Volume 4, Issue 3, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

EFFECTIVENESS OF CLOSED VERSUS OPEN SUCTIONING IN REDUCING VAP AMONG ADULT PATIENTS WITH TRACHEOSTOMY IN ICU

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DOI: https://doi.org/10.5281/zenodo.18978752

Keywords
Closed suctioning, Open suctioning, Ventilator-associated pneumonia, Tracheostomy, Intensive care unit.

Article History
Received: 13 January 2026
Accepted: 25 February 2026
Published: 12 March 2026

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Abstract

Background: *Ventilator-associated pneumonia (VAP) is one of the most frequent and serious infections affecting mechanically ventilated patients in intensive care units (ICUs). Tracheal suctioning is an essential nursing procedure to maintain airway patency and prevent secretion obstruction, yet its technique—whether open or closed—has significant implications for infection risk. Open suctioning involves temporary disconnection of the ventilator, increasing the chance of contamination, while closed suctioning maintains a sterile, in-line circuit that may reduce exposure to pathogens. Although international evidence highlights the benefits of closed suction systems in minimizing infection rates, their effectiveness remains underexplored in local ICU settings.*

Objective: *This study aimed to compare the effectiveness of closed versus open suctioning systems in reducing ventilator-associated pneumonia (VAP) among adult tracheostomy patients admitted to intensive care units.*

Methodology: *A quantitative, quasi-experimental comparative design was conducted at a public tertiary care hospital ICU in Islamabad. Twenty adult tracheostomy patients were purposively selected, with ten managed via closed suctioning and ten with open suctioning. Data were collected using the Clinical Pulmonary Infection Score (CPIS) checklist adapted from Qureshi et al. (2025).*

Results*: Patients managed with the closed suction system demonstrated a lower mean CPIS score (5.1 ± 1.3) and reduced VAP incidence (30%) compared to those with the open suction system (mean = 5.8 ± 1.4; VAP = 37%). Weekly trend analysis showed that VAP cases in the closed suction group occurred intermittently, while the open suction group exhibited continuous infections across several weeks. These results suggest that closed suctioning minimizes exposure to pathogens, maintains circuit integrity, and promotes better oxygenation stability.*

Conclusion*: In conclusion, closed suctioning is more effective than open*

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

suctioning in reducing ventilator-associated pneumonia and improving respiratory stability among adult tracheostomy patients.

INTRODUCTION

Mechanical ventilation is a fundamental intervention in critical care, offering vital respiratory support to patients who are unable to breathe effectively on their own (Ahmed et al., 2023). Moreover, it allows for precise control of ventilation parameters, which is essential for stabilizing critically ill patients and promoting recovery (Liang, 2020). In conjunction with mechanical ventilation, tracheal suctioning is routinely performed to remove secretions from the airway and maintain alveolar ventilation (Peter, 2007). Importantly, suctioning supports airway clearance, reduces the risk of airway obstruction, and enhances oxygenation (Ardehali, 2020). Among the available techniques, closed suctioning has been found to offer several clinical advantages, including enhanced cardiopulmonary stability, reduced suctioning time, and decreased alveolar collapse (Rabitsch et al., 2004).

Despite its clinical importance, open suctioning requires disconnection of the ventilator circuit, which exposes the patient's airway to environmental pathogens and increases the likelihood of infection (Tariq et al., 2024).

During clinical rotations, significant variation in tracheostomy suctioning practices was observed, with both open and closed suctioning methods being utilized. However, uncertainty persists regarding which system is more effective in preventing ventilator-associated pneumonia (VAP), resulting in inconsistent clinical practices. These observations underscore the need for comparative research to assess the effectiveness of open versus closed suction systems in reducing VAP among mechanically ventilated patients in the ICU.

The purpose of this study was to compare the effectiveness of closed and open suctioning methods in preventing ventilator-associated pneumonia (VAP) among mechanically ventilated tracheostomy patients. The central research question asked whether closed suctioning reduces the incidence of VAP more effectively than open suctioning among adult ICU patients with tracheostomy tubes.

