
We recommend you cite the published version.
The publisher’s URL is:
http://dx.doi.org/10.1111/j.1478-5153.2011.00465.x

Refereed: Yes

The definitive version is available at www.blackwell-synergy.com

Disclaimer

UWE has obtained warranties from all depositors as to their title in the material deposited and as to their right to deposit such material.

UWE makes no representation or warranties of commercial utility, title, or fitness for a particular purpose or any other warranty, express or implied in respect of any material deposited.

UWE makes no representation that the use of the materials will not infringe any patent, copyright, trademark or other property or proprietary rights.

UWE accepts no liability for any infringement of intellectual property rights in any material deposited but will remove such material from public view pending investigation in the event of an allegation of any such infringement.

PLEASE SCROLL DOWN FOR TEXT.
Chlorhexidine and Tooth-brushing as Prevention Strategies in Reducing Ventilator-Associated Pneumonia Rates

Keywords:
Chlorhexidine Gluconate (CHX)
Ventilator-Associated Pneumonia (VAP)
Mechanically Ventilated (MV)
Intensive Care Unit (ICU)
Colisistine (COL)
Abstract

Background: Ventilator-associated pneumonia (VAP) is a common complication of mechanical ventilation after endotracheal intubation. The role of chlorhexidine and tooth brushing has been considered as a clinical intervention to reduce infection rates however evidence to inform this needs appraising.

Aim: This paper presents a critical review on whether chlorhexidine gluconate (CHX) and tooth-brushing decreases rates of ventilator-associated pneumonia in adult mechanically ventilated patients cared for in intensive care settings.

Methods: A literature search was conducted using a number of bibliographic databases (n=6). A number of parameters were used to exclude irrelevant papers. A total n=17 papers were located and accessed which were directly related to the field.

Findings: CHX was successful in reducing the rate of VAP and using a combination of CHX and colistine resulted in better oropharyngeal decontamination which reduced and delayed VAP. Chlorhexidine was also effective in reducing dental plaque in patients cared for in intensive care and had the potential to reduce nosocomial infections. Results of studies investigating the use of tooth-brushing in reducing VAP incidence proved inconsistent, although all recommend tooth-brushing in maintaining good hygiene.

Conclusions: The use of chlorhexidine has been proven to be of some value in reducing VAP, although may be more effective when used with a solution which targets gram-negative bacteria. Tooth-brushing is recommended in providing a higher standard of oral care to mechanically ventilated patients and reducing VAP when used with chlorhexidine. However, limitations in study design and inconsistency in results suggests that further research is required into the effects of tooth-brushing.
What is already known about this topic-

- Ventilator-associated pneumonia (VAP) is a common complication of mechanical ventilation after endotracheal intubation.
- Bacteria is silently and continuously micro-aspirated past the tracheal cuff which can develop into pneumonia.
- The role of chlorhexidine and tooth-brushing in the reduction of VAP incidence is not fully understood.

What this paper adds-

- Nurses need to engage with existing oral care protocols to lessen VAP incidence, using decontamination substances and tooth-brushing.
- Tooth-brushing improves oral care in ventilated patients.
- Using a combination of gram-negative and gram-positive bacteria in oral cleaning solutions has a positive effect.
Introduction:

Whilst there is no universally accepted definition of ventilator-associated pneumonia (VAP) (Department of Health (DoH) 2010), it is viewed as a hospital-acquired infection caused by the aspiration of bacteria past the endotracheal cuff after 48 hours of being intubated, which can develop into pneumonia. VAP is known to extend intensive care unit (ICU) stay and has substantial cost implications of up to £12,000 per patient episode (Fletcher et al., 2008). Safadar et al., (2005) suggest that strategies for the prevention of VAP are urgently needed to help reduce hospitalisation costs, incidence of mortality and improve patient outcome.

Background:

In the United Kingdom (UK), chlorhexidine gluconate (CHX) has recently been recommended as a part of the oral hygiene regime for preventing VAP by lead health agencies in the ventilation care bundle (National Institute for Health and Clinical Excellence, NICE, National Patient Safety Agency, NPSA 2008). Chlorhexidine is a broad spectrum anti-bacterial found in ointment and solution form. Whilst it was beyond the scope of this review to compare the two, the benefits of a solution preparation are considered. Chlorhexidine has been found, in two randomised controlled trials, to reduce respiratory infections before and after elective cardiac surgery (DeRiso et al., 1996; Houston, 2002). There is minimal evidence on whether CHX can be beneficial in the care of critical care patients, something that needs further clarification.

