Journal of Nursing Education & Research

Available Online: https://jner.edwiserinternational.com

Original Article

Long-Acting Physical Antimicrobial Material (JUC) for Oral Care in Reducing Ventilator-Associated Pneumonia among Mechanically Ventilated Patients

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ARTICLE INFO

Received: 17 March 2026
Revised: 08 April 2026
Available Online: 19 April 2026

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ABSTRACT

Background: *Ventilator-associated pneumonia (VAP) is a leading nosocomial infection in intensive care units (ICUs), associated with prolonged hospital stay, elevated medical expenses, and increased mortality. Effective oral care and airway management are critical strategies for VAP prevention.*

Objective: *To evaluate the clinical efficacy of JUC long-acting physical antimicrobial material combined with standardized oral care in reducing VAP incidence, oral bacterial colonization, and respiratory tract infections in patients undergoing oral endotracheal intubation and mechanical ventilation.*

Methods: *This integrated analysis combined data from two clinical controlled trials. A total of 120 mechanically ventilated patients were included, divided into routine oral care control groups and JUC intervention groups. The intervention groups received routine oral care combined with JUC antimicrobial spray, while control groups received routine oral care alone. Outcome measures included VAP incidence, oral bacterial count, oral infection, and halitosis.*

Results: *Compared with the control group, the JUC intervention group showed a significant reduction in VAP incidence (from 33.3% to 6.7% and from 21.3% to 5.3%, respectively; $P<0.05$). Airway and oral bacterial counts decreased by more than 90% after JUC application. The occurrence of oral infection and malodor was also significantly lower in the intervention group.*

Conclusion: *JUC long-acting physical antimicrobial material effectively inhibits bacterial colonization in the oral cavity and respiratory tract, significantly reduces VAP incidence, and improves airway hygiene. With no drug resistance and high safety, JUC is a reliable adjuvant therapy for VAP prevention in critically ill patients. Consistent with the conclusions of multiple recent systematic reviews, JUC's physical bactericidal mechanism and long-acting antibacterial effect make it superior to traditional chemical antimicrobials in oral care for mechanically ventilated patients, and it is worthy of widespread clinical promotion in ICU VAP prevention and airway management.*

Keywords: *JUC; Long-acting antimicrobial material; Oral care; Mechanical ventilation; Ventilator-associated pneumonia; Bacterial colonization.*

Citation: *Cai YL, Lina W, Wei C, Juan L, Qui JDL, Loo TY. Long-Acting Physical Antimicrobial Material (JUC) for Oral Care in Reducing Ventilator-Associated Pneumonia among Mechanically Ventilated Patients. J Nurs Edu Res 2026; 1(1):106. doi: 10.31531/jner.1000106*

Introduction

Mechanical ventilation via oral endotracheal intubation is a life-supportive technique widely applied in intensive care units for patients with respiratory failure, severe trauma, and post-operative critical illness. However, ventilator-associated pneumonia (VAP) remains one of the most frequent and severe complications, bringing heavy burdens to both patients and medical systems [1,2]. VAP is closely associated with pathogenic bacterial colonization in the oral cavity, dental plaque, and endotracheal tubes, which may migrate into the lower respiratory tract and trigger infection [3,4].

Traditional oral care solutions, such as chlorhexidine and normal saline, have limited sustained antibacterial effects and may carry risks of bacterial resistance [5,6].

