Review Article

Oral Care and Positioning to Prevent Ventilator-Associated Pneumonia: A Systematic Review

SAGE Open Nursing
Volume 10: 1–13

DOI: 10.1177/23779608241271699
journals.sagepub.com/home/son
Sage

Eslam Bani Mohammad, RN, MSN, PhD[1], Amani A. Al Eleiwah, RN, MSN, PhD[2], Banan T. Qurdahji, RN, MSN, PhD[3], Ahmad Rayan, PhD, RN[4], Jafar A. Alshraideh, PhD, RN[5], Lourance A. Al Hadid, PhD[6], Muna S. Al Kharabsheh, RN, MSN[1], Heba N. Hudhud, MSN, CNS, RN[1] and Suad Jakalat, RN,MSN,PhD[7]

Abstract

Introduction: Ventilator-associated pneumonia (VAP) is one of the most common nosocomial infections in critical patients. The negative impacts of VAP on patient outcomes emphasize the importance of effective preventive measures such as oral care and patient positioning. The aim of this review was to investigate the impact of oral care and positioning on the prevention of VAP among patients in the intensive care unit.

Methods: This review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A comprehensive search was performed. The methodological quality of included studies was appraised using Joanna Briggs Institute checklists.

Results: In total 13 studies were included, all of them were randomized controlled trials. Six out of nine studies about oral care have significant results on VAP incidence. Regarding the position, Patients positioned at a 45-degree were less likely to develop VAP than those positioned at a 30-degree and those in a supine position.

Conclusion: Although patients positioned at 45-degree angle were less likely to develop VAP than those at 30-degree, it is necessary to individualize this practice before recommending it, once there are some contraindications, such as neurocritical patients. Regarding oral care to prevent VAP, considering the current guidelines' recommendation not to use oral chlorexidine, further studies evaluating alternatives are needed.

Keywords

Pneumonia, ventilator-associated, mouthwashes, critical care, oral hygiene, patient positioning

Received 23 September 2023; Revised 14 June 2024; accepted 28 June 2024

Introduction

Background

Ventilator-associated pneumonia (VAP) is the most common nosocomial infection among patients who receive mechanical ventilation in the intensive care unit (ICU) (Wu et al., 2019). Moreover, VAP is a substantial healthcare concern, especially among critically ill patients on mechanical ventilation (Torres et al., 2017). Ventilator-associated pneumonia is defined as pneumonia that develops 48 h or more after endotracheal intubation, is distinguished by its relationship with invasive mechanical ventilation and making critically

[1]Department of Nursing/Faculty of Nursing, Al-Balqa Applied University, Al-Salt, Jordan
[2]University of Jordan, Amman, Jordan
[3]Department of Nursing, School of Nursing, University of Jordan, Amman, Jordan
[4]Faculty of Nursing, Zarqa University, Zarqa, Jordan
[5]Clinical Nursing Department, School of Nursing, University of Jordan, Amman, Jordan
[6]Faculty of Nursing, Al-Balqa Applied University, Al-Salt, Jordan
[7]Midwifery Department, School of Nursing, Al-Balqa Applied University, Al-Salt, Jordan

Corresponding Author:
Ahmad Rayan PhD, RN, Faculty of Nursing, Zarqa University, Zarqa 13132, P.O.Box 132222, Jordan.
Email: arayan@zu.edu.jo, ahmed_rayan87@yahoo.com

ill patients particularly vulnerable (Zhao et al., 2020). Furthermore, VAP is caused by a complex interaction of elements such as weakened host defenses, aspiration of oropharyngeal secretions, and pathogenic microorganism colonization of the respiratory system (Cooper, 2021). As a result, therapies targeting these factors, such as oral care and optimum patient position, have emerged as viable techniques to reduce the incidence of VAP.

The presence of an endotracheal tube is one of the main risk factors for the development of VAP because it interferes with the normal protective upper airway reflexes, irritates the respiratory mucosa, increases the amount of mucus, and promotes micro aspiration of contaminated oropharyngeal secretions (Augustyn, 2007). The incidence of VAP is based on the duration of mechanical ventilation, and the diagnostic criteria used (Wu et al., 2019). Furthermore, VAP not only increases hospitalization time and expenses, but it also correlates to higher morbidity and mortality rates in intensive care unit (ICU) (Wu et al., 2019). The negative impact of VAP on patient outcomes emphasizes the significance of effective preventive measures.

Statement of the Problem

Ventilator-associated pneumonia constitutes a prevalent healthcare-associated infection characterized by lung infection and stands as the foremost contributor to mortality resulting in nosocomial infections in intubated ICU patients (Torres et al., 2017). Patients subjected to mechanical ventilation for a minimum duration of 48 h are susceptible to the development of VAP (Cooper, 2021). Furthermore, VAP is the most prevalent infection in ICU and it has the highest mortality rate as the crude mortality rates is between 20% and 75% (Hassan & Wahsheh, 2017). Ventilator-associated pneumonia increased mortality rate, hospital length of stay (LOS), increased use of health care resources and increased healthcare costs in critically ill patients (Wu et al., 2019). However, the incidence of nosocomial infections, particularly VAP, is directly associated with issues related to malfunctioning medical staff such as hand disinfection failure, lack of proper oral care, and poor suctioning (Hudáková, 2020).

Oral Care

Ventilator-associated pneumonia, a life-threatening consequence of mechanical ventilation, is caused by the aspiration of pathogenic microorganism-containing oral and pharyngeal secretions into the lower respiratory tract (Torres et al., 2017). As a result, VAP prevention is essential to reduce the colonization of potentially dangerous bacteria in the oropharynx (Torres et al., 2017). Regular oral care aimed to reduce microbial burden in the oral cavity, reducing the risk of aspiration, incidence of VAP in critically ill patients and subsequent VAP development (Choi et al., 2022; Zhao et al., 2020).

The World Health Organization has emphasized that strategies aimed at preventing VAP are characterized by their straightforwardness, cost-effectiveness, and reliance on the conscientious practices, accountability, and behavioral modifications of the healthcare personnel in ICU (Cotoia et al., 2020). Finally, a growing body of evidence, as reflected in studies, determined the significant impact of effective oral care in mitigating VAP risk and improving patient outcomes in critical care settings (Atashi et al., 2018; Choi et al., 2022; Irani et al., 2019).

Positioning

Positioning refers to the changing of body position as a specific technique for patient treatment (Stiller, 2000). In the ICU, positioning is considered an important intervention to decrease the rates of VAP (Conboy, 2023). Furthermore, the patient's body position may be intended to improve ventilation, perfusion, and the clearance of airway secretions with the aid of gravity (Stiller, 2000). Commonly positions that have impact on VAP are supine, prone and semi-recumbent positions. Semi-recumbent position seems to be the best position to reduce VAP incidence, hospital length of stay, the duration of mechanical ventilator (MV); whereas, prone position reduce the risk of mortality and the ICU length of stay (Pozuelo-Carrascosa et al., 2022).

For preventing VAP, a semi-recumbent position, elevation of the head of bed to 30 or 45°, is a recommendable measure in several clinical practice guidelines that have been extensively studied as a simple strategy for patients undergoing MV (Álvarez-Lerma et al., 2018). This position can help to avoid the entry of these gastric contents by reducing gastroesophageal reflux and contaminated oropharyngeal secretions entry into the lower airway, thus preventing VAP (Pozuelo-Carrascosa et al., 2022).

