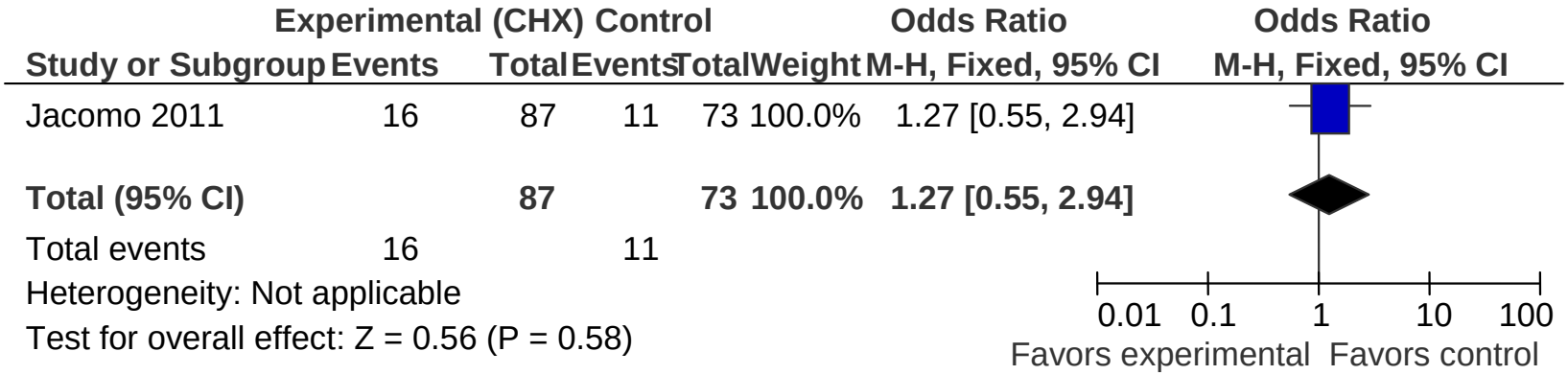


0.12% Cholorhexidine gluconate

Jacomo, A.D.N., Carmona, F., Matsuno, A.K., Manso, P.H., & Carlotti, A.P.C.P. Effect of oral hygiene with 0.12% chlorhexidine gluconate on the incidence of nosocomial pneumonia in children undergoing cardiac surgery. Infection Control and Hospital Epidemiology 2011;32(6):591-596. [Other: ClinicalTrials.gov identifier: NCT00829842]

This study is the second of three pediatric studies in this analysis. The authors employed a strong methodological approach. There was no difference in VAP incidence in patients receiving, or not receiving, 0.12% cholorhexidine gluconate in their oral care (see Figure 11).

Figure 11--0.12% cholorhexidine gluconate, Outcome: Incidence of VAP



Closed-system suctioning

Morrow, B. M., Mowze, R., Pitcher, R., Argent, A. Investigation into the effect of closed-system suctioning on the frequency of pediatric ventilator-associated pneumonia in a developing country. Pediatric Critical Care Medicine 2012;13(1):e25-32. [DOI: 10.1097/PCC.0b013e31820ac0a2]

This study is the last pediatric study in this analysis. There are several flaws to the methodological approach as it was an nonrandomized study. **Saline was not instilled before suctioning**. There was no difference in VAP incidence in patients which the closed-system or open-system suctioning was employed independent of the VAP criteria used (see Figure 12 and Figure 13).

Figure 12--Closed-system or open-system ETT suctioning, Outcome: Incidence of VAP using CDC criteria

	Experimental--Closed		Control--Open			Odds Ratio	Odds Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Fixed, 95% CI**	**M-H, Fixed, 95% CI**
Morrow 2012	13	83	34	180	100.0%	0.80 [0.40, 1.61]	
Total (95% CI)		**83**		**180**	**100.0%**	**0.80 [0.40, 1.61]**	
Total events	13		34				

Heterogeneity: Not applicable

Test for overall effect: Z = 0.63 (P = 0.53)