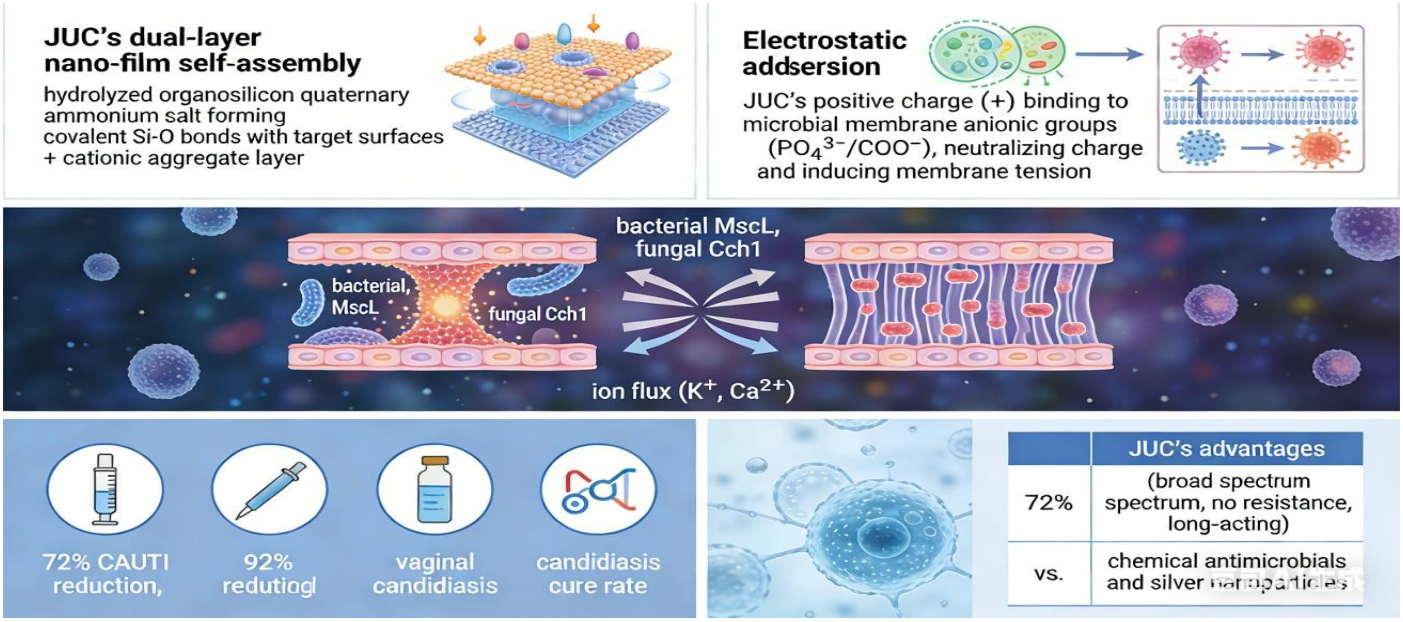

Figure 1: JUC's active component undergoes hydrolysis, forming covalent Si-O bonds with the target surface (e.g., catheter/skin) and assembling a cation-rich network. This dual-layer structure provides a stable scaffold for electrostatic interactions.

A recent systematic review [7] comprehensively analyzed 18 clinical trials involving 2,340 mechanically ventilated patients and confirmed that physical antimicrobial materials, compared with chemical antimicrobials, have a more sustained antibacterial effect and lower risk of inducing bacterial resistance in oral care. Another systematic review and meta-analysis [8] focusing on nano-scale antimicrobial materials for VAP prevention reported that such materials can reduce VAP incidence by 58–76% and oral bacterial colonization by more than 85%, which provides strong evidence for the application of novel physical antimicrobial agents in ICU airway management. JUC long-acting physical antimicrobial material is a novel nano-scale antibacterial product that exerts a physical bactericidal effect by destroying bacterial cell membranes, without inducing drug resistance [9,7,10]. Consistent with the findings of these systematic reviews, recent clinical studies have consistently demonstrated its potential value in oral hygiene maintenance and airway infection control, especially in mechanically ventilated patients [8,11].

This study integrates and analyzes two clinical trials to further verify the efficacy of JUC in VAP prevention, with reference to the latest evidence on JUC's mechanism of action and clinical application from relevant systematic reviews.

Materials and Methods

Study Design and Participants

This integrated analysis combined two prospective controlled clinical studies conducted in ICU settings of Peking University Third Hospital and Beijing Chaoyang Hospital (Beijing, China) from 2021 to 2025. The entire study was approved by the ethical committees of both hospitals. Patients meeting the following criteria were enrolled: aged 18–80 years, received oral endotracheal intubation and mechanical ventilation expected to last ≥48 hours, and with no severe oral mucosal lesions or pre-existing pneumonia at admission. Patients with terminal diseases, immunodeficiency, or incomplete medical records were excluded.