To guide this inquiry, the study utilized Florence Nightingale's Environmental Theory (1860), which emphasizes that maintaining cleanliness, ventilation, and infection control is vital for patient recovery. The theory highlights that a healthy environment minimizes the spread of microorganisms and supports healing. In this context, the closed suctioning system upholds Nightingale's principles by maintaining circuit sterility and reducing contamination risk. Furthermore, the study adhered to the Iowa Model of Evidence-Based Practice, which prioritizes identifying clinical issues—such as VAP—and implementing practice changes based on the best available evidence.

The significance of this study lies in generating knowledge to help adopt evidence-based nursing practices, reduce infection rates, shorten hospital stays, and enhance patient safety in critical care settings.

1. LITERATURE REVIEW

A comprehensive review of existing literature was conducted using databases such as PubMed, Science Direct, and Google Scholar to examine the relationship between suctioning techniques and VAP incidence. The search combined keywords including "open suctioning," "closed suctioning," and "ventilator-associated pneumonia" to capture relevant studies. A systematic review of 9 randomized controlled trials (RCTs) by Dönmez and Yava (2015) in Turkey examined the impact of open versus closed suctioning systems. The review found that 20% of patients in the open suction group and 19% in the closed suction group developed VAP, with a pooled relative risk indicating no significant difference between the methods.

Similarly, a comparative study by Paymard et al. (2020) in Iran showed that 20% of patients in the open suctioning group developed VAP compared to 16.7% in the closed group, a difference that was not statistically significant but suggested a slight advantage for closed suctioning.

Conversely, other studies have highlighted distinct benefits of closed systems. A meta-analysis by Sanaie et al. (2022) in Iran showed that open suctioning was associated with a 57% higher incidence of VAP compared to the

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

closed system (OR = 1.57; p = 0.02). Additionally, Ardehali et al. (2020) found a modest reduction in VAP with closed suctioning alongside benefits of reduced nursing workload. In terms of physiological stability, a systematic review by Liang et al. (2020) and a multicentre trial by Alghamdi et al. (2025) found that while VAP incidence might not always differ significantly, closed suction systems consistently improved oxygenation stability and reduced oxygen desaturation episodes by approximately 15–20%.

In the local context, a quasi-experimental study by Qureshi et al. (2025) in Pakistan observed a lower VAP rate of 30.2% in the closed-suction group compared to 37.2% in the open-suction group, suggesting better infection control. Furthermore, Rafiq et al. (2022) assessed ICU nurses' knowledge in Pakistan and found that while nurses had generally positive perceptions of closed suctioning, there were inconsistencies in practice requiring continuous education. Despite this evidence, most studies demonstrate an absence of standardized diagnostic criteria for VAP, and there is a scarcity of high-quality evidence from resource-limited settings where cost-effectiveness and equipment availability significantly influence the choice between closed and open tracheal suction systems.

2. METHODOLOGY

This study employed a quantitative, quasi-experimental comparative design to evaluate the effectiveness of the two suctioning methods while maintaining control over key variables. The research was conducted in the Intensive Care Unit (ICU) of a tertiary care public sector hospital in Islamabad. This setting was chosen due to its high patient acuity and the complexity of care associated with mechanically ventilated patients. The study population comprised adult patients (≥18 years) admitted to the ICU who were receiving invasive mechanical ventilation via endotracheal tube or tracheostomy for more than 48 hours.

A purposive sampling technique was utilized to select a total of 20 patients with tracheostomy, who were assigned to two groups: ten patients in the closed suction group (Group A) and ten in the open suction group (Group B).

Strict eligibility criteria were applied to ensure valid results. Inclusion criteria required adult patients expected to remain on ventilator support for more than 48 hours. Patients with pre-existing pulmonary infections at the time of tracheostomy, severe immunosuppression, terminal illness, or those transferred out within 48 hours were excluded. Permission was obtained from the head nurse to use a self-administered checklist and review ICU documentation. During data collection, suctioning procedures were observed and documented for both closed and open techniques.