Dental plaque is a complex and dynamic structure, which accumulates with a lack of mechanical elimination (Fourrier et al, 2000). Plaque originates from the colonisation of bacteria and can cover the entire tooth if allowed to accumulate. These pathogens migrate downwards and colonise in the lungs as a consequence of aspiration, which can develop into pneumonia (Scannapieco, 1999; Grap et al., 2004). According to Grap (2009), the relationship between oral health status and VAP rates has not been extensively studied and there is limited evidence of success in reducing VAP.
incidence (Munro et al., 2009). However, research into plaque suggests that reducing plaque accumulation would reduce the patient’s chances of developing pneumonia as pathogens that cause VAP can be found in the matrix of plaque (Munro et al., 2009).

Reviewing whether prevention methods are effective is paramount toward reducing VAP incidence (Ruffell & Adamcova, 2008). As it is a part of a nurse’s role to help reduce risk factors, preventing VAP is seen as a direct nursing responsibility (McFetridge, 2009). The Department of Health (DoH, 2007) recognises oral hygiene is key in prevention of VAP, but does not provide clear guidance on how it should be provided (McFetridge, 2009). Given nursing responsibilities for providing effective oral care, nurses need clarification of the evidence regarding tooth-brushing and chlorhexidine use to reduce VAP.

The aim of this paper was to critically review the effectiveness of CHX and tooth-brushing in reducing VAP incidence. To achieve this aim the review will consider two questions:

1. Can Chlorhexidine Gluconate Reduce Ventilator-Associated Pneumonia rates in Intensive Care Patients?

2. Can Tooth-brushing Reduce Ventilator-Associated Pneumonia Rates in Intensive Care Patients?

Methods:
A literature review was conducted, based on primary sources published since 2000, written in the English language and involving adult intensive care patients. No restriction was put on the types of research designs to be accessed or reviewed. Databases searched included MEDLINE PubMed, British Nursing Index, and Cumulative Index to Nursing and Allied Health Literature Plus, Cochrane Library, and Health Management Information Consortium. Relevant policies and guidelines, World Health Organization reports, Government publications and international and
national statistics were also accessed. To identify relevant sources, following key words were used in the search strategy: 'Dental plaque' or 'plaque' or 'oral care' or 'mouth care' or 'brushing' or 'tooth or oral' and Any word=('ventilator acquired pneumonia' or 'ventilator associated pneumonia')" Any word=('Intensive care' or 'ICU' or 'ITU' or ventilator or ventilation or 'MV' or intubated or mechanical)". Studies specific to cardiac ICU patients, children in paediatric ICUs and not meeting the above parameters were excluded.

Results:

A total n=17 papers were found closely related to the topic, and from these four key papers were reviewed and used to answer each question.

*Can Chlorhexidine Gluconate Reduce Ventilator-Associated Pneumonia rates in Intensive Care Patients?*

In relation to the above question four studies using randomised controlled trial design (RCT) were identified (Fourrier *et al.*, 2000, Koeman *et al.*, 2006, Scannapieco *et al.*, 2009, Munro *et al.*, 2009). The designs are similar although they use a variety of blinding and application methods. For all design specifics see Table 1.

Fourrier *et al.*, (2000) conducted a single blind randomised comparative study to document the effects of CHX on the occurrence of plaque colonization by nosocomial infections. The sample was drawn from a 16 bedded intensive care unit (ICU), although the size was unclear and unjustified. Fourrier’s *et al.*, (2000) and Scannapieco *et al.*, (2009) had the least diverse sample out of the four studies, making them less representative of their target population (Parahoo, 2006) and less generalisable.

It should be noted that Fourrier *et al.* (2000) allowed extubated patients to eat/drink freely. However, no allowance was made for the stimulation of saliva and its effects during mastication and subsequent production of immunoglobulin A, which obstructs microbial adherence, and lactoferrin, thereby inhibiting bacterial infection (Bagg *et al.*, 1999). Fourrier *et al.*, (2000) also used sodium bicarbonate as a placebo, which
dissolves mucus and loosens oral debris (Carl et al., 1999). This decreases the study’s validity and may have influenced the results (Berry et al., 2007). Fourrier et al. (2000) highlighted the standard of oral care accepted in ICU is insufficient to control plaque formation and oral infections by nosocomial pathogens. Chlorhexidine was able to decrease the growth of dental plaque and might reduce the incidence of nosocomial infections in MV ICU patients.