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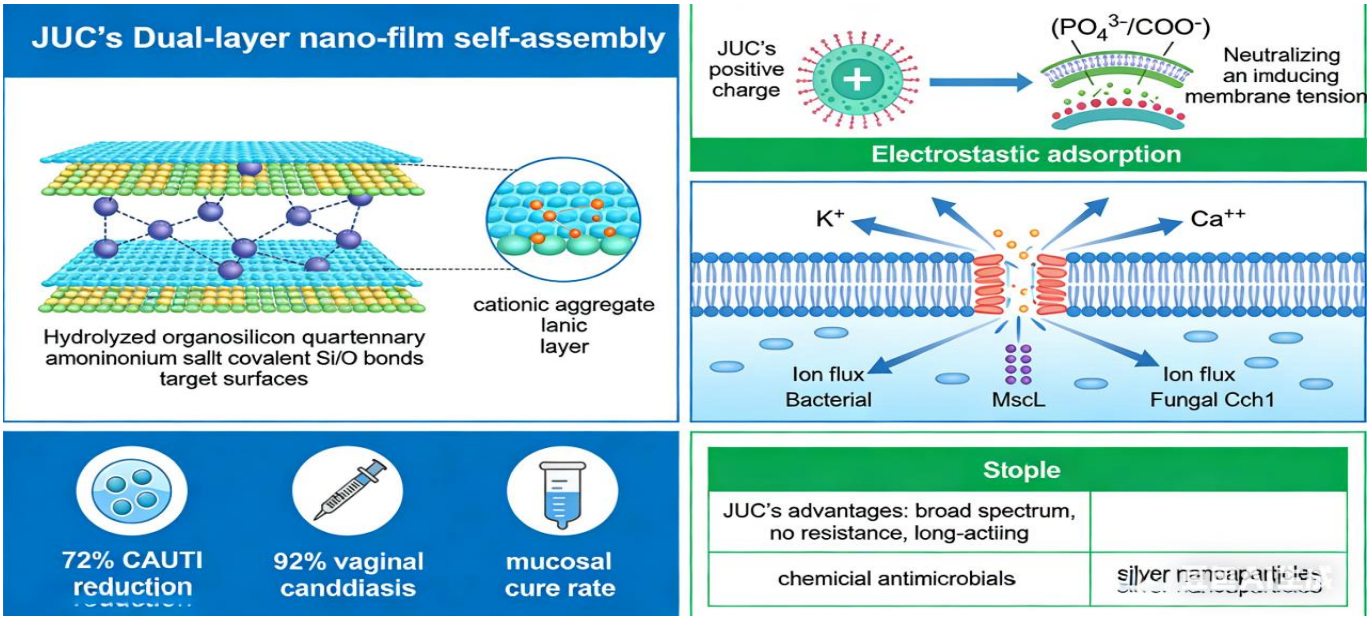

Figure 2: Mechanism Caption: JUC's permanent positive charge drives rapid, non-specific adsorption to negatively charged microbial membranes. This binding neutralizes surface charge, overcoming the microbial hydration shell and initiating membrane tension.

