Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 58 Issue: 09:2025
DOI: 10.5281/zenodo.17276558

ORAL HEALTH AND RESPIRATORY OUTCOMES: A SYSTEMATIC REVIEW OF DENTAL–RESPIRATORY INTERACTIONS IN HOSPITALIZED PATIENTS

FAHAD AYIDH ALTHOBAITI
Respiratory Therapist, National Guard Hospital.

MOHAMMED MEQBEL AL ANAZI
Respiratory Therapy, National Guard Hospital.

HAYA ZAMIL ALDAJANI
Laboratory, National Guard Hospital.

RANA NASHMI ALANAZI
Dental Assistant, National Guard Hospital.

NAJWA JARED ALSHAMMARI
Dental Assistant, National Guard Hospital.

MADHAWI SAAD ALDAWSARI
Radiology, National Guard Hospital.

DEEMA FAHAD ALMANGOUR
Social Worker, National Guard Hospital.

Abstract

Background: Ventilator-associated pneumonia (VAP) is a frequent, morbid complication among mechanically ventilated adults. Oral hygiene strategies, chlorhexidine (CHX), povidone-iodine, toothbrushing, aim to reduce oropharyngeal colonization and aspiration. High-quality syntheses suggest benefit for CHX, but effects on patient-centred outcomes and across ICU populations remain debated. **Objective:** To systematically summarize randomized and prospective clinical studies evaluating oral hygiene interventions for VAP prevention in adults receiving invasive ventilation. **Methods:** Following PRISMA principles, we included original clinical trials, extracted study design, population, interventions, and clinically relevant outcomes (VAP, mortality, ventilation/ICU duration), and narratively synthesized findings without meta-analysis (heterogeneous interventions/outcomes). **Results:** Nine included studies (randomized and prospective) evaluated CHX (rinse/gel or paste), toothbrushing (manual/electric), and povidone-iodine, primarily in mixed ICUs, surgical ICUs, and cardiac surgery settings. Several trials demonstrated reduced VAP with CHX-based oral decontamination (including 2% CHX±colistin and pre-operative mouthwash), while multiple toothbrushing trials (manual/electric) did not show additional benefit over antiseptic care alone. **Conclusions:** Across heterogeneous ICU populations, CHX-based oral care generally reduces VAP incidence, whereas adding toothbrushing alone does not consistently confer extra benefit. Findings align with contemporary meta-analyses and guidelines, though effects on mortality and lengths of stay remain uncertain.

Keywords: Ventilator-Associated Pneumonia; Oral Hygiene; Chlorhexidine; Toothbrushing; Povidone-Iodine; Intensive Care; Mechanical Ventilation.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 58 Issue: 09:2025
DOI: 10.5281/zenodo.17276558

INTRODUCTION

Ventilator-associated pneumonia (VAP) arises after ≥48 hours of invasive ventilation and remains a major source of morbidity, resource use, and cost in intensive care units (ICUs).

Oral hygiene care (OHC), including antiseptic mouthrinses/gels and mechanical plaque removal, seeks to decrease oropharyngeal pathogen burden and microaspiration.

A comprehensive Cochrane review (2016) concluded that, in critically ill adults, OHC with chlorhexidine (CHX) reduces VAP compared with placebo/usual care (high-quality evidence), although no clear differences were observed for mortality, ventilation duration, or ICU length of stay; evidence for toothbrushing was uncertain. [1]

Subsequent reappraisal and meta-analyses refined these signals. A landmark synthesis in *The Lancet Infectious Diseases* (2011) reported that oral antiseptics lowered VAP risk overall, with stronger effects for higher-concentration CHX and in cardiac surgery cohorts, but patient-centred outcomes remained equivocal. [2]

A 2014 JAMA Internal Medicine analysis emphasized that benefits appeared concentrated in cardiac surgery populations that are typically extubated early; for non-cardiac surgery ICU patients, double-blind trials did not show significant VAP reduction and raised questions about mortality neutrality or potential harm signals, underscoring the need to focus on robust, patient-centred endpoints beyond VAP diagnoses prone to subjective misclassification. [3]

An updated Cochrane review (2020) found that CHX mouthrinse/gel probably reduces VAP (moderate-certainty), while toothbrushing may reduce VAP and ICU stay but with low certainty; the review again found no clear differences in mortality or duration of ventilation/ICU stay and noted sparse adverse-event reporting. [4]

Dedicated synthesis of toothbrushing vs. no toothbrushing similarly suggested no clear advantage on key outcomes when high-quality antiseptic care is already provided. [5]

Against this backdrop, we systematically summarize the original randomized/prospective trials to clarify where evidence converges: (1) whether CHX-based oral care reduces VAP across mixed ICU settings; (2) whether toothbrushing adds incremental benefit over antiseptic care; and (3) what signals exist for povidone-iodine or combination regimens.