Purpose

This review aimed at investigating the impact of oral care and positioning on the prevention of VAP among patients in ICU.

Methods

This systematic review was not registered in the International Prospective Register of Systematic Reviews (PROSPERO) since this project was short in duration and limited resources were available to register it at the study start date. Unfortunately, submissions to PROSPERO must have been made before data extraction commences. That is why registration has been impossible at the later stages of the study. The review was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al., 2010).

The researchers also followed the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2019).

Searching Strategy

A search of Science Direct, Research Gate, Medline through (PubMed), Scopus, ISI Web of Knowledge, EBSCO, ERIC (Education Resources Information Center) and Cumulative Index to Nursing & Allied Health Literature (CINAHL) database for the years between January 2011 and September 2023 was done. The MeSH search and text word search that were used with the terms related to critical care, patient positioning, oral hygiene, mouthwashes, randomized controlled trial, and critical illness. The following descriptors were used in English in the six databases: Prevention and Control AND "Pneumonia, Ventilator-Associated" AND "Patient Care" AND "Intensive Care Units" AND "Patient Positioning" AND "Oral Hygiene" OR "Mouthwashes".

Selection and Eligibility Criteria

Three independent authors were responsible for removing the duplicates, screening the title and abstract, and analyzing the full content of the studies in accordance with the inclusion criteria. To be included in the systematic review, studies had to (a) be published in the English language; (b) be Randomized Control Trials (RCTs); (c) include age above 15 years, critically ill patients, intubated, and admitted to all kinds of ICUs; (d) evaluate the implementation of provide oral care and/or positioning in VAP prevention; (e) Full text; (f) Outcome incidence; (g) Any of these intervention or all of them; (h) Protocols, conference papers, abstracts, posters, and letters to editors and editorials were excluded. This electronic search was conducted by EHB-M and AA-E, and any differences were resolved by discussion with a third reviewer (BQ).

The research question was chosen based on the PICO strategy (problem, intervention, comparison, and outcomes), P: ventilator-associated pneumonia; I: VAP prevention strategies oral care and position; C: comparison of the VAP prevention strategies; O: reduction in the incidence of VAP. After removing duplicate retrieved records, two reviewers (EHB-M and AA-E) independently screened the titles and abstracts. Then, the reviewers evaluated the full-text articles, and when any discrepancy between the two independent reviewers occurred, a third coauthor was consulted to resolve it (BQ).

The researchers included RCTs that met the following inclusion criteria: patients on mechanical ventilation for at least 48 h and reported data on VAP incidence. The researchers included RCTs comparing different body positions or alternative degrees of positioning of mechanically ventilated patients: supine, semi-recumbent, prone or lateral. The main study outcome measure was the incidence of VAP (clinically suspected or microbiologically confirmed), and the secondary outcome variables were ICU length of stay, hospital length of stay, duration of MV and mortality.

Data Extraction and Synthesis

Data from the included RCTs were extracted by using the standardized data extraction form developed by Joanna Briggs Institute (Aromataris & Munn, 2020). The data about: (1) First author; (2) Year of publication; (3) Country; (4) Characteristics of the participants; (5) Outcomes: incidence of VAP (clinically suspected or microbiologically confirmed) (6) characteristics of the treatments: body position (supine, semi-recumbent, prone or lateral), angles, hours per day in this position, and the type of oral care; (7) Study design; (8) The period of study; and (9) Aim of study (Table 1). The included articles were discussed within the research team to divide them into categories. Furthermore, the researchers used the extracted data to determine the key components of the included interventions.

Quality Assessment

Methodological Quality. The quality of the selected articles was assessed with the Joanna Briggs Institute critical appraisal checklists for RCTs and Quasi Experimental Studies (Tufanaru et al., 2017). The checklists consist of several items which can be answered with "yes", "no", "unclear" or "not applicable". To calculate the score for each article, the proportion of items on the checklist marked with "yes" was calculated. The cut-off value for inclusion of a study was decided according to the Joanna Briggs Institute Manual (Institute, 2014).Two independent researchers (EHB-M and AA-E) assessed the risk of bias of the included studies and a third reviewer (BQ) was consulted to resolve discrepancies. Finally, the researchers calculated the proportion of the criteria that was fulfilled for each article. The expected a value smaller than 50% would lead to a too high risk of bias (Institute, 2014).

Two independent researchers assessed the risk of bias of the included studies, and a third reviewer was consulted to resolve discrepancies. For this, the researchers used the Cochrane Collaboration Risk of Bias Tool 2 (RoB2) (Sterne et al., 2019). To assess the following items of each included study: (1) The randomization process, (2) Deviations from the intended interventions, (3) The presence of missing outcome data, (4) Measurement of the outcome, (5) Selection of the reported results. In addition, overall bias was rated as "low risk", "some concerns" or "high" risk of bias.

Results

Search Results

The study selection process is demonstrated in Figure 1. Overall, the initial search yielded 17,011 records. After

Table 1. Main Characteristics of the Reviewed Studies.

Author (Year) Country	Study Design Quality score	Sample characteristic size N, (Age Range)	Period	Procedure	Outcome	Recommendation
(Atashi et al., 2018) Iran	RCT 77%	n = 80, (18–65)	(November 2016 to August 2017)	IG: Patients were randomized to be positioned in the LTP or in SRP, with the head of the bed elevated at least 30°, the frequency of care was determined every 12, 8, 6, and 4 h for patients with no, mild, moderate, and severe disorders, respectively. CG: routine care by elevation of the head of the bed from 30° to 45° and use of swab and chlorhexidine 0.2% solution every 12 h by nurses.	CG: VAP on the 3rd and 5th days was 15.80% (6) and 23.70% (9). IC: 10.50% (4) and 7.90% (3) The oral care program could not significantly decrease the incidence of VAP in critically ill patients compared with routine oral care practices.	Similar studies with a larger sample size and longer duration should be conducted for better results.
(Bassi et al., 2017) Spain	RCT 85%	n = 401 (≥18 years)	(December 2010 and April 2015)	LTP group, SRP group, with the head of the bed elevated at least 30°.	The incidence of microbiologically confirmed VAP was LTP = 0.5% (1/194). SRP = 4.0% (8/201) (relative risk 0.13, 95% CI 0.02–1.03, p = 0.04). (within the first 14 days)	The LTP can- not be recommended as a VAP preventive measure. Given the safety limitations, re-examine the targeted population
(Chacko et al., 2017) India	RCT 92%	N = 206, (≥16 years)	From 14 January 2014 to 27 December 2014.	CG: received routine oral care: the oral cavity was swabbed with sponges soaked in chlorhexidine gluconate 0.2%. IG: received oral care with a commercially prepared oral care kit with one toothbrush, disposable Yankauer suction catheter and a disposable syringe. Chlorhexidine gluconate 0.2% was instilled into the oral cavity	The incidence of VAP in the recruited group was only 10.1 per 1000 ventilator days, IG:8.6/1000 ventilator days CG: 11.6/1000 ventilator days (p = 0.82). there was no significant difference in incidence of VAP between the two groups.	Future research along similar lines could make the picture clearer
(Choi et al., 2022) Japan	RCT 77%	n = 73 (≥20 years)	(March 2017 to November 2017)	IG: received oral hygiene care from nurses (using oral swabs and CHX 0.12% solution) 24 h after mechanical ventilation initiation and every 8 h thereafter. Dental hygienists provided additional oral hygiene care (toothbrushes, CHX	CG: VAP =10.58	Further research must be conducted to study the long term effects of oral hygiene care on the incidence of VAP and to establish detailed guidelines

(continued)

Table 1. Continued.