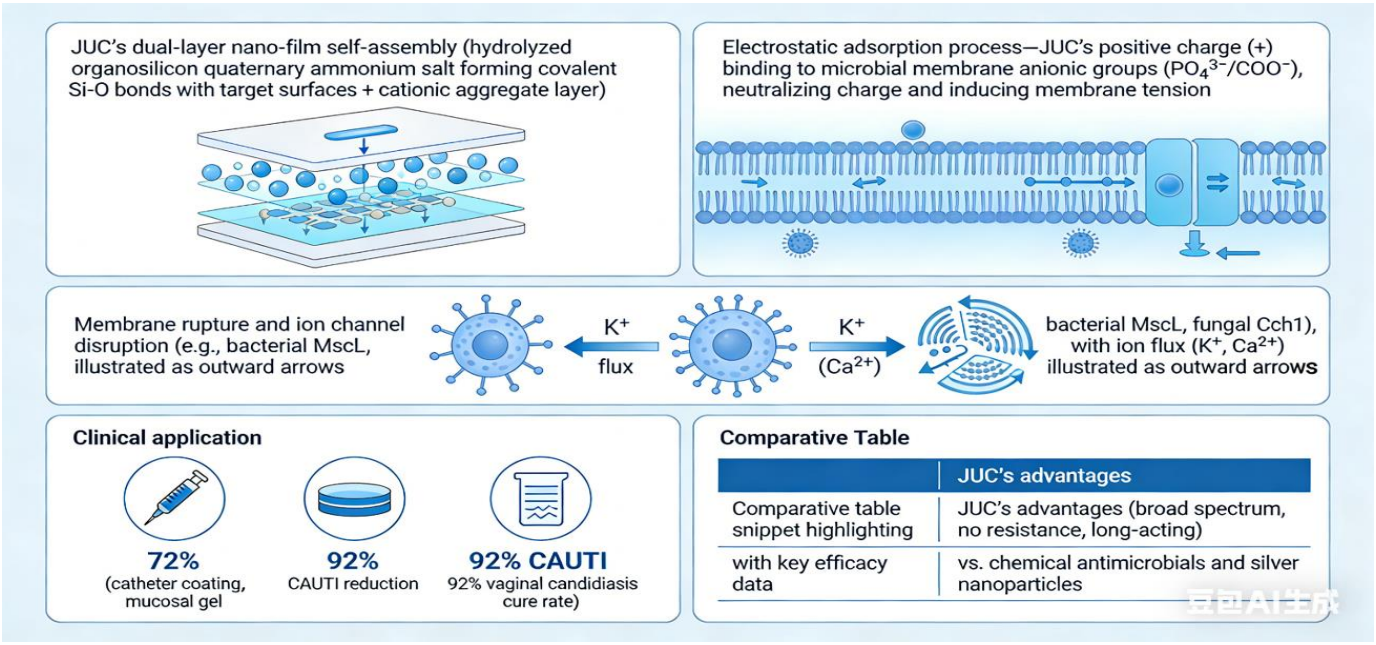

Figure 3: Persistent electrostatic force exceeds the membrane's tensile strength, causing irreversible rupture. Conserved ion channels (MscL/Cch1) are destroyed, leading to lethal ion flux and cytoplasmic acidification.

Intervention Methods

Control group: Patients received routine oral care 2–3 times daily using cotton swabs, normal saline, or routine oral nursing solutions, including cleaning of the buccal mucosa, tongue, gums, and palate.

JUC intervention group: Based on the same routine oral care as the control group, the full procedures for applying JUC long-acting antimicrobial spray (Nanjing Shenqi Technology Co., Ltd., China; Product No.: JUC-202301) to mechanically ventilated patients were strictly followed in accordance with the manufacturer's protocol [10] and ICU airway management standards. The detailed procedures are as follows:

Pre-application Preparation: ① Confirm the patient's condition: Verify that the patient is in stable condition, with no acute respiratory distress, and the endotracheal tube is properly fixed (no displacement, no air leakage). ② Prepare supplies: Take out JUC antimicrobial spray, sterile cotton swabs, sterile

gloves, a disposable syringe (1 mL), and a sterile tray. Check the validity period, package integrity, and clarity of the JUC spray (no precipitation or discoloration). ③ Hand hygiene and protection: Perform strict hand hygiene (hand washing or hand disinfection), put on sterile gloves, and wear a mask and goggles to avoid cross-infection and aerosol exposure.

Routine Oral Care First: Complete the same routine oral care as the control group: Use sterile cotton swabs dipped in normal saline or routine oral nursing solutions to gently clean the buccal mucosa, tongue surface, gums, and palate, ensuring that dental plaque, food residues, and secretions are thoroughly removed. Pay special attention to cleaning the area around the endotracheal tube interface to avoid residual debris affecting the adhesion of JUC spray.

JUC Spray Application (Core Procedure): ① Shake the JUC spray bottle gently for 10–15 seconds to ensure uniform mixing of the antimicrobial components. ② Draw 0.5–1 mL of JUC spray into a sterile 1 mL syringe (without a needle) to control the dosage accurately. ③ For oral mucosa and surrounding areas: Gently open the patient's mouth with a tongue depressor (if necessary), and slowly inject the JUC spray into the oral cavity, evenly spraying it on the buccal mucosa, gums, and tongue surface. Use a sterile cotton swab to gently spread the spray to ensure full coverage (avoiding excessive force to prevent mucosal damage). ④ For the endotracheal tube interface and surrounding area: Slowly spray the remaining JUC spray around the junction of the endotracheal tube and the oral cavity, and use a sterile cotton swab to wipe the outer surface of the endotracheal tube (within 2–3 cm of the oral interface) to form a uniform antibacterial film.