Our goal is to provide a structured, PRISMA-aligned narrative synthesis to inform practice and the forthcoming Discussion benchmarking against contemporary systematic reviews and guidance. [1–5]

METHODS

Protocol and eligibility. We followed PRISMA principles for question framing, eligibility, and reporting. Eligible studies were randomized or prospective clinical trials enrolling adults receiving invasive mechanical ventilation (or at imminent risk in cardiac surgery), evaluating oral hygiene interventions (CHX rinse/gel/paste ± colistin; povidone-iodine; manual/electric toothbrushing) versus placebo/usual care or another active strategy, and

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 58 Issue: 09:2025
DOI: 10.5281/zenodo.17276558

reporting VAP incidence and/or patient-centred outcomes (mortality, duration of ventilation, ICU stay).

Outcomes. The primary outcome was VAP incidence, as defined in each trial (clinical diagnostic criteria and/or microbiologic confirmation).

Secondary outcomes included ICU/hospital mortality, duration of mechanical ventilation, and ICU length of stay. Where available, colonization endpoints were noted.

Data extraction. Two reviewers independently extracted study characteristics (setting, design), sample size, intervention details (agent, concentration, frequency; toothbrushing modality), comparator, diagnostic approach for VAP, and main results. Discrepancies were resolved by discussion.

Risk of bias and synthesis. We qualitatively considered randomization/blinding, outcome assessment (including potential diagnostic subjectivity for VAP), and selective reporting. Given heterogeneity in interventions (0.12% vs 2% CHX; paste vs rinse; addition of colistin; peri-operative regimens), comparators, and outcome definitions, we conducted a narrative synthesis without meta-analysis, grouping studies by intervention class (CHX-based; toothbrushing; other antiseptics).

Certainty considerations. We contextualized findings against high-level evidence (Cochrane 2016, 2020; other meta-analyses and reappraisals) in the Discussion to appraise external validity and consistency. [1–5]

RESULTS

Study Overview

Nine clinical studies met eligibility: seven randomized controlled trials and two prospective interventional studies across mixed/surgical ICUs and peri-operative cardiac surgery settings.

Interventions included CHX (0.12% rinse/gel; 2% paste), CHX+colistin paste, povidone-iodine oral care, and manual/electric toothbrushing adjuncts. Sample sizes ranged from 61 to 561 participants. [6–14] (Table 1; Table 2)

Chlorhexidine-Based Regimens

Koeman 2006 (Am J Respir Crit Care Med) randomized 385 long-term ventilated adults to CHX 2% paste, CHX 2% plus colistin 2% paste, or placebo, applied four times daily to the buccal mucosa. Both CHX arms reduced daily risk of VAP vs placebo (HR 0.35 for CHX alone; HR 0.45 for CHX+colistin), with broader suppression of oropharyngeal/endotracheal colonization in the combination arm; no differences were detected for duration of ventilation, ICU stay, or ICU survival. [6]

Houston 2002 (Am J Crit Care) studied 0.12% CHX mouthrinse (Peridex) vs phenolic rinse in 561 adult cardiac surgery patients.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 58 Issue: 09:2025
DOI: 10.5281/zenodo.17276558

Overall pneumonia was numerically lower with CHX, reaching statistical significance in the highest-risk subgroup (intubated >24 h with high colonization burden). [11]

Genuit 2001 (Surgical Infections) performed a staged quality-improvement study in surgical ICU patients: implementing a ventilator weaning protocol (WP) decreased ventilation duration; adding 0.12% CHX twice daily further reduced and delayed VAP (particularly late VAP) versus WP alone. [12]

Lin 2015 (J Hosp Infect) randomized 94 elective cardiac surgery patients to pre-operative 0.2% CHX mouthwash vs saline; CHX significantly lowered postoperative VAP (8.5% vs 23.4%). [14]

These studies suggest that CHX, across formulations (rinse/gel/paste), concentrations, and timing, reduces VAP incidence, with strongest and most consistent effects in cardiac surgery and targeted ICU protocols, and mixed effects on colonization endpoints.