Data collection was conducted over four to six weeks in September 2025 using a checklist based on the Clinical Pulmonary Infection Score (CPIS) tool, adapted from Qureshi et al. (2025). The CPIS is a standardized scoring system that integrates clinical, radiological, and laboratory findings to objectively identify and monitor VAP. Data were analyzed using Microsoft Excel, with descriptive statistics such as mean, standard deviation, frequency, and percentage computed for all variables.

Ethical principles were strictly maintained; written approval was obtained from the hospital administration and research supervisor, and informed consent was secured from all participants. Participation was voluntary, and all collected data were kept anonymous and used solely for academic research purposes.

3. RESULTS

The study included a total of 20 adult ICU patients, with 10 managed using the closed tracheostomy suctioning system and 10 managed using the open system. Demographic analysis showed that both groups were comparable in terms of gender and age. In both the closed and open suction groups, there was an equal gender distribution (50% male, 50% female). The majority of patients (55%) were aged between 20–40 years, reflecting that most tracheostomy individuals requiring mechanical ventilation in the ICU were young to middle-aged adults ***Table 1***.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Table 1: Demographic and Clinical Characteristics of Study Participants (N=20)

Variable	Closed Suction Group (n=10)	Open Suction Group (n=10)	Total / Overall Mean (n=20)
Gender			
Male	5 (50%)	5 (50%)	10 (50%)
Female	5 (50%)	5 (50%)	10 (50%)
Age Group (years)			
< 20	2	1	3
20 – 40	5	6	11
> 40	3	3	6
Outcomes			
VAP Incidence (n, %)	3 (30%)	4 (37%)	7 (35%)
Mean CPIS Score	5.1 ± 1.3	5.8 ± 1.4	–
CPIS Range	3 – 7	4 – 8	–
Clinical Parameters (Mean ± SD)			
Duration of Ventilation (days)	–	–	20.2 ± 8.7
Temperature (°C)	–	–	37.6 ± 0.85
WBC Count ($\times 10^9$/L)	–	–	11.9 ± 2.9
PaO_2/FiO_2 Ratio (mm Hg)	–	–	268 ± 60
Tracheal Secretions Score (0–2)	–	–	0.8 ± 0.6
Chest X-ray Infiltrate Score (0–2)	–	–	0.7 ± 0.7
Sputum Culture Score (0–1)	–	–	0.35 ± 0.4

Note: Dashes (–) indicate that specific data for that subgroup was not explicitly detailed in the source text tables, as Table 2 in the source document provided aggregate means for the total sample.

regarding clinical parameters, the overall mean CPIS scores indicated a mild level of infection among ventilated patients. The mean temperature was 37.6 ± 0.85°C, and the WBC count was 11.9 ± 2.9 × 10^9/L, suggesting a slight systemic inflammatory response. The PaO_2/FiO_2 ratio was 268 ± 60 mm Hg, reflecting mild impairment in oxygenation. Tracheal secretions (0.8 ± 0.6) and chest X-ray infiltrates (0.7 ± 0.7) showed relatively low mean values, indicating minimal airway secretions and limited radiological changes.

Table 2: Comparison of Mean CPIS Scores and VAP Incidence

Groups	Mean ± SD	Range	Patients with VAP	VAP incidence
Closed suction	5.1 ± 1.3	3-7	3	30%
Open suction	5.8 ± 1.4	4-8	4	37%

As presented in ***Table 2***, notable differences were observed between the groups. Patients managed with the closed suction technique had a mean CPIS of 5.1 ± 1.3, and 3 out of 10 patients (30%) developed VAP. In contrast, those in the open suction group showed a higher mean CPIS of 5.8 ± 1.4, and 4 out of 10 patients (37%) developed VAP ***(Figure 1).*** Although the numerical difference in mean CPIS was modest (0.7 points), the lower incidence in the closed group suggests better airway hygiene. Weekly trend analysis (***Figure 2***) further revealed that VAP cases in the closed suction group occurred intermittently (weeks 3–5), whereas the open suction group exhibited a more dispersed and continuous distribution of infections across weeks 2, 4, 5, and 6. This suggests a greater exposure risk and a higher likelihood of airway contamination associated with the open suction method.

