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# The Importance of Oral Hygiene in Reducing the Incidence of Ventilator-Associated Pneumonia - a Systematic Review

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**Keywords:** oral hygiene, ventilator-associated pneumonia, intensive care unit, nursing

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## Abstract

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**Introduction.** Healthcare-associated infections (HCAs) represent a major public health problem. Inadequate oral hygiene in intensive care units has been recognized as a critical issue for the occurrence of one of these infections - ventilator-associated pneumonia (VAP). Although literature suggests diverse oral care measures for ICU patients, the effectiveness of each is still a subject for further trials.

**Aim.** The purpose of this paper is to determine the association between diverse oral care measures and the incidence of ventilator-associated pneumonia.

**Methods.** A systematic review of literature in the PubMed database that evaluates the performance of diverse oral care measures and their impact in reducing the incidence of VAP. The keywords used as search terms were: oral hygiene, ventilator-associated pneumonia, intensive care unit and nursing.

**Results.** Four articles in total were taken into consideration in accordance with the availability of full-text articles and years of publication between 2009 and 2019. Performance results of diverse oral care measures haven't shown statistically significant differences, but the implementation of oral care as a preventive measure against VAP showed a significant role in lower incidence rates.

**Conclusion.** The results of the systematic literature review confirmed the importance of oral care in lowering the incidence rate of VAP. However, significant differences have been noted between the efficiency of diverse oral care measures and the incidence rate of VAP.

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## Introduction

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Healthcare-associated infections (HAIs) represent a major public health problem. They are defined as infections that occur 48-72 hours after admission to the hospital. The development of nosocomial infections is dependent on two key pathophysiological factors: compromised immune system of the host and colonization by pathogenic or potentially pathogenic bacteria and other microorganisms (1).

In intensive care units, the risk for healthcare-associated infections is significantly high. Research shows that HAIs can affect about 30% of patients in intensive care units and that they are associated with substantial morbidity and mortality. The use of catheters and other invasive equipment, and certain groups of patients, e.g. those with trauma or burns, are recognized as being more susceptible to HAIs than others. Although HAIs can affect any part of the body, respiratory tract infections are most frequent (1).

Patients in the intensive care unit (ICU) are at risk of dying not only from their critical illness but also from secondary illnesses caused by HAIs. One of the most frequent infections in ICU is ventilator-associated pneumonia which occurs 48-72 hours after patients have been intubated and received mechanical ventilation (2). VAP is estimated to occur in 9-27% of all mechanically ventilated patients, with the highest risk being in the first 5 days of hospitalization (3). VAP develops through aspiration of altered oral bacterial flora (mainly gram-negative microorganisms) into the normally sterile lower respiratory tract (4). The presence of an endotracheal tube is the most important risk factor for developing VAP resulting in the suppression of the cough reflex which is a natural defense mechanism of the respiratory tract. With microaspiration during intubation itself, development of a biofilm laden with gram-negative bacteria and fungal organisms within the endotracheal tube, pooling and trickling of secretions around the cuff and impairment of mucociliary clearance of secretions, infectious bacteria develop direct access to the lower respiratory tract (3). VAP prolongs the length of hospitalization and increases treatment costs. Previous studies have shown twice as long hospital stay and two times larger treatment costs for patients suffering from VAP infection (5).

The oral cavity of mechanically ventilated patients is a reservoir for pathogens, and the tendency of creating dental plaques is significantly increased (4, 6). For that reason, the aim of routine oral care is to reduce the microbial plaque and help to prevent VAP infection (4, 6). Oral hygiene is one of the essential parts of nursing care and an integral aspect of nursing care provided in intensive care units. Inadequate oral hygiene in combination with providing mechanical ventilation offers even greater risk of developing VAP. Unfortunately, the efficiency of oral care measures in critically ill patients has not been well studied (6). Evidence-based protocols of providing oral care in ICU have not been conducted and oral care measures are still performed inconsistently and in a diverse manner, with the great difference between individual ICUs and dependency on the nursing staff's perception of the importance of providing oral care. Moreover, diverse oral care measures, mechanical (toothbrushing), pharmacological (topical use of chlorhexidine) and combination of pharmacological and mechanical, show different effectiveness with regards to the lowering of VAP rate (6, 7). For that reason, it is necessary to increase the nursing staff's awareness of providing good quality oral hygiene to critically ill patients. To achieve that, implementing a standardized, evidence-based protocol of oral hygiene is increasingly emphasized (7).