Author (Year) Country	Study Design Quality score	Sample characteristic size N, (Age Range)	Period	Procedure	Outcome	Recommendation
				0.12% solution and cotton balls) every 24 h. CG: only received oral hygiene care from the nurses (using oral swabs and CHX 0.12% solution) 24 h.	IG: VAP = 0 post intervention. p < 0.001	
after mechanical ventilation initiation and every 8 h thereafter.						
(Ghezeljeh et al., 2017) Iran	RCT 54%	n = 120 (≥18 years)	(February to July 2016)	The patients were allocated into 3 groups. 2IG: received interventions consisting of HOB elevation to 30 ° and 45 ° for 3 consecutive days. CG: routine position in the bed for 3 consecutive days.	Statistically significant differences were reported in terms of VAP between the groups of the HOB 30 ° (32.50%) and 45 ° (20.00%) and control groups (52.50%) (P = 0.01).	Need for larger sample sizes and longer duration of intervention for investigating different factors affecting VAP
(Güner & Kutlutürkan, 2022) Turkey	RCT 85%	n = 60 (≥18 years)	(January and July 2019)	parallel groups of three arms 20 patients each group <30 °, 30 ° and 45 °.	VAP in <30 ° = 55%, 30 °= 25%, and 45° = 20% The frequency of VAP was significantly lower in the 45 compared with the <30 degree, there were no significant differences between the <30 °,30°, as well as the 45 and 30 study groups.	To increase sample size
(Haghighat et al., 2022) Iran	RCT 62%	N = 71, (18–65)	(October 2019 to February 2020)	Three groups by the researcher. A7-day oral care by using swab (group 1), two-times-brushing group (group 2), and four-times-brushing group (group 3) by using chlorhexidine.	The incidence of VAP first group (35.00%) was significantly higher than that of the two intervention groups (10.00%) (p = 0.03). Third group was significantly lower seven days after the intervention than before the intervention (p = 0.04) and the fourth day of intervention (p = 0.003). In the first group, this score was significantly higher in the fourth day of the intervention than the seventh day (p = 0.003)	Use of oral care protocol is recommended to provide a minimum level of oral care and reduce the risk of VAP in MV patients.
(Hassankhani	RCT 85%	N = 25, adult		ARM 1: Semi-recumbent position 45°	IG: VAP was 20%.	Increase sample size

(continued)

Table 1. Continued.

Author (Year) Country	Study Design Quality score	Sample characteristic size N, (Age Range)	Period	Procedure	Outcome	Recommendation
et al., 2017) Iran			(June 2011 to April 2012)	angle; n = 11 ARM 2: Semi-recumbent position 60° angle; n = 10	CG: 73% (p = 0.016).	
(Irani et al., 2019) Iran	RCT 69%	n = 70 (18–65)	Conducted in 2018	This two-group pretest-posttest, single-blinded randomized clinical. IG: oral care was administered using miswak. CG: chlorhexidine mouthwash in the control group.	a significant difference between the two groups in terms of VAP incidence (P = 0.01)	Miswak is strongly recommended to be administered to ICU patients
(Izadi et al., 2023) Iran	RCT 54%	n = 73(15–85)	(September 2019 to March 2020)	The patients entered into 1 of the 2 groups of mouthwash containing CHG or OZW. The intervention was carried out in both groups every 8 h for 5 days.	There was also difference in the incidence of VAP Incidence of VAP in the CHG mouthwash group was 45.9%, and 25% in the OZW mouthwash group.	Need larger sample
(Karimi et al., 2023) Iran	RCT 92%	200 (≥18 years)	Not mention the period of	IG: received oral health care based on evidence based oral health protocol CG: routine oral health care groups.	IG = 5% of VAP CG = 64% of VAP statistically significant (P < 0.001).	requires further studies
(Kaya et al., 2017) Turkey	RCT 46%	N = 88, Adult	(January 2014 and August 2015)	IG: received oral care with 5% glutamine CG: received oral care with 2% chlorhexidine gluconate solution.	there is no significant difference between the use of chlorhexidine gluconate and glutamine.	bigger sample size and longer term should be conducted for better results.
(Vidal et al., 2017) Brazil	RCT 92%	N = 213, (≥18 years)	(July 2013 to January 2014).	CG: Oral hygiene with 0.12% chlorhexidine solution every 12 h	VAP occurred in 45 (21.1%), 28 being patients from CG and 17 from the IG, with incidence density equal to 14.2 by 1.000 MV/ day.	More studies are needed
				IG: toothbrushing plus 0.12% chlorhexidine gel every 12 h	The use of toothbrushing plus 0.12% chlorhexidine gel demonstrated a lower incidence of VAP throughout the follow up period, although the difference was not statistically significant (p = 0.084).	

Note. VAP = Ventilator Associated Pneumonia, HOB = Head Of Bed, LTP = lateral Trendelenburg Position, SRP = Semirecumbent Position, HOBE = Head-of-Bed Elevation, T = Volume Tidal, MV = Mechanical Ventilation, PEEP = Positive End-Expiratory Pressure, CG = Control Group, IG = Intervention Group.

removing duplicates, 10,010 records were screened by title and abstract for potential relevance. Of these, 9911 records were irrelevant and excluded and 99 full-text articles were screened. Finally, 86 articles were excluded and 13 articles were included in the review (Atashi et al., 2018; Bassi et al., 2017; Chacko et al., 2017; Choi et al., 2022; Ghezeljeh et al., 2017; Güner & Kutlutürkan, 2022; Haghighat, Mahjobipoor & Gavarti, 2022; Hassankhani et al., 2017; Irani et al., 2019; Izadi et al., 2023; Karimi et al., 2023; Kaya et al., 2017; Vidal et al., 2017).

The quality rating varied over this selection of studies (Table 1). The percentage rating was calculated according to the proportion of the criteria, which based on the Joanna Briggs Institute Manual that was fulfilled for each article (Institute, 2014). Three studies had a quality rating between 50% and 60% (Ghezeljeh et al., 2017; Izadi et al., 2023; Kaya et al., 2017). Four studies had a quality rating between 62% and 77% (Atashi et al., 2018; Choi et al., 2022; Haghighat et al., 2022; Irani et al., 2019). Six studies had a quality rating between 85% and 92% (Bassi et al., 2017; Chacko et al., 2017; Güner & Kutlutürkan, 2022; Hassankhani et al., 2017; Karimi et al., 2023; Vidal et al., 2017).