Scannapieco et al., (2009) conducted a double blinded placebo controlled trial to determine the minimum frequency of CHX application necessary to reduce respiratory bacterial pathogens (PRPs). They used a CHX mixture containing 95% ethanol and 5% peppermint oil. Essential oils remain untested in ICU patients and the antiseptic properties of alcohol (Berry et al., 2007) may have had an additional therapeutic effect, potentially affecting the results. This could have a great impact on the results by further decreasing the infection rate and therefore decreasing the validity of the study. Scannapieco et al., (2009) found CHX reduced the number of Staphylococcus aureus, however, didn’t reduce the number of the other target PRPs in dental plaque. One reason being, that gram-negative bacteria are not sensitive to CHX.

Munro et al., (2009) adopted a randomised 2x2 factorial experimental design to examine the effects of tooth-brushing and chlorhexidine with VAP rates. Munro et al., (2009) recommended further investigation in to the potential risks of tooth-brushing, as the research may have increased patients’ susceptibility to VAP. Munro et al., (2009) suggested patients receiving tooth-brushing had higher Clinical Pulmonary Infection Scores (CPIS) due to bacteria being dislodged in the oral cavity and, potentially, then colonising in the lungs. This raises ethical concerns as the intervention increased the patient’s susceptibility to infection. Halm & Armola (2009) classed Munro et al.,’s (2009) study as harmful to the patients and/or not beneficial. Chlorhexidine was found to be effective in reducing early onset VAP, whereas tooth-brushing did not reduce the incidence of VAP. Munro et al.,’s (2009) study found the use of both interventions did not have the additional benefit.

Koeman et al., (2006) conducted an RCT using both CHX and colisistine (COL) administered four times daily as a way of attempting to reduce VAP incidence. They
included five different hospitals, most with mixed ICUs thus, providing the study with the most diverse sample of the four being reviewed. The study was conducted in the Netherlands where prevalence rates of multi-resistant strains are extremely low (Koeman et al., 2006). These interventions may not therefore be as effective in areas of high prevalence rates, such as the UK. To be more reliably applicable to this country a similar study would need to be replicated in this country. Nonetheless, Koeman et al.,’s (2006) study appears to be the most rigorous, as it gained a substantial amount of reliability and validity through its study design and has the largest and most diverse sample. Halm & Armola (2009) also argued that the study provided excellent evidence to support practice. Treatment groups had reduced and delayed development of VAP. Daily risk of VAP was reduced by 65% with CHX and 55% with CHX/COL. Koeman et al., (2006) encouraged the use of CHX to reduce the daily risk of VAP and of both CHX and COL to reduce multi-resistant bacteria.

Due to the lack of an acceptable gold standard in diagnosing VAP, the accuracy of these methods is controversial (Rea-Neto et al., 2008). Koeman et al., (2006) diagnosed the patients using the combination of the clinical, microbiological and radiographic criteria with a high sensitivity but relatively low specificity. Therefore, the incidence of VAP may have been over-estimated despite Koeman et al.,(2006) having recognised this limitation. In a similar thread, Porter (2007) recognised that the study carried out by Fourrier et al., (2000) lacked a clear explanation of the diagnosis criteria possibly leading to a poor evaluation of the study.

Fourrier et al., (2000) and Scannapieco et al., (2009) both used Blind Quantitative Bronchoalveolar Lavage (BQBAL) to aid diagnosis. This is theoretically considered to be the gold standard for diagnosing VAP (Turton, 2008). A bronchoscope is passed into the lungs and used to obtain a sample of fluid for examination (Turton, 2008). Munro et al., (2009) and Scannapieco et al., (2009) both used CPIS to aid diagnosis which, rather than BQBAL is not as diagnostically accurate (Rea-Neto et al., 2008). Using the most accurate method of diagnosis is vital to the study as any misdiagnosis throughout the study would give ambiguous results and therefore can decrease the validity of the study.
Can Tooth-brushing Reduce Ventilator-Associated Pneumonia Rates in Intensive Care Patients?