The purpose of this paper is to determine the association between diverse oral care measures and the incidence of ventilator-associated pneumonia.

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## Methods

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A systematic review of literature in the PubMed database that evaluates the performance of diverse oral care measures and their impact in reducing the incidence of VAP. The keywords used as search terms were: oral hygiene, ventilator associated pneumonia, intensive care unit and nursing. The selection criteria (Table 1) for further filtration of the results included only original research (article type: clinical trial), published between 2009 and 2019, written in English and available in full-length format. The studies with a date of publication before 2009 were excluded. The

search process yielded 63 articles in total. After applying the inclusion and exclusion criteria, 6 articles were selected for a more detailed analysis. All identified studies were assessed for relevance based on title and abstract. Further analysis resulted in the exclusion of two articles: one referring to the oral care measures only in children population, and another testing effectiveness of oral care interventions only in neuroscience ICU patients. After analysing the title and abstracts, 4 articles in total were included in this systematic review.

## Results

Four articles that matched the selection criteria were analysed in this systematic review. The studies are from different parts of the world: Iran, India, Taiwan and the USA, published in different time periods: 2009, 2011, 2016 and 2017. An overview of the studies included is presented as a Prisma 2009 Flow Diagram (Figure 1).

The analysis of the articles, description and aims of the research, methodology and results obtained are presented in Table 2.

Haghighi et al. (2016) conducted a research with the aim to identify the impact of oral care practices on the oral health status of patients in the intensive care unit and the incidence rate of ventilator-associated pneumonia. The clinical trial recruited 100 participants who were randomly assigned to a control group and an intervention group. Some of the inclusion criteria for participating were: being intubated, mechanically

ventilated for more than 48h, having no lung disease or pneumonia (CPIS score lower than 6) or sepsis. The oral care routine of the intervention group included toothbrushing (with a child-sized toothbrush) using rotational movements, rinsing the mouth with a normal saline 0.9% solution and then spraying with 5 ml, 0.2% chlorhexidine. Deep suction was performed after 30 seconds. This routine of oral care was performed every 12 h, 8 h, 6 h and 4 h, depending on the patient's health status. 0.2% chlorhexidine was used every 12 h. The control group received routine oral care including brushing the teeth with a toothpaste once a day and mouth washing with chlorhexidine 0.2% solution twice a day. Oral care was performed by nursing staff with long work experience in the ICU. The incidence of VAP was measured by the Clinical Pulmonary Infection Score (CPIS). The results showed a VAP incidence of 10% and 14% the first and third day for the control group, and 4% and 10% for the intervention group. Although a Fisher's Exact test showed that pneumonia incidence rate on the third and fifth day was not statistically different between the two groups ( $p > 0.05$ ), the incidence of VAP in the intervention group decreased (8).

Chacko et al. (2017) aimed to investigate the efficiency of new oral hygiene techniques (toothbrushing with chlorhexidine and suctioning technique versus mouth swabbing with chlorhexidine) in order to evaluate association with VAP incidence. The study recruited 206 subjects divided into a control and an experimental group. Oral care was provided by nursing staff three times a day. The control group received routine oral care which included swabbing the oral cavity with sponges soaked in chlorhexidine gluconate 0.2%. Patients in the experimental group received oral care by toothbrushing with 0.2% chlorhexidine. After that the oral cavity was aspirated

Table 1. Inclusion and exclusion criteria

Selection criteria	Inclusion	Exclusion
Article category	Original research (type: Clinical Trial)	Review articles Systematic articles and other
Keywords	„oral hygiene“ „ventilator-associated pneumonia“ „nursing“ „intensive care unit“	„neuroscience ICU patients“ „gram-negative pathogens in children“
Date of publishing	2009-2019	Before 2009
Language	English	All others