As evidenced by the assigned percentage ratings, the examination of research quality revealed a wide range of methodological rigor among the included studies. Notably, numerous studies, like Chacko et al. (2017), Vidal et al. (2017), and Karimi et al. (2023), achieved 92%, demonstrating a high level of methodological rigor and reliability in their research designs. Similarly, Bassi et al. (2017), Güner and Kutlutürkan (2022), and Hassankhani et al. (2017) received 85%, indicating a high level of quality. Two studies received percentages of 77%, indicating relatively acceptable methodological quality (Atashi et al., 2018; Choi et al., 2022). However, Ghezeljeh et al. (2017), Irani et al. (2019), and Izadi et al. (2023) obtained percentages of 54%, indicating a moderate degree of quality. In addition, Haghighat et al. (2022) and Kaya et al. (2017) received percentages of 62% and 54%, suggesting lesser methodological quality. These disparities in percentages highlight the variety in study quality within the field of positioning and oral care's impact on VAP prevention, needing careful analysis and interpretation of each study's findings.

Characteristics of Included Studies

The characteristics of these 13 included studies are presented in Table 1. All of these studies were RCT and the outcome was about VAP. In terms of interventions, the included interventions were divided into two categories: Oral care intervention (Atashi et al., 2018; Chacko et al., 2017; Choi et al., 2022; Haghighat et al., 2022; Irani et al., 2019; Izadi et al., 2023; Karimi et al., 2023; Kaya et al., 2017; Vidal et al., 2017) and positioning intervention (Bassi et al., 2017; Ghezeljeh et al., 2017; Güner & Kutlutürkan, 2022; Hassankhani et al., 2017). Overall, these 13 included studies reported the results from 1680 participants including patients aged 15 years or more. In terms of comparison groups, all studies included a control and intervention group.

This section outlines the results obtained from the examination of a total of 1013 patients who were under ICU care. This encompassed both the interventional group and the control group, focusing on examining the effects of oral care, and positioning with the aim of preventing VAP in patients within the ICU. The initial segment of the results delineates the characteristics of the incorporated studies, followed by a subsequent segment detailing the obtained results. Lastly, the subsequent section encapsulates the overarching themes distilled from the comprehensive review.

Assessment Methodology of VAP

Pugin et al. (1991) developed the Clinical Pulmonary Infection Score (CPIS) for this assessment. Based on factors such as body temperature, white cell count, pulmonary secretion color, Pao2/FiO2, chest radiography, sputum smear, and culture, researchers evaluated VAP occurrence by combining quantitative Broncho alveolar lavage (BAL) and mini-BAL cultures with CPIS.

Methodological Approaches

While all the studies incorporated randomization of participant allocation, two studies stood out with their multicenter-controlled, single-center prospective randomized controlled parallel group designs (Bassi et al., 2017). Blinding techniques also varied, including single-blind (Hassankhani et al., 2017). Double-blinding (Ghezeljeh et al., 2017; Güner & Kutlutürkan, 2022). Even triple-blinding to minimize potential biases (Bassi et al., 2017).

Main Themes

The review of several studies on oral care interventions and their impact on the prevention of VAP in mechanically ventilated patients reveals a diverse range of outcomes. The studies included in the review encompass a range of study designs, sample characteristics, countries, periods, procedures, outcomes, and recommendations. The major themes that emerge from the review of these studies include four themes: (1) Effectiveness of oral care interventions. (2) Comparison of oral care techniques. (3) Patient characteristics and demographics. (4) Variation in VAP incidence and pathogens.

Effectiveness of Oral Care Interventions

The studies collectively reveal a spectrum of outcomes in terms of the effectiveness of various oral care interventions in reducing the risk of VAP. While some interventions,

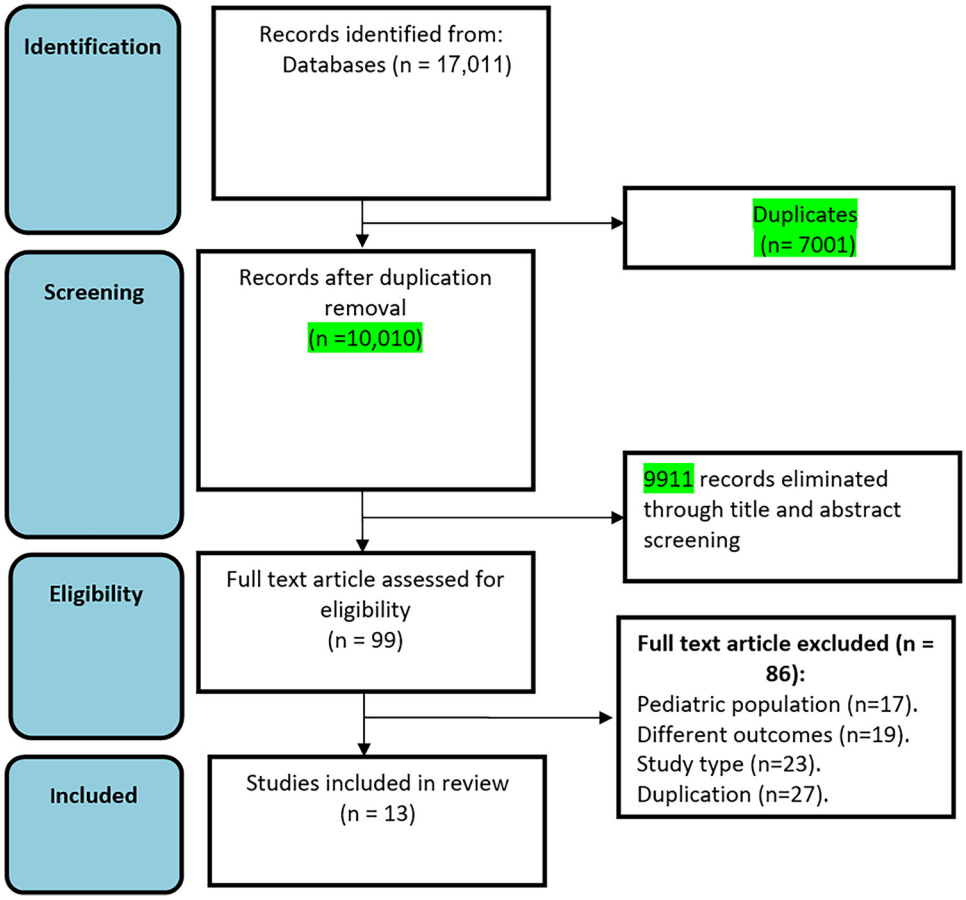

Figure 1. PRISMA Flow Diagram of Literature Search.

such as professional oral care leaded to 100% VAP reduction, $p < 0.001$ (Choi et al., 2022). Another study demonstrated that tooth brushing plus chlorhexidine gel reduced VAP by 97%, $p = 0.084$ (Vidal et al., 2017). Similarly, VAP was reduced by 95%, $p < 0.001$ using oral health protocols which showcased promising results with decreased VAP incidence, other interventions like a new oral care technique (Karimi et al., 2023). There was no significant difference compared to routine care, $p > 0.05$(Chacko et al., 2017). Furthermore, the incidence of VAP in the ozonated water (OZW) mouthwash group (25%) was lower than in the chlorhexidine (CHG) mouthwash group (45.9%) (Izadi et al., 2023). These varying outcomes highlight the necessity for comprehensive research and tailored approaches to oral care interventions for VAP prevention based on patient-specific factors and context.