The four studies relating to this question were all quantitative (Simmons-Trau et al., 2004; Mori et al., 2006; Hutchins et al., 2009; Pobo et al., 2009). The designs are all different and reflect mainly positive results with a variety of recommendations. Simmons-Trau et al. (2004), Mori et al. (2006) and Hutchins et al. (2009) did not look solely at tooth-brushing, but considered the use of an oral care package. The designs are all different and reflect mainly positive results with a variety of recommendations. For all design specifics see Table 1.

Hutchins et al. (2009) conducted a performance improvement project and implemented an oral care protocol to discover if VAP rates were affected. In comparison with an RCT the design has less reliability and validity and increased bias due to a relative lack of objectivity (Holloway & Wheeler, 2010). The design is subject to bias as no one blinded and anyone could influence the results, greatly minimising the validity of the study. The sample size was not recorded, leaving it difficult to judge its appropriateness.

Hutchins et al. (2009) and Simmons-Trau et al. (2004) both use hydrogen peroxide to cleanse the oral cavity post tooth-brushing. Hydrogen peroxide has been untested in ICU patients for many years. Berry et al. (2007) questioned its safety and cited studies that found significant abnormalities when treating patients with it. The use of hydrogen peroxide has not been subjected to rigorous randomized controlled trials and therefore cannot be recommended for use in the critically ill (Berry & Davidson, 2006). Neither study justified its use or mentioned its advantages or disadvantages. Hutchins et al. (2009) suggested increased teamwork, increased education, increased suctioning and moisturiser application lowered VAP rates, recommending these be applied to practice.

Simmons-Trau et al. (2004) devised a similar improvement project but focused on strategic initiatives involving the multidisciplinary team as a way of reducing VAP. It does however exclude vital information required to review it, including sample size and design details. They stated the research team had two one-hour meetings
weekly. The study gives no justification as to why these meetings took place and what the outcome was, making study methods unclear. Simmons-Trau et al., (2004) suggested the drop in VAP incidence was due to their six stigma approach—‘leadership support, understanding the process, validating the root cause, developing solutions the impact outcomes and the process management to sustain our improvements’. They made changes to oral care packages as a result of the research, although it is not clear what this included.

Mori et al., ‘s (2006) historical controls design led to a substantial amount of bias, decreased reliability and decreased validity as the study fails to acknowledge the differences seen in ICU’s some 8 years on. The researchers used a historical control to examine whether it was beneficial to provide oral care as a way of reducing VAP incidence. Mori et al., (2006) also used tooth-brushing with acidic water as it has been said to stimulate saliva despite the side effect of causing xerostomia (Miller and Kearney, 2001). Similar to lemon and glycerol swabs these are no longer recommended for oral care as they have an acidic nature and a decalcifying effect on tooth enamel (Fitch et al., 1999). They used povidine-iodine for cleansing the oral cavity, which is known to be useful in treating mucosal wounds following surgery, however, it does not have an anti-plaque effect, and prolonged use of it may result in a significant amount of it being absorbed (Chandu et al, 202). Subsequently, povidine–iodine’s use in critically ill patients is questionable (Berry and Davidson, 2006). Mori et al., (2006) discovered VAP was significantly lower in oral care patients as a pose to patients who did not receive oral care.

Pobo et al., (2009) conducted an RCT and examined standard oral care with CHX against oral care with electric tooth-brush and their affect VAP rates. A population of 147 medical surgical ICU patients was a result of a power calculation, however, no significant difference was discovered between the groups. None of the researchers declared storing or cleaning tooth brushes properly (including Munro et al., (2009) and Scannapieco et al., (2009) from question 1), this has serious ethical issues surrounding it and could put patients at an increased susceptibility of VAP if tooth brushes are contaminated. While Pobo et al., (2009) noted that interventions were safe they subsequently did not provide details in order to judge what was considered ‘safe’.
As discussed previously the criteria for diagnosis of VAP is essential and can compromise the validity and reliability of the study by being too strict or loose. Hutchins et al., (2009) did not specify criteria for VAP diagnosis in detail, but did specify that the diagnosis was made by the clinical judgement of a doctor. As doctors were aware of the studies, this could have led to bias and adversely affected the results. Mori et al., (2006) noted the use of more than one doctor to diagnose VAP increasing the accuracy of diagnosis. Simmons-Trau et al., (2004) did not disclose how VAP was diagnosed making it impossible to judge whether their criteria was appropriate. Pobo et al., (2009) provided diagnosis criteria, but could have used BQBAL as a way of obtaining lower airway lung secretions.