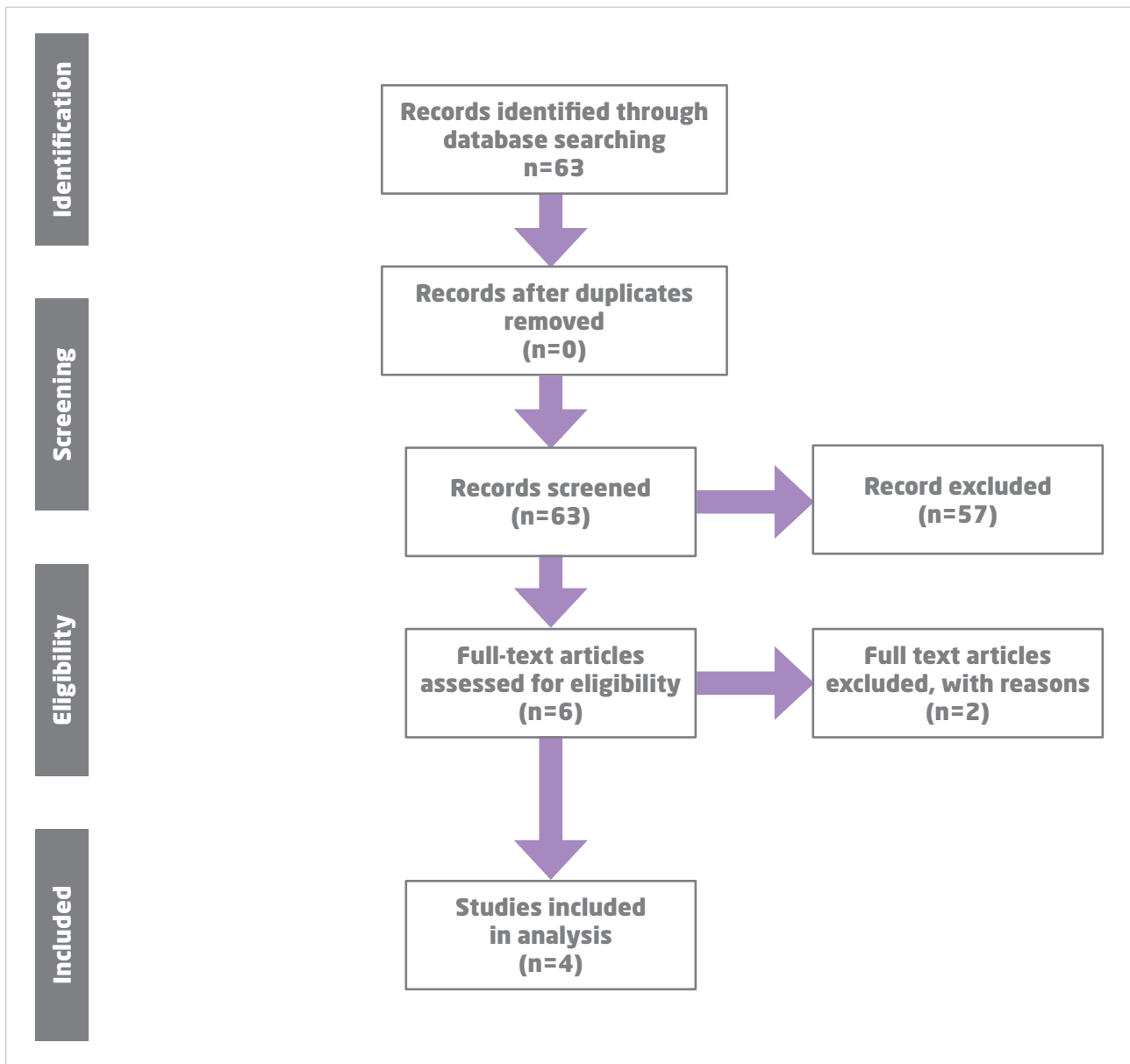


Figure 1. **Flowchart of article search and selection process**

with the Yankauer suction catheter. Of the 206 subjects recruited, 12 patients developed VAP, 5 from the experimental group and 7 from the control group. The incidence of VAP in the recruited group was only 10.1 per 1000 ventilator days, 8.6/1000 ventilator days for the experimental group and 11.6/1000 ventilator days in the control group. Consequently, there was no statistically significant difference in the incidence of VAP between the two groups ( $p>0.05$ ) (9).

In the year 2009 Munro and associates wanted to examine the effects of mechanical (toothbrushing),

pharmacological (topical oral chlorhexidine), and combination (toothbrushing plus chlorhexidine) oral care on the development of ventilator-associated pneumonia in critically ill patients receiving mechanical ventilation. For that purpose, they conducted a randomized controlled clinical trial. The trial consisted of 547 participants who were randomly assigned to a 1 of 4 treatments: 5ml 0.12 % chlorhexidine oral swab twice a day, toothbrushing three times a day, both toothbrushing and chlorhexidine (every 12 h), or control group (usual care). The VAP incidence was meas-