Comparison of Oral Care Techniques

The studies included in this review underscore the paramount importance of comparing diverse oral care techniques in order to determine their relative efficacy in preventing VAP. Among the interventions scrutinized within these studies are toothbrushing, swab-based oral care, chlorhexidine mouthwash, miswak, and ozonated water, each evaluated for its potential to mitigate the risk of VAP. However, the findings reveal a nuanced narrative where no singular technique emerges as universally superior across all investigations. The intricate nature of oral care's impact on infection risk within the ICU setting becomes evident as the outcomes exhibit variability. This intricate reality accentuates the imperative for meticulous, in-depth comparative assessments and direct head-to-head evaluations of distinct oral care methodologies. Such comprehensive analyses are indispensable for facilitating evidence-based decision-making processes aimed at determining the most suitable oral care approach for effectively preventing VAP.

Patient Characteristics and Demographics

The patient population's characteristics, including age, gender, and the severity of illness, play a role in the outcomes of oral care interventions. Different patient groups might respond differently to the same intervention due to their unique health profiles. Studies like Irani et al. (2019) and Kaya et al. (2017) demonstrate the relevance of demographic

factors, such as age and consciousness levels, in influencing the efficacy of oral care interventions in preventing VAP. For instance, Irani et al. (2019) investigation involved 70 ICU patients aged 18–65 years, with a sample size estimated at 35 patients per group. The results indicated a significant difference in VAP incidence between the miswak group (82.9% male, 17.1% female) and the chlorhexidine group (74.3% male, 25.7% female) (P = 0.01) (Irani et al., 2019). Kaya et al. (2017) demonstrated that, involving 88 patient, patients consciousness levels played a significant role in the efficacy of oral care interventions, where the chance of VAP occurrence in patients with lower levels of consciousness was significantly higher (OR: 2.38; 95%CI: 1.11-5.26) (P < 0.05).

Variation in VAP Incidence and Pathogens

The studies reveal variations in VAP incidence rates and the types of pathogens observed. While some studies report significant reductions in VAP incidence (Choi et al., 2022; Karimi et al., 2023). Other studies showed that the mouthwashes that were used led to a decrease in the incidence of VAP in the intervention groups, although the difference was not statistically significant (Izadi et al., 2023; Vidal et al., 2017). Furthermore, the types of pathogens associated with VAP differed between studies. These variations could be attributed to differences in study design, patient populations, and interventions, highlighting the complexity of VAP prevention and the importance of context-specific considerations. For instance, in the study by Choi et al. (2022), the experimental group showed a remarkable reduction in the incidence of VAP, with a difference of 10.58 between the control group (10.58) and experimental group (0) post-intervention. Moreover, in Vidal et al. (2017) research, the use of tooth brushing plus 0.12% chlorhexidine gel demonstrated a lower incidence of VAP throughout the follow-up period, although the difference was not statistically significant (p = 0.084). Meanwhile, studies like Haghighat et al. (2022) and Kaya et al. (2017) emphasized the need for tailored oral care protocols to cater to patient-specific requirements.

Almost all studies call for larger sample sizes, longer follow-up durations, and more comprehensive evaluations to establish more robust conclusions about the effectiveness of various oral care interventions in preventing VAP. The diversity in findings underscores the importance of conducting rigorous, well-designed studies to build a more solid evidence base for guiding clinical practice.

Positioning

In this section, the key themes were derived from four RCTs that examined the effects of head-of-bed (HOB) elevation angles on VAP among patients in ICU. In addition to 606 participants, these trials supply valuable insights.

Study Context and Demographics

The research was carried out in a variety of geographic regions and in a variety of ICU settings in the selected RCTs. Furthermore, head of bed elevation angles were evaluated for their impact on VAP incidence in the trials. These studies focused on patients aged 15 years or more in ICU units with mechanical ventilators (MVs). According to the country, most of the included studies were done in Iran (Atashi et al., 2018; Ghezeljeh et al., 2017; Haghighat et al., 2022; Hassankhani et al., 2017; Irani et al., 2019; Izadi et al., 2023; Karimi et al., 2023). In addition, two studies were conducted in Turkey (Güner & Kutlutürkan, 2022; Kaya et al., 2017), one in Spain (Bassi et al., 2017), one in India (Chacko et al., 2017), one in Japan (Choi et al., 2022), and one in Brazil (Vidal et al., 2017).

Impact of HOB Elevation on VAP Incidence

The year 2017 saw the convergence of three studies (Bassi et al., 2017; Ghezeljeh et al., 2017; Hassankhani et al., 2017) exploring HOB elevation effects on VAP incidence. Notably, two studies scrutinized the role of HOB elevation angles. The findings proved significant differences in VAP rates between groups with HOB elevation to 30 degrees (32.50%) and 45 degrees (20.00%), compared to the control group (52.50%) (P = 0.01). Moreover, Ghezeljeh et al. (2017) discovered that elevating the HOB from 45° to 60° lowered VAP risk more than threefold (relative risk = 3.64). These studies collectively endorsed HOB elevation to 45 or 60 degrees for mechanically ventilated ICU patients, aligning with the advice from Hassankhani et al. (2017). However, the study by Bassi et al. (2017) diverged, investigating the impact of lateral Trendelenburg position (LTP) versus semi-recumbent position (SRP). The trial ended prematurely due to a scarcity of VAP occurrences, no secondary benefits, and adverse events. The secondary outcomes examined mortality, duration of mechanical ventilation, and ICU stay length.

In 2021, a study compared semi-recumbent positions at 30 and 45 degrees with HOB elevation to <30 degrees. Notably, VAP incidence was notably lower in the 45-degree group (20%) than in the <30-degree group (55%), echoing earlier findings (Ghezeljeh et al., 2017; Hassankhani et al., 2017). Intriguingly, the HOB elevation degree appeared unrelated to the timing of VAP occurrences (early or late) (P = .703).

Discussion

The purpose of this review is to investigate the impact of oral care and positioning on the prevention of VAP in patients in the ICU. Based on the gathered empirical data, which focuses on the incidence of VAP among patients in ICUs, a specific study undertook a comparative analysis of two distinct mouthwash formulations: CHG and ozonated water OZW.

Notably, the study concluded that OZW exhibited superior efficacy compared to CHG in diminishing the VAP risk within ICU patients (Izadi et al., 2023). In contrast, the employment of CHG demonstrated limited capability in mitigating the risk of VAP. Kocaçal Güler and Türk (2019) conveyed that CHG displayed greater effectiveness (at a concentration of 0.2%) in reducing VAP incidence when compared to dental gels and normal saline. However, Tran and Butcher (2019) conducted a comprehensive review of diverse studies, revealing inconclusive outcomes for CHG administered at varying concentrations (ranging from 0.12% to 2%) with regard to reducing VAP incidence.

On the other hand, the European Society of Intensive Care Medicine (ESICM) Annual Congress in 2017 reported that there was a statistically significant increase in hospital mortality among 438 patients in an ICU who had been on MV and had mouth wash with chlorhexidine gluconate (Azevedo et al., 2017). Furthermore, there are contraindications regarding the use of oral chlorhexidine for safety reasons such as dry mouth and calculus formation (Zanatta et al., 2010). Oral chlorhexidine can lead to respiratory arrest, severe anaphylaxis, and hypersensitivity reactions (Klompas et al., 2022; Rose et al., 2019; Vieira et al., 2022). Severe anaphylaxis was reported at an incidence of 0.78 per 100,000 exposures (Rose et al., 2019). Another emerging issue with chlorhexidine is the antimicrobial resistance (Kampf, 2016). However, these discrepancies in findings may potentially emanate from disparities in the characteristics of the study cohorts, the interventions implemented, and the procedural aspects of oral care.