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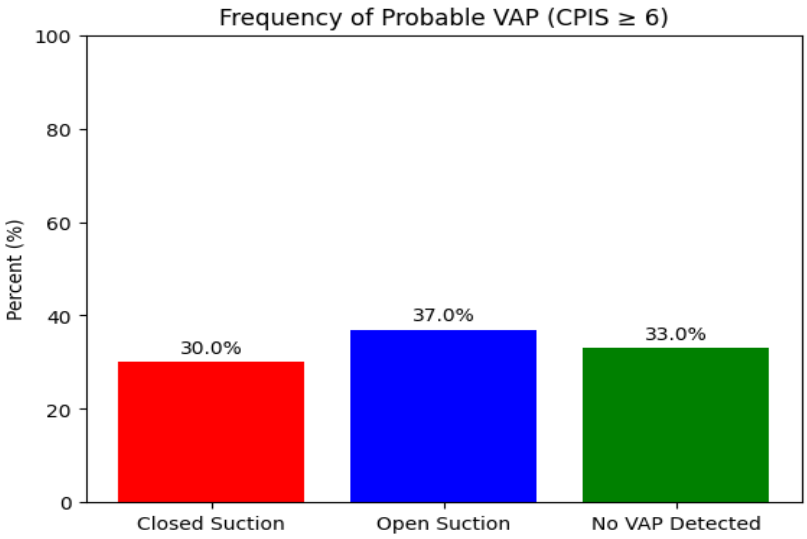

Figure1: Frequency of Probable VAP (CPIS ≥ 6)