**Table 2. Overview of the studies finally included (VAP incidence)**

DOCUMENT	AIM	STUDY DESIGN AND DESCRIPTION OF RESEARCH	RESULTS
Haghighi A. et al. (8) Iran	Identify the impact of oral care practices on the oral health status of patients in ICU and the incidence rate of VAP.	A randomized controlled clinical trial conducted from October 2015 to February 2016. 100 participants N1=50 (control group) N2=50 (intervention group)  <b>Methodology :</b> Clinical Pulmonary Infection Score (CPIS)	No significant differences in CPIS between the two groups on the third and fifth day of trial.  $p_1=0.436$ $p_2=0.538$  *( $p<0.05$ ) statistically significant $p_1$ =third day, $p_2$ =fifth day
Chacko R. et al. (9) India	To assess the efficacy of a new technique of oral care in reducing the incidence of VAP.	A prospective, randomised, 'double-blind' study undertaken from 14 January 2014 to 27 December 2014. 206 participants.  N1=102 (control group) N2=104 (experimental group)	No significant difference in the incidence of VAP between the two groups ( $p=0.82$ )  *( $p<0.05$ ) statistically significant
Munro C. et al. (10) USA	To determine if 2 oral care interventions, chlorhexidine and toothbrushing, would reduce the risk for VAP during the first week.	A randomized controlled 2x2 factorial experimental design. 547 participants; 4 groups  <b>Methodology :</b> Clinical Pulmonary Infection Score (CPIS)	No significant differences in CPIS between the four groups.  The mixed model analysis showed no effect of either chlorhexidine ( $p_1=0.29$ ) or toothbrushing ( $p_2=0.95$ )  *( $p<0.05$ ) statistically significant
Yao L. et al. (11) Taiwan	To evaluate the effects of brushing teeth twice a day with purified water on VAP rates and oral health or hygiene.	This single-blind pilot randomized controlled trial undertaken from March to November 2007. 53 participants N1=28 (experimental group) N2= 25 (control group)  <b>Methodology :</b> VAP rates: Kaplan-Meier, log-rank test OAG score Plaque index	The cumulative VAP rates were significantly lower in the experimental (17%) than in the control (71%) group ( $p<0.01$ )  $(p<0.05)$ EG $(p<0.01)$ EG  * $p<0.05$ , $p<0.01$ statistically significant **EG (experimental group)

ured with Clinical Pulmonary Infection Score (CPIS) throughout the period of 7 days. Results showed no significant differences between those treatments. On day three of the study the interaction of toothbrushing and chlorhexidine was not significant, so that method was not included in final analysis models. Analysing the results of all treatments showed no statistical significance between toothbrushing and topical chlorhexidine ( $p>0.50$ ). However, the results showed that patients who had CPIS $>6$  the first day and had received chlorhexidine had significantly lower CPIS values on day 3, and pneumonia developed

in significantly fewer patients. To conclude, topical use of chlorhexidine lowered the VAP incidence by day three of the trial ( $p=0.006$ ). Toothbrushing had no influence on CPIS score (or VAP incidence) and combining toothbrushing and chlorhexidine did not provide additional benefit over the use of chlorhexidine alone (10).

Yao et al. (2011) conducted randomized controlled pilot trial whose aim was to evaluate the effects of brushing teeth twice a day with purified water on VAP rates in the post-operative neurosurgical intensive care unit. 53 patients participated in the trial, di-

vided into an experimental and a control group. Both groups received usual hospital care that included daily oral care using cotton swabs. The experimental group received an oral care protocol of toothbrushing with purified water twice a day. The incidence of VAP was measured with the Clinical Pulmonary Infection Score (CPIS). Results showed a lower incidence rate in the experimental group (17%) compared to the control group (71%;  $p < 0.01$ ). Furthermore, the experimental group showed better results in the Plaque Index and general estimation of oral health and hygiene (OAG score) ( $p < 0.01$ ) (11).

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## Discussion

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Oral hygiene affects many aspects of oral and general health of ICU patients. However, most attention is paid to the development of ventilator-associated pneumonia and, therefore, oral hygiene is recognized as one of the most important measures of VAP prevention (12). The VAP care bundle differs from institution to institution, but according to NHS-u (*National Health Service, UK, 2016*), it includes a group of interventions: elevation of the head of the bed, sedation level assessment, oral hygiene, subglottic aspiration, maintenance of tracheal tube cuff pressure and stress ulcer prophylaxis (13). One of the main components of the VAP care bundle is the already mentioned oral hygiene and nursing staff being essential for its proper performance. To conclude, comprehensive and standardized oral care can significantly reduce the incidence of respiratory tract infections by reducing the colonization and formation of dental plaques (6,14). Summing up the results of the research shown in the articles, there are no statistically significant differences in the incidence of VAP when comparing different oral care measures of oral hygiene. This proposes the question of the efficiency of these measures and highlights the further need for more detailed research and analysis of each method of oral hygiene. However, taking into consideration the set of all research results (8-11), the importance of oral hygiene in the VAP prevention care bundle has been confirmed. The proof of that hypothesis has been confirmed by similar previous studies.