Discussion:

It is acknowledged that VAP is a serious complication of mechanical ventilation. It has the potential to affect ICU patients internationally (Ruffell and Adamcova, 2008). However, this review has identified a dearth of studies exploring the impact of CHX and tooth-brushing as part of preventative oral hygiene and a need for further research. It is also clear that the effect of tongue brushing has not been considered within these studies, a limitation that needs addressing. However, those studies reviewed, whilst failing to draw consensus, offer useful guidance for nursing practice.

Four intervention studies explored the effect of CHX in reducing VAP. Studies by Fourrier et al (2000), Koeman et al., (2006) and Munro et al., (2009) found CHX was successful in reducing the rate of VAP. Koeman et al., (2009) using CHX measured a 65% reduction in VAP. A combination of CHX and colistine was used to reduce the daily risk of VAP to 55%, a lower percentage than seen in the use of CHX alone. However, they suggest using a combination of CHX and colistine resulted in better oropharyngeal decontamination which reduced and delayed VAP. Fourrier et al., (2000) and Munro et al., (2009) concluded that CHX was able to reduce VAP, dental plaque in ICU patients and had the potential to reduce nosocomial infections. However, Scannapieco et al., (2009) was unable to identify benefits of CHX use in the reduction of dental plaque or potential respiratory pathogens. They noted CHX was unable to target gram-negative bacteria. Overall the findings suggest that if,
nurses use CHX in oral care delivery dental plaque and nosocomial infection rates may be reduced. However, using a combination of substances, such as CHX and colistine in oral care delivery, would provide capability to target both gram-negative and gram-positive bacteria and reduce VAP.

A strength of the four intervention studies reviewed was the range of ICU samples used drawn from trauma, surgical, medical and general units. This makes the findings more readily transferable for nurses to use in caring for ICU patients. However, more rigorous designs are needed to support the research of both Koeman et al., (2006) and Munro et al., (2009) to achieve more generalisable findings.

Munro et al., (2009), cited above, along with Simmons-Trau et al., (2004), Mori et al., (2006), Hutchins et al., (2009) and Pobo et al., (2009) investigated the use of toothbrushing in reducing VAP incidence. Interestingly, the results in respect of VAP were inconsistent, although the studies recommend tooth-brushing as important in maintaining good oral hygiene. This is an important result for ICU nurses providing oral care to ventilated patients.

The findings of research by Pobo et al., (2009) suggest the addition of electric toothbrushing to standard oral care with CHX was not effective with the prevention of VAP. However, poor oral hygiene is associated with irreversible damage to the teeth and colonisation of pathogens that may be associated with VAP, therefore the nurses role in maintaining oral hygiene through tooth brushing is important to VAP reduction. Similar prevention methods are proposed by Munro et al., (2009). Whilst tooth-brushing did not alone reduce rates, it is recommended as part of providing oral care.

The remaining three studies also concluded tooth-brushing had a positive impact on the incidence of VAP, further supporting its use by nurses. However, these studies did not solely look at tooth-brushing but incorporated the practice into an oral care package. Therefore, different variables could have contributed to these positive results.
Simmons-Trau et al., (2004) and Hutchins et al., (2009) reported reductions in VAP from the introduction of protocol intervention. Hutchins et al., (2009) noted a 89.7% reduction of VAP following the use of a protocol that included the use of hydrogen peroxide. They suggest hydrogen peroxide is cost effective and could be implemented in oral hygiene practice after further investigation. Simmons-Trau et al., (2009) achieved a lesser reduction of VAP, recorded at 54%, in the surgical ICU and a 33% drop in the general ICU patients. The study claimed the successes seen were due to the implemented management plan.

Whilst the studies suggest generalising the findings could improve the delivery of oral care, caution should be taken in suggesting ICU's adopt specific protocols to guide practice. Generalising these findings could have cost and resource implications for practice, requiring education, additional team effort and managerial support in the implementation of a management plan. Any unit considering such adoption would need to refer resourcing implications.