Conversely, a study by Chacko et al. (2017) reported no significant distinction in the incidence of VAP between the two subject groups. Their findings did not provide evidence to support the superiority of tooth-brushing over regular oral care in reducing VAP occurrence. On a different note, Bassi et al. (2017) arrived at a divergent conclusion, asserting that toothbrush-based oral care demonstrated superiority over conventional oral care in mitigating the incidence of VAP. This variance in conclusions emphasizes the nuanced nature of oral care's impact on VAP, possibly stemming from differences in study methodologies, protocols, and patient populations.

In this comprehensive analysis, four studies indicated a tendency towards lower rates of ventilator-associated pneumonia, albeit without achieving statistical significance. These varied findings collectively underscore the complexities and divergent outcomes associated with different oral care strategies in VAP prevention, indicating the need for careful consideration of factors such as methodology and patient population.

The results of this systematic review emphasize that a 30° elevation is insufficient in preventing VAP among mechanically ventilated patients. The researchers recently came across some research that suggests that patients positioned at a semi recumbent angle of 45° are less likely to develop VAP compared to those in a supine position (Ghezeljeh et al., 2017). Interestingly, the clinical diagnosis of VAP notably diminishes in patients positioned this way. A 30° backrest elevation may not be adequate in preventing VAP in mechanically ventilated patients (Ghezeljeh et al., 2017).

Additional interesting information were found in a systematic review and meta-analysis conducted by Zhuo and colleagues which showed that patients positioned at a 45° semi-recumbent angle have a lower incidence of ventilator-associated pneumonia compared to those in a 30° semi-recumbent position (Zhuo et al., 2021). This provides further evidence for the efficacy of the 45° semi-recumbent position in preventing VAP in mechanically ventilated patients, the odds ratio (OR) of 0.48 with a 95% confidence interval (CI) of 0.28 to 0.84 ($Z = 2.59$; $P = 0.009$) underscores the advantage of the 45° position. In contrast, the impact of lateral Trendelenburg positioning on clinically diagnosed VAP incidence is like that observed among semi recumbent-positioned patients (Bassi et al., 2017). In addition, the impact of the prone position showed a no significant tendency to reduce VAP incidence on patients on mechanical ventilator Mora-Arteaga et al. (2015) Implementing a 45° bed head elevation can be a challenge, despite its effectiveness in preventing ventilator-associated pneumonia. According to empirical evidence, only about 26.4% of bedridden patients can maintain an elevation angle exceeding 30°, as observed in a study on semi-sitting positions conducted by (MJ & García, 2011). According to MJ and García (2011) this highlights the importance of finding alternative methods to prevent VAP in mechanically ventilated patients who may not be able to maintain the recommended position.

In terms of positioning, it is important to highlight that, for critical patients in general, the current recommendation is to raise the head of the bed from 30 to 45 degrees (Zhuo et al., 2021). Previous literature has identified the factors that contribute to the challenges of implementing a 45° bed head elevation. For the neurocritical patient, it is already well established that the recommendation for neuroprotection is exactly 30 degrees, in order to maintain adequate cerebral perfusion and avoid secondary neurological damage (Durward et al., 1983). Head of bed elevation to 45 degrees in neurocritical patients could result in a drop in cerebral blood flow and consequent cerebral ischemia (Musick & Alberico, 2021). It is understandable that discomfort, concerns about pressure ulcers, and the need for frequent position changes can make it difficult for patients to maintain this position (Lyerla et al., 2010). Consequently, the practicality of a 45° bedside elevation should be determined in accordance with the patient's condition and their physical tolerance level (Lyerla et al., 2010).

Strengths and Limitations

Among the strengths, this systematic review has provided a comprehensive and insightful analysis of the impact of oral care and positioning on the prevention of VAP among

patients within ICUs. Additionally, the review highlights the potential of alternative oral care and positioning approaches to contribute positively to VAP prevention, emphasizing the significance of their unique antimicrobial properties. Among the limitations, the definition of VAP is not the same in all studies as the CDC has changed the criteria for defining VAP over the years. Therefore, there is a limitation in evaluating the effectiveness of each of the VAP prevention bundles, as the definition of VAP itself varies between studies. Furthermore, considering the effect of chlorhexidine mouth wash on mortality, mortality was not the primary outcome of any of the included studies.

Recommendations

Several key recommendations emerge from the comprehensive review of studies investigating oral care interventions and position and their impact on preventing VAP among patients in ICU. To begin, the disparities in the outcomes of various oral care interventions highlight the importance of personalized approaches tailored to individual patient factors and care contexts. There is a need for more studies to define which oral care would be more appropriate for patients on mechanical ventilation, considering the effectiveness in preventing VAP and the safety of the intervention. As more studies are needed into the possibility of alternative substances, such as ozonated water, another mouthrinse, or just toothbrushing with sterile water.

Patient characteristics such as age, gender, and level of consciousness should be taken into account because they can influence how patients respond to interventions. Longer follow-up periods are required to understand the long-term impact of VAP prevention interventions. Larger sample size research, standardized protocols, and multidisciplinary collaboration are recommended. Finally, several interventions could perhaps be implemented in VAP prevention bundles, including head of bed elevation by 45 degrees for patients without contraindications (such as those with neurological injury, in whom the recommendation remains to position the head of bed at 30 degrees in order to avoid cerebral hypoperfusion).

Conclusion

Through an in-depth exploration of diverse studies, this review has highlighted several key themes, including the effectiveness of oral care interventions, comparisons of oral care techniques, patient characteristics and demographics, and variations in VAP incidence. The divergent outcomes could be attributed to variations in protocols, interventions, patient populations, and study durations.

The review reveals a complex landscape where various oral care strategies and interventions have yielded diverse outcomes in preventing VAP. Notably, the effectiveness of interventions demonstrated temporal dependencies and variations based on concentrations and methods of administration. Regarding the oral care of patients on mechanical ventilation, considering the possibility of harm from oral hygiene with chlorhexidine, and the non-recommendation of current guidelines, more studies are needed to robustly establish a more effective and also safe alternative, such as ozonated water, other mouthrinses or toothbrushing with sterile water. It is safe to provide oral care with toothbrushing but without chlorhexidine.

Patients positioned at a 45-degree semi-recumbent angle were less likely to develop VAP than those positioned at a 30-degree. Therefore, guidelines should evaluate changing the recommendation to elevate the head of the bed to 45 degrees in VAP prevention bundles for critically ill patients on mechanical ventilation who do not have contraindications. For those with neurological damage, the 30-degree head recommendation remains to avoid cerebral hypoperfusion due to reduced cerebral blood flow. It is important to highlight that although the critical patient in general can benefit from positioning at 45 degrees, it is necessary to assess whether there is neurological damage and individualize this practice before recommending it.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

ORCID iDs

Eslam Bani Mohammad https://orcid.org/0000-0003-3569-7875
Ahmad Rayan https://orcid.org/0000-0002-8377-2297
Jafar A. Alshraideh https://orcid.org/0000-0002-2118-5257
Suad Jakalat https://orcid.org/0000-0003-1074-3142

References

Álvarez-Lerma, F., Palomar-Martínez, M., Sánchez-García, M., Martínez-Alonso, M., Álvarez-Rodríguez, J., Lorente, L., Arias-Rivera, S., García, R., Gordo, F., & Añón, J. M. (2018). Prevention of ventilator-associated pneumonia: The multimodal approach of the Spanish ICU "pneumonia zero" program. *Critical Care Medicine*, *46*(2), 181. https://doi.org/10.1097/CCM.0000000000002736

Aromataris, E., & Munn, Z. (2020). *JBI manual for evidence synthesis*. Joanna Briggs Institute.