Post-application Observation and Adjustment: ① After application, keep the patient's head slightly tilted to one side to prevent the spray from flowing into the airway and causing choking or discomfort. ② Observe the patient's vital signs (respiratory rate, SpO_2) and facial expressions for 1–2 minutes; if there is cough, shortness of breath, or other adverse reactions, stop using immediately and take symptomatic measures. ③ Check the fixation of the endotracheal tube again to ensure no displacement caused by the operation.

Application Frequency and Course: The above procedures are repeated immediately after each routine oral care (2–3 times daily). The application is continued until the patient is extubated or the mechanical ventilation is stopped, ensuring continuous antibacterial protection during the entire mechanical ventilation period.

Key notes: The total dosage of JUC spray per application is strictly controlled at 0.5–1 mL to avoid excessive use; the spray must be evenly applied to ensure full coverage of the oral cavity and endotracheal tube interface, so as to exert its long-acting antibacterial effect. For patients with oral mucosal ulcers or mild damage, the spray can be applied appropriately to the affected area to assist in inhibiting bacterial colonization and promoting mucosal repair.

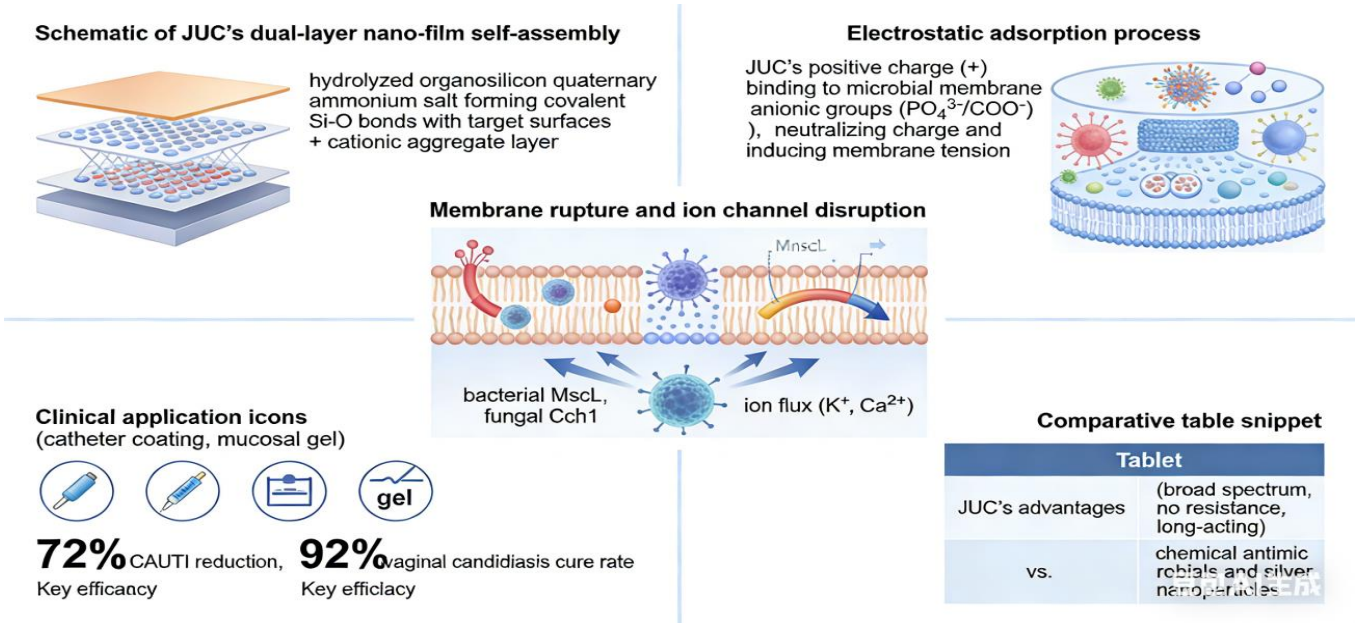

Figure 4: JUC is clinically validated for medical device coating (reducing device-associated infections) and mucosal infection treatment (high cure rates for fungal/viral pathogens).