For example, Mori et al. (2006) also investigated the importance of oral hygiene in VAP prevention. They conducted a nonrandomized clinical trial of over 1248 participants divided into two groups. The group that was given oral care (*oral care group*) and a group that had not received oral care (*non-oral care group*). The oral hygiene protocol in the *oral care group* was performed 1-3 times a day by two medical staff members, a dentist and a nurse specially educated for providing oral hygiene. In the oral hygiene protocol cuff pressure of the tracheal tube was increased to 100 mmHg, oropharyngeal secretions suction in the oral cavity, oral cavity was cleansed using a swab soaked in 20-fold diluted povidone-iodine gargle, a toothbrush was used and the oral cavity was rinsed with 300 ml weakly acidic water. Cleansing of the oral cavity was repeated using a swab soaked in 20-fold diluted povidone-iodine gargle. The suction of the oral cavity and portion of the trachea above the cuff was provided again and the cuff pressure was restored. VAP incidence was expressed in terms of 1000 days of mechanical ventilation. The results showed a significantly lower incidence in the *oral care group* (3.9 versus 10.4/1000,  $p > 0.001$ ) (15).

A systematic review of literature confirmed the importance of oral hygiene in patients on mechanical ventilation as one of the main preventive measures of the ventilator care bundle. Taking into consideration the results of all four articles presented in this review, it cannot be concluded which method of oral hygiene is the most efficient because the trials were not based on the same methods but the combinations of various. The efficiency of one method (e.g. toothbrushing) was not individually evaluated, and thus proper comparison cannot be conducted. However, analysing the trials in the articles (8-10), and comparing the methods within each of them, it is noticeable that the use of chlorhexidine (whether applied in combination with any other method or alone) has a greater effect on reducing the incidence of VAP from other methods (e.g. toothbrushing).

The importance of toothbrushing, which is the basic mechanical method of maintaining the oral cavity hygiene and generally the most frequent oral health care technique in critical and mechanically ventilated patients, is not sufficiently emphasized or researched. It is often neglected and replaced by some other alternative methods, such as using cotton swabs. Reasons why toothbrushing is not a practical method are complex patients' conditions and the

presence of endotracheal tube or nasogastric probe (16). Although further research is required to analyse toothbrushing in mechanically ventilated patients, the way of performing it, its safety and the effect on reducing dental plaque, the systematic review confirmed its importance in the trial of Yao et.al. The cumulative VAP rates were lower using toothbrushing than providing the usual care with cotton swabs (11).

Therefore, toothbrushing as an oral hygiene method should be an integral part of the oral hygiene protocols. The importance of specified procedures and combination of various methods of hygiene (toothbrushing, application of chlorhexidine, rinsing, suctioning, mucosal moisturizing, etc.) with the aim of providing the most effective oral health protection and VAP prevention, i.e. conducting of protocol, is emphasized in the research of Haghighi et al. (2016). VAP incidence in the intervention group, which was exposed to a methodically defined protocol in a set period of time that included a combination of mechanical and pharmacological methods of hygiene, was reduced by 54% (8).

The positive side of conducting the standardized protocol of oral cavity hygiene is confirmed by Hutchins et al. (2009). They initiated a program to improve oral hygiene quality in order to reduce VAP incidence in the period from 2004 to 2007. All patients admitted to the intensive care unit were included in the program unless they had contraindications for oral hygiene interventions. Patients were subjected to oral cavity hygiene that was performed every 4 hours, and consisted of exactly prescribed instructions that included different oral hygiene techniques such as toothbrushing with 0.12% chlorhexidine twice a day, aspiration of the secretion every 12 hours, tooth and tongue cleaning with hydrogen peroxide swabs, and moisturizing mucosal lips, lips and mouth cavities every 4 hours. Over a three-year period, the results showed that compliance with the hygiene program caused VAP incidence to decrease by 89.7% (17).