Atashi, V., Yousefi, H., Mahjobipoor, H., Bekhradi, R., & Yazdannik, A. (2018). Effect of oral care program on prevention of ventilator-associated pneumonia in intensive care unit patients: A randomized controlled trial. *Iranian Journal of Nursing and Midwifery Research*, *23*(6), 486. https://doi.org/10.4103/ijnmr.IJNMR_164_17

Augustyn, B. (2007). Ventilator-associated pneumonia: Risk factors and prevention. *Critical Care Nurse*, *27*(4), 32–39. https://doi.org/10.4037/ccn2007.27.4.32

Azevedo, J., Montenegro, W., Sousa, C., Silva, M., Leitao, A., Maranhao, J., & Araujo, R. (2017). Ventilator-associated events: Prevalence, outcome, and preventability. *Intensive Care Medicine Experimental*, *5*(2), 44.

Bassi, G. L., Panigada, M., Ranzani, O. T., Zanella, A., Berra, L., Cressoni, M., Parrini, V., Kandil, H., Salati, G., & Selvaggi, P. (2017). Randomized, multicenter trial of lateral trendelenburg versus semirecumbent body position for the prevention of ventilator-associated pneumonia. *Intensive Care Medicine*, *43*, 1572–1584. https://doi.org/10.1007/s00134-017-4858-1

Bassi, G. L., Senussi, T., & Xiol, E. A. (2017). Prevention of ventilator-associated pneumonia. *Current Opinion in Infectious Diseases*, *30*(2), 214–220. https://doi.org/10.1097/QCO.0000000000000358

Chacko, R., Rajan, A., Lionel, P., Thilagavathi, M., Yadav, B., & Premkumar, J. (2017). Oral decontamination techniques and ventilator-associated pneumonia. *British Journal of Nursing*, *26*(11), 594–599. https://doi.org/10.12968/bjon.2017.26.11.594

Choi, M.-I., Han, S.-Y., Jeon, H.-S., Choi, E.-S., Won, S.-E., Lee, Y.-J., Yang, J.-H., Baek, C.-Y., Shim, H., & Mun, S.-J. (2022). The influence of professional oral hygiene care on reducing ventilator-associated pneumonia in trauma intensive care unit patients. *British Dental Journal*, *232*(4), 253–259. https://doi.org/10.1038/s41415-022-3986-3

Conboy, G. (2023). Early Mobilization as a Strategy to Decrease Rates of Ventilator Associated Pneumonia.

Cooper, A. S. (2021). Oral hygiene care to prevent ventilator-associated pneumonia in critically ill patients. *Critical Care Nurse*, *41*(4), 80–82. https://doi.org/10.4037/ccn2021314

Cotoia, A., Spadaro, S., Gambetti, G., Koulenti, D., & Cinnella, G. (2020). Pathogenesis-targeted preventive strategies for multidrug resistant ventilator-associated pneumonia: A narrative review. *Microorganisms*, *8*(6), 821. https://doi.org/10.3390/microorganisms8060821

Durward, Q. J., Amacher, A. L., Del Maestro, R. F., & Sibbald, W. J. (1983). Cerebral and cardiovascular responses to changes in head elevation in patients with intracranial hypertension. *Journal of Neurosurgery*, *59*(6), 938–944. https://doi.org/10.3171/jns.1983.59.6.0938

Ghezeljeh, T. N., Kalhor, L., Moghadam, O. M., Lahiji, M. N., & Haghani, H. (2017). The Comparison of the Effect of the Head of Bed Elevation to 30 and 45 degrees on the Incidence of Ventilator Associated Pneumonia and the Risk for Pressure Ulcers: A Controlled Randomized Clinical Trial. *Iranian Red Crescent Medical Journal*, *19*(7).

Güner, C. K., & Kutlutürkan, S. (2022). Role of head-of-bed elevation in preventing ventilator-associated pneumonia bed elevation and pneumonia. *Nursing in Critical Care*, *27*(5), 635–645. https://doi.org/10.1111/nicc.12633

Haghighat, S., Mahjobipoor, H., & Gavarti, S. G. (2022). Comparative study of the effect of three oral care protocols on ventilator-associated pneumonia in critically ill patients: A clinical trial. *Iranian Journal of Nursing and Midwifery Research*, *27*(2), 99. https://doi.org/10.4103/ijnmr.IJNMR_243_20

Hassan, Z. M., & Wahsheh, M. A. (2017). Knowledge level of nurses in Jordan on ventilator-associated pneumonia and preventive measures. *Nursing in Critical Care*, *22*(3), 125–132. https://doi.org/10.1111/nicc.12273

Hassankhani, H., Akbarzadeh, S., Lakdizaji, S., Najafi, A., & Mamaghani, E. A. (2017). Effects of 60 degrees semi-recumbent position on preventing ventilator-associated pneumonia: A single-blind prospective randomised clinical trial. *Journal of Clinical and Diagnostic Research*, *11*(12), OC36–OC39.

Higgins, J., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M. J., & Welch, V. J. H. W. (2019). *Cochrane handbook for systematic reviews of interventions*. Wiley.

Hudáková, T. (2020). Prevention of ventilator-associated pneumonia in intensive departments from the nursing perspective. *Україна. Здоров'я нації*, *2*(3).

Institute, T. J. B. (2014). *Joanna Briggs Institute Reviewers' Manual: 2014 Edition*. The Joanna Briggs Institute Australia.

Irani, H., Sargazi, G., Dahmardeh, A. R., & Mofrad, Z. P. (2019). The effect of oral care with miswak versus chlorhexidine on the incidence of ventilator-associated pneumonia: a clinical trial study. *Medical-Surgical Nursing Journal*, *8*(4). https://doi.org/10.5812/msnj.100387

Izadi, M., Bagheri, M., Far, A. B., Bagheri-Baghdasht, M. S., Ghasemzadeh, G., Sureda, A., & Soodmand, M. (2023). Reduce the risk of ventilator-associated pneumonia in ICU patients by ozonated water mouthwash: A double-blind randomized clinical trial. *American Journal of Infection Control*, *51*(7), 779–785. https://doi.org/10.1016/j.ajic.2022.10.015

Kampf, G. (2016). Acquired resistance to chlorhexidine–is it time to establish an 'antiseptic stewardship'initiative? *Journal of Hospital Infection*, *94*(3), 213–227. https://doi.org/10.1016/j.jhin.2016.08.018