Conclusions and Implications:

This integrative review on the impact of CHX and tooth-brushing as preventative strategies in reducing VAP rates identified a limited number of studies and the need for more robust designs to support the use of CHX. In particular, the combination of CHX and colistin warrants further study given the potential to target both gram-positive and gram-negative pathogens. Those studies reviewed emphasised the cost-effectiveness of both CHX and tooth-brushing and the potential ease of implementation into protocols and practice. However limitations in the evidence prevent prescription of frequency of application and equipment as both areas require further research.

Any change of protocol will require considered implementation given the experiences of Babcock et al., (2004). The introduction of practice change would require education and emphasis to ensure practice change. Increasing nurses' knowledge and ability to practice the skills required is key to the prevention of VAP. Previous studies by Zack et al., (2002) and Cason et al., (2007) have demonstrated improved adherence to care protocols that reduce VAP rates can be achieved through
education, heightening awareness of the care issues. Indeed, Kleinpell (2006) proposed that if nurses kept up-to-date with current literature on prevention strategies it would facilitate optimal care delivery.

Whilst differing views on tooth-brushing exist those studies did provide some consistency in practice for guidance. Simmons-Trau et al., (2004), Mori et al., (2006) and Hutchins et al., (2009) suggested tooth-brushing was beneficial in maintaining oral care, though confirmed the need for larger studies with more rigorous designs.

On the basis of the findings, ICU nurses need to engage with existing oral care protocols to lessen VAP rates, using decontamination substances and tooth-brushing. Whilst a range of decontamination substances might be employed, CHX has been proven effective in a limited number of studies and its use has been supported by NICE (2008) guidelines. Additionally, its use as part of a combination of solutions, such as CHX and Colisitine is suggested to have some effect. Nevertheless, the need for further research into other decontamination substances that target gram-negative bacteria is recommended. The findings also supported the need for good patient hygiene, including tooth-brushing as part of a management plan or care protocol. Adherence would be supported if nurses’ understanding of VAP was increased and skills maintained.

Ventilator-Associated Pneumonia is a common complication of mechanical ventilation after endotracheal intubation. The role of chlorhexidine and tooth brushing has been considered as a clinical intervention to ameliorate this problem. This thesis discovered CHX and tooth-brushing were both found to be effective in reducing VAP rates but exposes the lack of robust evidence provided for tooth-brushing. The use of CHX has been proven to be an attractive prevention strategy, however, this may require the use of another substance which targets gram-negative bacteria. Although tooth-brushing has not been rigorously proven to be effective it may still be useful in providing better oral care to Mechanically Ventilated (MV) patients. It was noted when adding to recommendations for further research that researchers noted the poor standard of oral care received by patients in ICU could be an area for further development in attempting to raise standards of oral care in ICU.
References