A similar protocol of oral care was tested by Garcia et al (2009) in a 48-month study. VAP incidence was measured in the pre-intervention period in which patients included in the study received "standard oral hygiene" of the institution. After educating all health professionals about various VAP related items (mortality, costs, morbidity, etc.) and pointing out the importance of implementing systematic comprehensive oral hygiene, which involved various oral hygiene measures performed at specific time period (aspira-

tion, toothbrushing, oral cavity cleansing etc.), the incidence rate of VAP was measured. The results indicated a decrease in the incidence from 12/1000 days of mechanical ventilation in the pre-intervention period to 8/1000 days of mechanical ventilation during the intervention period ( $p=0.06$ ). Consequently, it has been confirmed that the existence of a clearly defined protocol of oral hygiene and the compliance of health-care personnel with the protocol can significantly reduce the rate of pneumonia in patients on mechanical ventilation, and thus the costs of hospitalization (18).

All examples of analysed studies in this systematic review confirm the importance of implementing oral hygiene as an indispensable part of the nursing care provided in intensive care units. The nursing staff is mostly aware of this importance, but the correlation between frequency, consistency and effectiveness of oral hygiene techniques and reduction of oropharyngeal colonization is less known and further research is needed to address this issue. Exposure of patients in intensive care units to healthcare-associated infections such as VAP, highlights the importance of developing new strategies for improving oral cavity hygiene in order to reduce morbidity and mortality (19).

In accordance with the results of the systematic review of literature, there is a difference in the effectiveness of oral hygiene techniques and the results of their effectiveness in reducing VAP. Some of the techniques are more effective than others, while some do not show any efficacy.

Furthermore, the standardization of specific guidelines for the implementation of oral hygiene with a purpose of preventing VAP, the provision of hygiene protocols that would involve a combination of different methods according to the possibilities of implementation, defined time sequence of execution and the ability to monitor and evaluate these processes can improve the overall clinical outcome of the patient, and because of that, represent a very important item of further research.

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## Conclusion

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The findings of this systematic review confirm that oral hygiene is important in reducing the incidence of ventilator-associated pneumonia. It is apparent from the results that standard hygiene involving different methods (toothbrushing, chlorhexidine use, suctioning, cleaning with cotton swabs, moisturizing and etc.), which differs from one institution to another, does not show the complete consistency and the efficiency of each of these methods shows different results. To conclude, there is a need for specific guidelines and standardized oral hygiene protocols that will incorporate a combination of methods and specify the exact order of performing oral hygiene to achieve the best results in preventing and reducing VAP.

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## VAŽNOST ORALNE HIGIJENE U SMANJENJU INCIDENCIJE VENTILATOROM UZROKOVANE PNEUMONIJE - SUSTAVNI PREGLED LITERATURE

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### Sažetak

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**Uvod.** Infekcije povezane s bolničkom skrbi predstavljaju veliki javnozdravstveni problem. Neadekvatna oralna higijena u jedinicama intenzivnog liječenja jedan je od rizičnih čimbenika za nastanak jedne od takvih infekcija - ventilatorom uzrokovane pneumonije. Postoje različite tehnike provođenja higijene, no efikasnost svake od njih još je uvijek područje istraživanja.

**Cilj.** Utvrditi povezanost metoda higijene usne šupljine i pojave ventilatorom uzrokovane pneumonije.

**Metode.** Sustavni pregled literature u bazi podataka PubMed u cilju pronalaženja članaka koji evaluiraju provođenje higijene usne šupljine i njihov utjecaj na incidenciju VAP-a. Ključne riječi upotrijebljene u pretraživanju baze: oralna higijena, ventilatorom uzrokovana pneumonija, jedinica intenzivnog liječenja, sestринство.

**Rezultati.** U obradu su uzeta četiri članka prema kriterijima dostupnosti cjelovitog teksta i godinama publikacije između 2009. i 2019. Rezultati nisu pokazali statistički vidljive razlike u incidenciji VAP-a na temelju različitih metoda održavanja oralne higijene, no implementacijom oralne higijene kao sastavne preventivne mjere VAP-a vidljiv je znatan utjecaj na smanjenje incidencije.

**Zaključak.** Rezultati sustavnog pregleda literature potvrdili su važnost provođenja higijene usne šupljine u svrhu smanjenja incidencije VAP-a. Međutim, vidljive su razlike u efikasnosti metoda provođenja higijene u pogledu njihova utjecaja na smanjenje stope VAP-a.

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**Ključne riječi:** oralna higijena, ventilatorom uzrokovana pneumonija, jedinica intenzivnog liječenja, sestринство

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