Karimi, S., Kolyaei, E., Karimi, P., & Rahmani, K. (2023). Effectiveness of supervised implementation of an oral health care protocol on ventilator-associated pneumonia patients in intensive care units: A double-blind multicenter randomized controlled trial. *Infection Prevention in Practice*, *5*(3), 100295. https://doi.org/10.1016/j.infpip.2023.100295

Kaya, H., Turan, Y., Tunalı, Y., Aydın, GÖ, Yüce, N., Gürbüz, Ş, & Tosun, K. (2017). Effects of oral care with glutamine in preventing ventilator-associated pneumonia in neurosurgical intensive care unit patients. *Applied Nursing Research*, *33*, 10–14. https://doi.org/10.1016/j.apnr.2016.10.006

Klompas, M., Branson, R., Cawcutt, K., Crist, M., Eichenwald, E. C., Greene, L. R., Lee, G., Maragakis, L. L., Powell, K., & Priebe, G. P. (2022). Strategies to prevent ventilator-associated pneumonia, ventilator-associated events, and nonventilator hospital-acquired pneumonia in acute-care hospitals: 2022 update. *Infection Control & Hospital Epidemiology*, *43*(6), 687–713. https://doi.org/10.1017/ice.2022.88

Kocaçal Güler, E., & Türk, G. (2019). Oral chlorhexidine against ventilator-associated pneumonia and microbial colonization in intensive care patients. *Western Journal of Nursing Research*, *41*(6), 901–919. https://doi.org/10.1177/0193945918781531

Lyerla, F., LeRouge, C., Cooke, D. A., Turpin, D., & Wilson, L. (2010). A nursing clinical decision support system and potential predictors of head-of-bed position for patients receiving mechanical ventilation. *American Journal of Critical Care*, *19*(1), 39–47. https://doi.org/10.4037/ajcc2010836

MJ, F. M., & García, Z. (2011). Evaluation of the compliance of semirecumbent position between 30-45° in intubated patients. *Enfermeria Intensiva*, *22*(3), 117–124. https://doi.org/10.1016/j.enfi.2010.11.005

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. (2010). Preferred reporting items for systematic and meta-analysis (PRISMA) group. Preferred reporting items for systematic reviews and

meta-analyses: The PRISMA statement. *International Journal of Surgery*, *8*, 336–341. https://doi.org/10.1016/j.ijsu.2010.02.007

Mora-Arteaga, J., Bernal-Ramírez, O., & Rodríguez, S. (2015). The effects of prone position ventilation in patients with acute respiratory distress syndrome. A systematic review and metaanalysis. *Medicina Intensiva (English Edition)*, *39*(6), 359–372. https://doi.org/10.1016/j.medine.2014.11.004

Musick, S., & Alberico, A. (2021). Neurologic assessment of the neurocritical care patient. *Frontiers in Neurology*, *12*, 588989. https://doi.org/10.3389/fneur.2021.588989

Pozuelo-Carrascosa, D. P., Cobo-Cuenca, A. I., Carmona-Torres, J. M., Laredo-Aguilera, J. A., Santacruz-Salas, E., & Fernandez-Rodriguez, R. (2022). Body position for preventing ventilator-associated pneumonia for critically ill patients: A systematic review and network meta-analysis. *Journal of Intensive Care*, *10*(1), 9. https://doi.org/10.1186/s40560-022-00600-z

Pugin, J., Auckenthaler, R., Lew, D. P., & Suter, P. M. (1991). Oropharyngeal decontamination decreases incidence of ventilator-associated pneumonia: a randomized, placebo-controlled, double-blind clinical trial. *Jama*, *265*(20), 2704–2710.

Rose, M. A., Garcez, T., Savic, S., & Garvey, L. H. (2019). Chlorhexidine allergy in the perioperative setting: A narrative review. *British Journal of Anaesthesia*, *123*(1), e95–e103. https://doi.org/10.1016/j.bja.2019.01.033

Sterne, J. A., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates, C. J., Cheng, H.-Y., Corbett, M. S., & Eldridge, S. M. (2019). RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ*, *366*.

Stiller, K. (2000). Physiotherapy in intensive care: Towards an evidence-based practice. *Chest*, *118*(6), 1801–1813. https://doi.org/10.1378/chest.118.6.1801

Torres, A., Niederman, M. S., Chastre, J., Ewig, S., Fernandez-Vandellos, P., Hanberger, H., Kollef, M., Bassi, G. L., Luna, C. M., & Martin-Loeches, I. (2017). International ERS/ESICM/ESCMID/ALAT guidelines for the management of hospital-acquired pneumonia and ventilator-associated pneumonia: Guidelines for the management of hospital-acquired pneumonia (HAP)/ventilator-associated pneumonia (VAP) of the European Respiratory Society (ERS), European Society of Intensive Care Medicine (ESICM), European Society of Clinical Microbiology and Infectious Diseases (ESCMID) and Asociación Latinoamericana del Tórax (ALAT). *European Respiratory Journal*, *50*(3). https://doi.org/10.1183/13993003.00582-2017

Tran, K., & Butcher, R. (2019). Chlorhexidine for oral care: A review of clinical effectiveness and guidelines.

Tufanaru, C., Munn, Z., Aromataris, E., Campbell, J., & Hopp, L. (2017). Systematic reviews of effectiveness. In *Joanna Briggs institute reviewer's manual* (pp. 3–10). The Joanna Briggs Institute Adelaide.

Vidal, C. F., Vidal, A. K. d. L., Monteiro, J. G. d. M., Cavalcanti, A., Henriques, A. P. d. C., Oliveira, M., Godoy, M., Coutinho, M., Sobral, P. D., & Vilela, CÂ (2017). Impact of oral hygiene involving toothbrushing versus chlorhexidine in the prevention of ventilator-associated pneumonia: A randomized study. *BMC Infectious Diseases*, *17*, 1–9. https://doi.org/10.1186/s12879-017-2273-4

Vieira, P. C., de Oliveira, R. B., & da Silva Mendonça, T. M. (2022). Should oral chlorhexidine remain in ventilator-associated pneumonia prevention bundles? *Medicina Intensiva*, *46*(5), 259–268. https://doi.org/10.1016/j.medin.2020.09.009

Wu, D., Wu, C., Zhang, S., & Zhong, Y. (2019). Risk factors of ventilator-associated pneumonia in critically III patients. *Frontiers in Pharmacology*, *10*, 482. https://doi.org/10.3389/fphar.2019.00482

Zanatta, F. B., Antoniazzi, R. P., & Rösing, C. K. (2010). Staining and calculus formation after 0.12% chlorhexidine rinses in plaque-free and plaque covered surfaces: A randomized trial. *Journal of Applied Oral Science*, *18*, 515–521. https://doi.org/10.1590/S1678-77572010000500015

Zhao, T., Wu, X., Zhang, Q., Li, C., Worthington, H. V., & Hua, F. (2020). Oral hygiene care for critically ill patients to prevent ventilator-associated pneumonia. *Cochrane Database of Systematic Reviews*, (12). https://doi.org/10.1002/14651858.CD009543.pub3

Zhuo, X., Pan, L., & Zeng, X. (2021). The effects of the 45° semi-recumbent position on the clinical outcomes of mechanically ventilated patients: A systematic review and meta-analysis study. *Annals of Palliative Medicine*, *10*(10), 10643–10651. https://doi.org/10.21037/apm-21-2359