Effects on ventilator days, ICU stay, and mortality were generally neutral. [6, 11, 12, 14] Munro 2009 (Am J Crit Care) used a 2×2 factorial RCT (n=547) testing toothbrushing thrice daily, 0.12% CHX twice daily, both, or usual care.

Among patients without pneumonia at baseline, CHX reduced early VAP by day 3; toothbrushing had no effect on CPIS-based VAP and did not enhance CHX efficacy. [7]

Pobo 2009 (Chest) randomized 147 ICU patients to standard CHX 0.12% oral care with or without electric toothbrushing every 8 h; microbiologically confirmed VAP rates were similar, with no differences in mortality, antibiotic-free days, ventilation duration, or ICU stay. [8]

Lorente 2012 (Eur J Clin Microbiol Infect Dis) randomized 436 ventilated adults to oral CHX with manual toothbrushing vs CHX without brushing; VAP incidence did not differ (9.7% vs 11.0%), nor did secondary outcomes. [9]

In these trials, toothbrushing did not improve outcomes when antiseptic oral care was already provided, aligning with meta-analytic findings that mechanical debridement alone is insufficient to influence VAP risk beyond antiseptic effects. [7–9]

Seguin 2014 (Crit Care Med) enrolled 179 severely brain-injured/hemorrhagic patients and randomized to oropharyngeal povidone-iodine vs placebo six times daily; no reduction in VAP was observed (31% vs 28%), and there was a concerning signal for acute respiratory distress syndrome in the povidone-iodine arm (p=0.06). [13]

Özcaka 2012 (J Periodont Res) randomized 61 dentate ICU patients to oral swabbing with 0.2% CHX vs saline four times daily; VAP incidence was significantly lower in the CHX group (41.4% vs 68.8%). [10]

Povidone-iodine did not demonstrate benefit in a high-risk neurocritical cohort, while CHX swabbing did reduce VAP in a small dentate cohort, reinforcing class differences among antiseptics. [10, 13]

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 58 Issue: 09:2025
DOI: 10.5281/zenodo.17276558

Table 1: Characteristics of included clinical studies (chronological)

Study (year)	Setting/Population (n)	Design	Intervention	Comparator	Primary VAP ascertainment	Key finding
Genuit 2001	Surgical ICU adults (95)	Prospective before-after	Add CHX 0.12% BID to weaning protocol	Weaning protocol alone	Clinical surveillance	Decrease overall and late VAP with CHX add-on; ventilation duration fell with weaning protocol. [12]
Houston 2002	Cardiac surgery (561)	RCT	0.12% CHX rinse	Phenolic rinse	CDC criteria	Decrease pneumonia in high-risk subgroup (>24 h intubated with heavy colonization). [11]
Koeman 2006	Mixed ICUs (385)	RCT, double-blind	CHX 2% paste or CHX 2%+colistin 2% QID	Placebo paste	Clinical diagnosis with adjudication	HR 0.35 (CHX) and 0.45 (CHX+COL) vs placebo for daily VAP risk; neutral on LOS/mortality. [6]
Munro 2009	Mixed ICUs (547)	RCT, 2×2 factorial	Toothbrushing TID; CHX 0.12% BID; both	Usual care	CPIS	CHX reduced early VAP in those pneumonia-free at baseline; brushing no benefit. [7]
Pobo 2009	Med-surg ICU (147)	RCT, simple-blind	Electric toothbrushing + CHX 0.12%	CHX 0.12% alone	Quantitative cultures	No VAP reduction; no differences in secondary outcomes. [8]
Lorente 2012	Med-surg ICU (436)	RCT	CHX 0.12% ± manual brushing	CHX 0.12% alone	Clinical + surveillance cultures	No difference in VAP (9.7% vs 11.0%). [9]
Özcaka 2012	Respiratory ICU dentate (61)	RCT, double-blind	0.2% CHX swabbing QID	Saline swabbing	Clinical + cultures	Decrease VAP (41.4% vs 68.8%); no mortality difference. [10]
Seguin 2014	Neurocritical (179)	Multicenter RCT, double-blind	Povidone-iodine Q6h	Placebo	Clinical	No VAP benefit; ARDS signal in intervention arm. [13]
Lin 2015	Cardiac surgery (94)	RCT, single-blind	Pre-op 0.2% CHX gargles	Saline gargles	Post-op VAP surveillance	Decrease VAP (8.5% vs 23.4%). [14]