<table>
<thead>
<tr>
<th>Authors/Year</th>
<th>Study Design</th>
<th>Population</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koeman et al., (2006)</td>
<td>Randomised controlled trial (RCT) Both CHX &amp; COLISISTINE were administered 4 times daily. with gloved fingertip on both sides of buccal cavity, taught to each nurse. Oral swabs were obtained.</td>
<td>Two university hospitals 385 patients.</td>
<td>Treatment groups had reduced and delayed development of VAP. Daily risk of VAP reduced by 65% with CHX and 55% with CHX/COL. Encourage the use of CHX and COL for multi-resistant gram-negative bacteria.</td>
</tr>
<tr>
<td>Scannapieco et al., (2009)</td>
<td>RCT, double blinded placebo controlled trial. CHX 0.12% applied with foam applicator 8am &amp; 8pm for 1min, excess suctioned, normal oral care with suction tooth brush for 2-3mins mouth moisturizer and deep suctioning every 12hrs. Taught procedure by study research nurses. reviewed every 3 months.</td>
<td>175 trauma ICU, Power calculated, 53 pts per treatment arm.</td>
<td>CHX reduced the number of S. aureus however did not reduce the number of the other target PRPs in dental plaque. One reason being that gram-negative bacteria are not sensitive to CHX.</td>
</tr>
<tr>
<td>Fourrier et al., (2000)</td>
<td>Single blind Randomized comparative study, Physicians and dental hygienist blinded. 0.2% CHX at 8.00, 14.00, 22.00, used gel, sterile gloved fingertip after mouth rinse and oropharyngeal aspiration (patients were allowed to eat/ drink freely according to their medical condition). Patients in control group C had standard oral care mouth rinse with bicarbonate isotonic serum gentle oropharyngeal sterile aspiration 4 x daily.</td>
<td>Tertiary care medical surgical ICU.</td>
<td>Revealed ICU patients’ colonize a high rate of dental plaque, highlighting the standard of oral care accepted in ICU is insufficient to control plaque formation and oral infections by nosocomial pathogens. CHX was able to decrease the growth of dental plaque and might reduce the incidence of nosocomial infections in MV ICU patients.</td>
</tr>
<tr>
<td>Munro et al.,</td>
<td>Randomized 2x2 factorial</td>
<td>3 ICUs Virginia</td>
<td>CHX was found to be effective in reducing early onset VAP where as tooth-</td>
</tr>
<tr>
<td>Study (Year)</td>
<td>Description</td>
<td>Design</td>
<td>Findings</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>(2009)</td>
<td>Patients received one of four interventions: 5mls of 0.12% CHX swab at 10am &amp; 10pm, tooth-brushing at 9am, 2pm and 8pm, both CHX and tooth-brushing or the placebo (usual care provided by ICU). Biotene tooth paste used. Suctioning and moisturizing gel applied post intervention.</td>
<td>Commonwealth university medical centre medical surgical and trauma enrolled within 24hr of intubation 547 patients</td>
<td>Tooth brushing did not reduce the incidence of VAP. The use of both interventions did not have the additional benefit. Suggested perhaps that dislodgement of dental plaque could have created larger pools of organisms for translocation to the lungs.</td>
</tr>
<tr>
<td>Pobo et al., (2009)</td>
<td>RCT single blind, researchers and physicians were blinded. Nurses taught protocol of standard care. Uses standard oral care with CHX against oral care with electric toothbrush interventions every 8hrs.</td>
<td>Medical surgical ICU, randomised, power calculation 147.</td>
<td>No significant difference between either group. Type II error. Didn’t reduce use of antibiotics or health care resources. That combining the two CHX and electric tooth-brushing would not be of any added benefit, suggested from the results.</td>
</tr>
<tr>
<td>Mori et al., (2006)</td>
<td>Not randomised, historical controls oral care against, no oral care. Uses povidone-iodine to cleanse oral cavity, and tooth-brush with acidic water, 3x daily. Interventions at different frequencies and were examined by multivariate analysis and therefore were eliminated with statistical correction. 8 year study, changes in ICU MV</td>
<td>Medical surgical ICU, 1,666 1 hospital. (Japanese study)</td>
<td>VAP was significantly lower in oral care patients. MV and length of ICU stay was not significant. Recommends oral care to reduce oropharyngeal colonisation.</td>
</tr>
<tr>
<td>Hutchins et al., (2009)</td>
<td>Performance improvement project not controlled. No control group or randomisation. Brushed teeth with cetylpyridinium chloride (swapped to CHX in 2007) using a suction tooth brush 2 a day</td>
<td>12 bedded ICU, 9 bedded CCU in 1 hospital didn’t record a sample size from May 2005 to Dec 2007.</td>
<td>Increased teamwork to lower VAP rates. Increased education on VAP and factors affecting e.g. head elevation and suctioning. Increased suctioning and moisturiser applied. Reduced because of 1-reduction in oral colonisation bacteria mechanical debridement of hydrogen peroxide which could have led to reduced VAP rates in 2004-2007 CHX in 2007.</td>
</tr>
<tr>
<td>Simmons-Trau <em>et al.</em>, (2004)</td>
<td>Multidisciplinary team (chief trauma/surgical resident, respiratory therapist, staff nurses from neuro and surgical ICU, case managers. Suction tooth-brush 2xday &amp; hydrogen peroxide to cleanse including moisturiser and tongue brushing &amp; deep oropharyngeal suctioning. Staff from the oral care team were present in ICU 24 hours a day for the first couple of days.</td>
<td>Multiple ICUs.</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 stigma approach- ‘leadership support, understanding the process, validating the root cause, developing solutions the impact outcomes and the process management to sustain our improvements. Recommends the same oral care should be carried on throughout transfer.</td>
<td>size of sample.</td>
<td></td>
</tr>
</tbody>
</table>