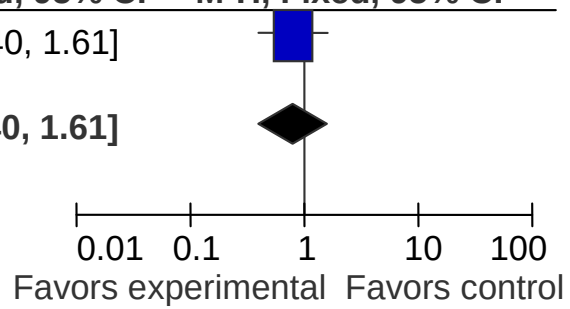
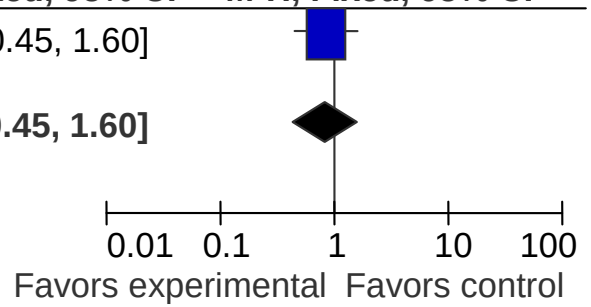


Figure 13-- Closed-system or open-system ETT suctioning, Outcome: Incidence of VAP--CPIS criteria

	Experimental--Closed		Control--Open			Odds Ratio	Odds Ratio
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Fixed, 95% CI**	**M-H, Fixed, 95% CI**
Morrow 2012	17	83	42	180	100.0%	0.85 [0.45, 1.60]	
Total (95% CI)		**83**		**180**	**100.0%**	**0.85 [0.45, 1.60]**	
Total events	17		42				

Heterogeneity: Not applicable

Test for overall effect: Z = 0.51 (P = 0.61)



Synthesis of studies providing background data:

<table>
<tr><th>Author, date, country, and industry of funding</th><th>Patient Group</th><th>Level of Evidence (Oxford)</th><th>Research design</th><th>Significant results</th><th>Limitations</th></tr>
<tr><td>Tang, C.W., Liu, P.Y., Huang, Y.F., Pan, J.Y., Lee, S.S.J., Hsieh, K.S., Liu, Y.C., Ger L.P. Ventilator-associated pneumonia after pediatric cardiac surgery in southern Taiwan. J Microbiol Immunol Infect 2009;42: 413-9.</td><td>Children younger than 18 yoa with CHD who underwent cardiac surgery from January 2005 to December 2007</td><td>Oxford: 2b</td><td>Retrospective Cohort Study</td><td>The study aimed to examine the incidence of VAP, the risk factors for VAP, outcomes associated with VAP, and the microbiological pathogens involved in the development of VAP.
Significant risk factors were:
<table>
<tr><th>Variable</th><th>OR</th><th>95% CIs</th></tr>
<tr><td>Complex CHD</td><td>7.698</td><td>0.957-61.926</td></tr>
<tr><td>Acyanotic CHD</td><td>2.41</td><td>0.690-8.419</td></tr>
<tr><td>>7 postoperative days in ICU</td><td>2.107</td><td>0.642-6.921</td></tr>
<tr><td>≥ 120 minutes on cardiopulmonary bypass</td><td>3.447</td><td>1.046-11.342</td></tr>
<tr><td>≥ 5 Ventilator day</td><td>9.565</td><td>2.413-37.705</td></tr>
<tr><td>≥ 5 Chest tube days</td><td>3.309</td><td>0.943-11.616</td></tr>
<tr><td>≥ 7 Central venous catheter days</td><td>18.425</td><td>3.768-90.103</td></tr>
</table></td><td>Wide variance in CIs suggests population variance.
This study did not provide bundle data; however, it may provide insightful background information.</td></tr>
<tr><td>Deng, C., Li, X., Zou, Y., Wang, J., Wang, J., Namba, F., Hiroyuki, Y., Yu, J., Yamauchi, Y., & Guo, C. (2011). Risk factors and pathogen profile of ventilator-associated pneumonia in a neonatal intensive care unit in china. Pediatrics International, 53, 332-337. doi: 10.1111/j.1442-200X.2011.03382.x</td><td>Infants in a level III 25-bed NICU at a teaching hospital in China</td><td>3b</td><td>Case Control Study</td><td>The study aimed to examine the incidence of VAP, the risk factors for VAP, outcomes associated with VAP, and the microbiological pathogens involved in the development of VAP.
Significant risk factors (P < 0.001) identified were: Age < 3 days, Gestation age < 37 wks., Birthweight between 960-3999 g, Neonate respiratory distress syndrome, Bronchopulmonary dysplasia, Blood stream infection, Hypoxic ischemic encephalopathy, Parenteral alimentation, Reintubation, Frequent drawing of blood, and Bronchoscopy.</td><td>Foglia criteria was used to diagnosis VAP.
This study did not provide bundle data; however, it may provide insightful background information.</td></tr>
</table>