Table 2: Outcome signals across studies

Intervention class	VAP incidence	Mortality	Ventilation duration	ICU LOS
CHX (rinse/gel/paste)	Consistent reduction vs placebo/usual care in several trials; strongest in cardiac surgery and with 2% paste regimens. [6,11,12,14]	No difference. [6,11,12,14]	Neutral. [6,12]	Neutral. [6,12]
Toothbrushing adjunct	No added benefit over CHX/no-CHX controls in RCTs. [7–9]	No difference. [7–9]	No difference. [7–9]	No difference. [7–9]
Povidone-iodine	No benefit in high-risk neuro cohort. [13]	No difference; potential safety concerns (ARDS signal). [13]	Not improved. [13]	Not improved. [13]

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 58 Issue: 09:2025
DOI: 10.5281/zenodo.17276558

DISCUSSION

This review of randomized/prospective clinical studies demonstrates that CHX-based oral care generally lowers VAP incidence in ventilated adults, while toothbrushing adjuncts, manual or electric, do not reliably add benefit when antiseptic care is already deployed. These findings align with high-quality syntheses. The 2016 Cochrane review (38 trials) found that CHX mouthrinse/gel reduces VAP from decrease24% to decrease18% (RR decrease0.75) with no clear impact on mortality, ventilation duration, or ICU stay; toothbrushing evidence was uncertain. [1] The 2020 update judged the CHX effect probable (moderate-certainty, RR decrease0.67) and suggested that toothbrushing may lower VAP and ICU stay but with low certainty, reflecting heterogeneity and risk of bias. [4] Conversely, an influential reappraisal emphasized population-specific effects: benefits appear strongest in cardiac surgery cohorts (short ventilation, different outcome definitions), whereas double-blind trials in general ICU patients did not demonstrate significant VAP reduction and raised concern about signal noise around mortality. [3] Our included portfolio mirrors this gradient: pre-operative and post-operative CHX trials in cardiac surgery consistently reduced postoperative VAP, while mixed ICU trials reported VAP reductions without downstream effects on LOS or mortality. [6, 11, 12, 14]

The lack of incremental value for toothbrushing in three RCTs is concordant with meta-analyses indicating that mechanical plaque removal alone is insufficient when high-quality antiseptic care is present. [5, 7–9] Regarding povidone-iodine, our included multicentre neurocritical trial showed no benefit and a concerning ARDS signal, consistent with systematic evidence indicating no clear advantage vs placebo or CHX and underscoring the need for safety vigilance. [6] (Context from broader evidence base)

Recent network meta-analysis suggests that oxidizing solutions may be promising and that saline rinse might even associate with lower ICU mortality relative to no mouthwash, while antimicrobial mouthwashes (including CHX) may carry potential risks, though certainty remains low and high-quality head-to-head trials are needed. [7] Contemporary guidance (ISID 2024) still supports structured oral care as part of multimodal VAP prevention bundles, particularly pertinent to resource-limited settings with higher baseline VAP rates, while emphasizing elevation of the head of bed, sedation minimization, subglottic secretion management, and device care. [8] Finally, the oral-respiratory link extends beyond ICU patients: community evidence connects poor denture hygiene with increased pneumonia risk, strengthening the biological plausibility that oral biofilm control influences lower-airway infection risk across contexts. [9]

Implications: For mixed ICU populations, CHX-based oral care appears to reduce VAP, but clinicians should recognize (1) limited effects on mortality/LOS; (2) lack of added value from toothbrushing when antiseptics are used; (3) uncertain benefit and potential downsides with povidone-iodine; and (4) the need to prioritize bundle elements with proven patient-centred benefits. Future research should prioritize blinded, adjudicated outcomes, patient-centred endpoints, safety surveillance, and pragmatic head-to-head comparisons across agents and concentrations.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 58 Issue: 09:2025
DOI: 10.5281/zenodo.17276558

CONCLUSION

Across heterogeneous ICU settings, chlorhexidine-based oral care reduces VAP incidence but has uncertain effects on mortality and lengths of stay; toothbrushing does not consistently add benefit when antiseptic care is provided; povidone-iodine shows no clear advantage and potential safety concerns in neurocritical patients. These findings align with contemporary systematic reviews and reappraisals and support incorporating structured oral hygiene within comprehensive VAP prevention bundles while focusing on patient-centred outcomes and safety. Further high-quality, blinded trials comparing oral agent's head-to-head are warranted to refine optimal regimens.

References

1) Hua F, Xie H, Worthington HV, Furness S, Zhang Q, Li C. Oral hygiene care for critically ill patients to prevent ventilator-associated pneumonia. Cochrane Database Syst Rev. 2016; (10):CD008367. doi: 10.1002/14651858.CD008367.pub3.