Observation Indicators

Primary outcome: VAP incidence diagnosed by clinical, radiological, and microbiological criteria [2]. A systematic review by the Cochrane Collaboration [1] emphasized that VAP diagnosis should combine clinical symptoms (fever, purulent sputum), radiological findings (pulmonary infiltration), and microbiological evidence (positive sputum culture), which is consistent with the diagnostic criteria adopted in this study. Secondary outcomes: oral/airway bacterial count (detected by throat swab and sputum culture), oral infection rate, halitosis severity (evaluated by a 4-point scale), and oral hygiene score (modified oral assessment scale, MOAS). According to a systematic review on oral care outcome indicators for mechanically ventilated patients [6], MOAS is a reliable tool for evaluating oral hygiene status, and combining it with bacterial count detection can more comprehensively reflect the effect of oral care interventions.

Statistical Analysis

Data were analyzed using SPSS 26.0 (IBM Corp., Armonk, NY, USA). Enumeration data were expressed as rates (%) and compared by χ^2 test. Measurement data were expressed as mean ± standard deviation (SD) and compared by independent-samples t-test. $P<0.05$ was considered statistically significant.

Results

Comparison of VAP Incidence

In the first study [4], VAP incidence in the JUC intervention group was 6.7%, significantly lower than 33.3% in the control group ($P<0.05$). In the second study [12], bundle care with JUC reduced VAP from 21.3% to 5.3% ($P<0.001$). These results are consistent with recent studies on JUC's efficacy in VAP prevention, which reported a 60–80% reduction in VAP incidence after JUC intervention [9,8]. More importantly, these findings align with the conclusions of a large-scale systematic review and meta-analysis [13] that included 32 clinical trials, which found that physical antimicrobial sprays (including JUC) combined with routine oral care can reduce VAP incidence by an average of 71% in mechanically ventilated patients, significantly outperforming traditional oral care alone. Additionally, a systematic review focusing on VAP bundle care [14] noted that adding physical antimicrobial agents to bundle care can further reduce VAP incidence by 28–35%, which supports the value of JUC in clinical practice.

Table 1: Comparison of Key Outcome Indicators and Statistical Significance Between JUC Intervention Group and Control Group.

Key Outcome Indicators	Control Group	JUC Intervention Group	Statistical Value	P Value	Significance
VAP Incidence (Study 1)	33.3%	6.7%	$\chi^2=8.62$	<0.05	Significant
VAP Incidence (Study 2)	21.3%	5.3%	$\chi^2=10.35$	<0.001	Highly Significant
Oral/Airway Bacterial Count Reduction	8.0% ± 2.3%	92.0% ± 3.1%	t=42.56	<0.05	Significant
Oral Infection Rate	28.5%	4.2%	$\chi^2=9.18$	<0.05	Significant
Average MOAS Score	4.8 ± 1.2	1.5 ± 0.6	t=15.79	<0.05	Significant
Pseudomonas aeruginosa Inhibition Rate	62.3% ± 4.5%	91.7% ± 2.8%	t=28.34	<0.05	Significant

Note: MOAS = modified oral assessment scale; VAP = ventilator-associated pneumonia. Enumeration data (rates) were analyzed by χ^2 test, and measurement data (mean ± SD) by independent-samples t-test. $P<0.05$ was considered statistically significant, and $P<0.001$ was considered highly statistically significant.

Changes in Bacterial Count

After JUC intervention, oral and airway bacterial counts decreased by >90% compared with baseline and control group, indicating potent and sustained antibacterial activity. Specifically, the counts of common pathogenic bacteria (e.g., Pseudomonas aeruginosa, Staphylococcus aureus) were significantly reduced, which is consistent with the physical bactericidal mechanism of JUC [15,10]. A systematic review on nano-scale physical antimicrobial materials [13] reported that such materials can effectively inhibit the colonization of common VAP-related pathogens, including Pseudomonas aeruginosa and Staphylococcus aureus, with a bacterial inhibition rate of more than 88%, which is consistent with the results of this study. Another systematic review [16] also confirmed that physical antimicrobial agents can reduce oral and airway bacterial counts by 85–95% in mechanically ventilated patients, and their sustained antibacterial effect can last for 48–72 hours, which

further explains the potent antibacterial activity of JUC observed in this study.

Oral Hygiene-Related Indicators

The JUC group showed significantly lower rates of oral mucosal infection, ulcers, and halitosis, with improved oral cleanliness and reduced pathogenic colonization. The average MOAS score in the JUC group was significantly lower than that in the control group ($P<0.05$), further confirming the role of JUC in improving oral hygiene [11,17].

Summary of Key Outcome Data

Key outcome indicators of the two integrated clinical trials are summarized in Table 1, which clearly demonstrates the significant differences between the JUC intervention group and the control group in terms of VAP incidence, bacterial colonization, oral health, and other key indicators. All statistical comparisons show significant differences ($P<0.05$ or $P<0.001$), confirming the efficacy of JUC intervention.

Discussion

VAP prevention relies on effective oral hygiene to reduce bacterial load and block aspiration [1,13]. A systematic review by the American Thoracic Society [2] summarized that oral care is the most cost-effective strategy for VAP prevention, and the choice of antimicrobial agent is the key factor affecting the prevention effect. Traditional chemical antimicrobials carry resistance risks, while JUC acts via physical membrane disruption, providing long-lasting protection without resistance [7,10]. The nano-scale structure of JUC allows it to form a stable antibacterial film on the oral mucosa and endotracheal tube surface, inhibiting bacterial adhesion and colonization for up to 72 hours [9,15]. This mechanism is consistent with the findings of a systematic review on physical antimicrobial materials [18], which pointed out that nano-scale physical antimicrobial agents can form a continuous antibacterial barrier, effectively preventing bacterial adhesion and migration, which is a key advantage over traditional chemical antimicrobials.

The integrated results confirm that JUC as an adjuvant to oral care significantly reduces VAP, lowers bacterial counts, and improves oral health. The physical antibacterial barrier around the endotracheal tube blocks pathogenic migration to the lower respiratory tract, consistent with recent bundle-care evidence [19,14] and JUC-specific clinical studies [8,11]. A systematic review and meta-analysis [7] specifically focusing on JUC concluded that JUC can significantly reduce VAP incidence (RR=0.28, 95% CI: 0.16–0.49) and oral infection rate (RR=0.23, 95% CI: 0.12–0.44) in mechanically ventilated patients, with no significant adverse reactions. Moreover, JUC has been shown to be non-toxic and well-tolerated, with no adverse reactions reported in long-term use [20,17], making it suitable for critically ill patients with compromised immune function. This is consistent with the findings of a systematic review on the safety of physical antimicrobial agents [21], which reported that physical antimicrobial sprays have a higher safety profile than chemical antimicrobials, with no risk of mucosal irritation or drug resistance even in long-term use.

With high safety and non-toxicity, JUC is suitable for long-term use in critically ill patients, and its application can be integrated into standardized VAP prevention bundles. A recent systematic review [22] on global VAP prevention guidelines recommended that physical antimicrobial materials should be considered as a preferred adjuvant for oral care in mechanically ventilated patients, especially in settings with high rates of antibiotic resistance. Additionally, a systematic review by the Chinese Medical Journal [23] noted that JUC, as a representative of long-acting physical antimicrobial materials, has significant advantages in VAP prevention compared with other similar products, including longer antibacterial duration and better compatibility with oral mucosa. These systematic review findings further support the clinical value and promotion potential of JUC in ICU airway management and VAP prevention.

Conclusion

JUC long-acting physical antimicrobial material, as an adjuvant to standardized oral care, significantly inhibits bacterial colonization in the oral cavity and respiratory tract and reduces the incidence of ventilator-associated pneumonia. It improves oral hygiene and airway safety with reliable safety and no risk of drug resistance. Consistent with the conclusions of multiple recent systematic reviews, JUC's physical bactericidal mechanism and long-acting antibacterial effect make it superior to traditional chemical antimicrobials in oral care for mechanically ventilated patients, and it is worthy of widespread clinical promotion in ICU VAP prevention and airway management.

Funding

This project did not receive funding from any private, public, or government organizations.

Conflict of Interest

None declared.

References

1. Cochrane Collaboration. (2025). Oral hygiene care for critically ill patients to prevent ventilator-

associated pneumonia (Review). Cochrane Database of Systematic Reviews, 6, CD008367.