2) Labeau SO, Van de Vyver K, Brusselaers N, Vogelaers D, Blot SI. Prevention of ventilator-associated pneumonia with oral antiseptics: a systematic review and meta-analysis. Lancet Infect Dis. 2011; 11 (11):845–854.

3) Klompas M, Speck K, Howell MD, Greene LR, Berenholtz SM. Reappraisal of routine oral care with chlorhexidine gluconate for patients receiving mechanical ventilation: systematic review and meta-analysis. JAMA Intern Med. 2014; 174 (5):751–761.

4) Zhao T, Wu X, Zhang Q, Li C, Worthington HV, Hua F. Oral hygiene care for critically ill patients to prevent ventilator-associated pneumonia. Cochrane Database Syst Rev. 2020; (12):CD008367. doi: 10.1002/14651858.CD008367.pub4.

5) Gu WJ, Gong YZ, Pan L, Ni YX, Liu JC. Impact of oral care with versus without toothbrushing on prevention of ventilator-associated pneumonia: systematic review and meta-analysis of RCTs. Crit Care. 2012; 16(5): R190.

6) Koeman M, van der Ven AJAM, Hak E, et al. Oral decontamination with chlorhexidine reduces the incidence of ventilator-associated pneumonia. Am J Respir Crit Care Med. 2006; 173(12):1348–1355.

7) Munro CL, Grap MJ, Jones DJ, McClish DK, Sessler CN. Chlorhexidine, toothbrushing, and preventing ventilator-associated pneumonia in critically ill adults. Am J Crit Care. 2009; 18(5):428–438.

8) Pobo A, Lisboa T, Rodriguez A, et al. A randomized trial of dental brushing for preventing ventilator-associated pneumonia. Chest. 2009; 136(2):433–439.

9) Lorente L, Lecuona M, Jiménez A, et al. Ventilator-associated pneumonia with or without toothbrushing: a randomized controlled trial. Eur J Clin Microbiol Infect Dis. 2012; 31(10):2621–2629.

10) Özcaka Ö, Başoğlu ÖK, Buduneli N, Taşbakan MS, Bacakoglu F, Kinane DF. Chlorhexidine decreases the risk of ventilator-associated pneumonia in ICU patients: a randomized clinical trial. J Periodont Res. 2012; 47(5)? (Early online). doi:10.1111/j.1600-0765.2012.01470. x.

11) Houston S, Hougland P, Anderson JJ, LaRocco M, Kennedy V, Gentry LO. Effectiveness of 0.12% chlorhexidine gluconate oral rinse in reducing nosocomial pneumonia in patients undergoing heart surgery. Am J Crit Care. 2002; 11(6):567–570.

12) Genuit T, Bochicchio G, Napolitano LM, McCarter RJ, Roghmann MC. Prophylactic chlorhexidine oral rinse decreases ventilator-associated pneumonia in surgical ICU patients. Surg Infect (Larchmt). 2001; 2(1): (Early online).

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 58 Issue: 09:2025
DOI: 10.5281/zenodo.17276558

13) Seguin P, Laviolle B, Dahyot-Fizelier C, et al. Effect of oropharyngeal povidone-iodine preventive oral care on ventilator-associated pneumonia in severe brain injury/cerebral hemorrhage: multicenter RCT. Crit Care Med. 2014;42(1):1–8.

14) Lin Y, Xu L, Huang X, et al. Reduced occurrence of ventilator-associated pneumonia after cardiac surgery using preoperative 0.2% chlorhexidine oral rinse: single-centre randomized trial. J Hosp Infect. 2015? (Accepted manuscript).

15) Emami Zeydi A, Parvizi A, Haddadi S, et al. Effect of oral care with povidone-iodine in prevention of VAP: a systematic review and meta-analysis. Arch Acad Emerg Med. 2023; 11(1): e31.

16) He Q, Peng Z, He C, Zhang C, Hu R. Effect of different mouthwashes on ventilator-related outcomes and mortality in ICU patients: a network meta-analysis. Aust Crit Care. 2025; 38:101095.

17) Rosenthal VD, Memish ZA, Bearman G, et al. Recommendations for the Prevention of Ventilator-Associated Pneumonia. In: ISID Guide to Infection Control in the Healthcare Setting. June 2024.

18) Kusama T, Aida J, Yamamoto T, Kondo K, Osaka K. Infrequent denture cleaning increased risk of pneumonia among community-dwelling older adults: population-based cross-sectional study. Sci Rep. 2019; 9:13734.