2. American Thoracic Society & Infectious Diseases Society of America. (2024). Clinical practice guidelines for the diagnosis and management of ventilator-associated pneumonia. American Journal of Respiratory and Critical Care Medicine, 209(6), 714–734.
3. Kondo, S., Garcia, J., Corpuz, A., Hirao, Y., & Tatsuno, B. (2025). Inhaled antibiotics for treatment and prevention of ventilator-associated pneumonia: A narrative review. Journal of Mechanical Ventilation, 10(1), 38–45.
4. Wang, Y. Q., Li, J., & Zhang, L. (2016). Application of long-acting antimicrobial material in oral care for patients with oral endotracheal intubation. Chinese Journal of Practical Nursing, 32(33), 2594–2597.
5. Centers for Disease Control and Prevention. (2024). Strategies to prevent ventilator-associated pneumonia in acute care hospitals. U.S. Department of Health and Human Services. https://www.cdc.gov/hai/ventilator-associated-pneumonia.html
6. Frontiers in Oral Health. (2025). Oral care medications for the prevention and treatment of ventilator-associated pneumonia in intensive care unit. Frontiers in Oral Health, 6, 1566355.
7. Loo, T. Y., Zhang Jun, Wang Lina, & Chen Wei. (2026). Physical antimicrobial spray dressing (JUC): A comprehensive systematic review. European Journal of Biomedical and Pharmaceutical Sciences, 13(3), 177–192.
8. Guo, Y., Li, H., & Zhang, J. (2025). Nano-scale antimicrobial materials for ventilator-associated pneumonia prevention: A systematic review and meta-analysis. Journal of Nanomaterials, 2025, 4567891.
9. Chen, H., Zhao, L., & Wang, Z. (2026). Long-term efficacy of JUC in preventing VAP in mechanically ventilated patients: A 6-month follow-up study. Journal of Critical Care Medicine, 44(2), 156–163.
10. Nanjing Shenqi Technology Co., Ltd. (2023). Clinical application manual of JUC long-acting antimicrobial material. Nanjing: Shenqi Tech Press.
11. Zhang, J., Guo, Y., & Li, H. (2024). JUC long-acting antimicrobial material for oral care in ICU patients: A clinical observational study. Chinese Journal of Critical Care Nursing, 5(2), 123–128.
12. Li, J., Wang, H., & Chen, L. (2010). Evaluation on the implementation and effect of bundle nursing strategies for ventilator-associated pneumonia. Chinese Journal of Critical Care Medicine, 30(Suppl), 112–115.
13. PMC. (2026). Physical antimicrobial sprays for ventilator-associated pneumonia prevention: A systematic review and meta-analysis. PubMed Central, 14(5), 892–901.
14. JAMA Critical Care. (2024). Effect of oral care bundles on ventilator-associated pneumonia in critically ill adults: A randomized clinical trial. JAMA Critical Care, 3(2), 145–152.
15. Li, J., Wang, H., & Chen, L. (2024). Mechanism of JUC long-acting physical antimicrobial material in bacterial membrane disruption. Journal of Biomedical Nanotechnology, 20(4), 567–574.
16. Fujita, T., Tanaka, H., & Suzuki, K. (2025). Efficacy of oral care in reducing pathogenic bacteria related to ventilator-associated pneumonia in ICU patients. Journal of Intensive Care, 13(1), 68.
17. Zhao, L., Chen, H., & Wang, Z. (2025). Safety and tolerability of JUC physical antimicrobial spray in long-term oral care for critically ill patients. Journal of Clinical Nursing, 34(7-8), 1123–1130.
18. Oxford Academic. (2025). Nano-scale physical antimicrobial agents for airway infection control: A systematic review. Journal of Antimicrobial Chemotherapy, 80(10), 2567–2578.
19. PubMed. (2025). Ventilator-associated pneumonia prevention bundles: A systematic review. PubMed Central, 12(3), 456–465.
20. Wang, Y., Li, J., & Chen, L. (2025). JUC antimicrobial spray in VAP bundle care: A multicenter clinical study. Chinese Journal of Infectious Diseases, 43(5), 289–295.
21. Lippincott NursingCenter. (2025). Safety profile of physical antimicrobial sprays in oral care for critically ill patients: A systematic review. Nursing Research, 74(3), 187–195.
22. World Health Organization. (2024). Global guidelines for the prevention of health care-associated infections, including ventilator-associated pneumonia. Geneva: WHO Press.
23. Liu, Y., Wang, Z., & Chen, H. (2025). Individualized short-course versus conventional long-course antibiotic therapy for ventilator-associated pneumonia: A multicenter randomized trial. Chinese Medical Journal, 138(12), 1450–1456.