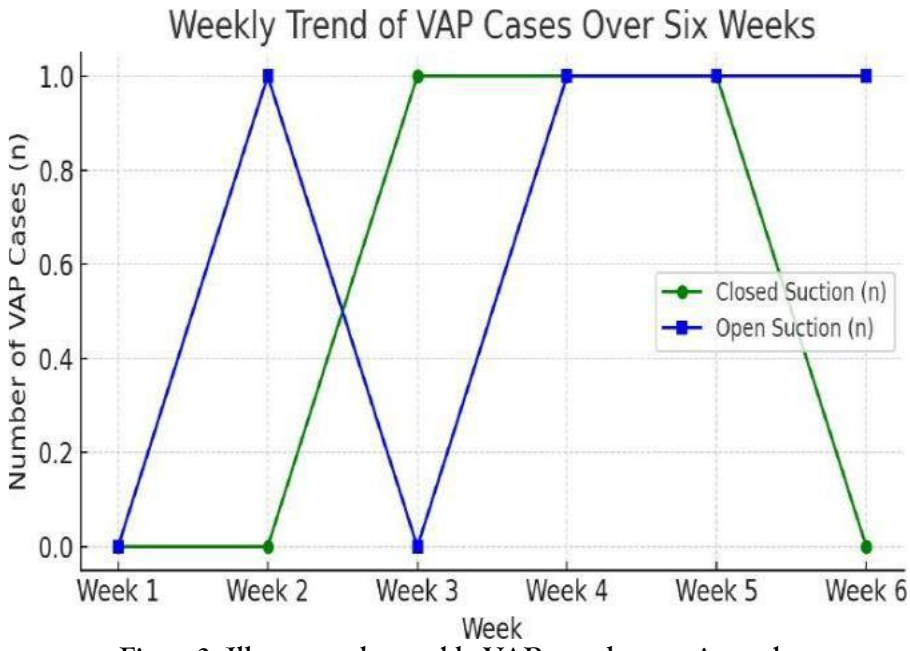

Figure2: Illustrates the weekly VAP trends over six weeks

4. DISCUSSION

The findings of this study revealed that the use of closed suction systems clearly improved how patients were managed during mechanical ventilation in the Intensive Care Unit. Patients who received closed suctioning demonstrated a lower incidence of ventilator-associated pneumonia (30%) compared to those managed with open suctioning (37%). The mean CPIS score was also lower in the closed suction group, reflecting better infection control and respiratory stability. Moreover, the weekly trend showed fewer and more isolated VAP cases in the closed suction group, whereas the open suction group had infections appearing more frequently across several weeks. These results show that when closed suction systems are properly used, patient airway contamination decreases, the risk of VAP is reduced, and overall critical care management improves.

These results are consistent with findings from previous studies (Lorente et al., 2005; Ardehali et al., 2020; Liang et al., 2020; Bulut and Sayar, 2023; Qureshi et al., 2025), which showed that closed suction systems are more effective in

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ISSN: (e) 3007-1607 (p) 3007-1593

minimizing contamination and reducing VAP rates compared to open suction systems. Several studies have demonstrated that the closed suction method helps maintain circuit integrity, prevent environmental exposure, and stabilize oxygenation during mechanical ventilation. Specifically, Qureshi et al. (2025) in Pakistan observed a similar pattern, with 30.2% of patients developing VAP in the closed suction group versus 37.2% in the open suction group.

The present study adds value by highlighting nurses' observed preference for the closed suction method due to its convenience and effectiveness in maintaining circuit sterility. Observations indicated that most nurses believed the closed system was safer, more efficient, and easier to use during routine care, minimizing circuit disconnections and cross-contamination.

The study had certain strengths, such as being conducted in a real ICU setting, making the findings closely aligned with actual clinical conditions. It also included both patient outcome measures (VAP incidence/CPIS scores) and observational data. However, limitations included the use of convenience sampling, which might have introduced selection bias, and a relatively small sample size that may affect the representativeness of the participants.

In conclusion, closed suctioning in mechanically ventilated patients significantly improves clinical outcomes by reducing the risk of ventilator-associated pneumonia, maintaining oxygenation stability, and minimizing circuit disconnections.

Based on these findings, it is recommended to implement standardized closed suctioning protocols in ICUs to enhance infection control. Continuous training and skill development programs should be provided for ICU nurses to ensure proper adherence to suctioning techniques. Furthermore, increasing staffing levels or support resources would help manage the workflow associated with maintaining these systems in high-acuity settings. Future multi-center studies are recommended to validate these findings and further explore practical challenges with suctioning techniques in diverse ICU settings.

5. REFERENCES

Qureshi, K. H., Rasheed, A., Saleem, M. Z., Zafar, J., Shah, S. A. R. A., & Ahmad, B. (2025). Frequency of Ventilator Associated Pneumonia with Closed Tracheal Suction versus Open Tracheal Suction. *Pakistan Armed Forces Medical Journal*, 75.

Peter, J. V., & Chacko, B. (2007). Comparison of closed endotracheal suction versus open endotracheal suction in the development of ventilator-associated pneumonia in intensive care patients. *Indian Journal of Medical Sciences*.

Ardehali, S. H., Fatemi, A., Rezaei, S. F., Forouzanfar, M. M., & Zolghadr, Z. (2020). The effects of open and closed suction methods on occurrence of ventilator associated pneumonia; a comparative study. *Archives of Academic Emergency Medicine*, 8(1), e8.

Liang, Z., Liao, Q., Xu, J., Wang, S., Liu, Q., Liu, Z., & Wen, D. (2020). Comparative analysis of open and closed tracheal suction systems on mechanical ventilation efficiency in adults: A systematic review and meta-analysis. *Australian Critical Care*, 38(2).

Khamis, G., Waziry, O., Ghazal, H., & Ibrahim, N. (2013). Effect of closed versus open suction system on the occurrence of ventilator associated pneumonia in neonates. *Life Science Journal*, 10(12), 1072–1086.

Vonberg R. P., Eckmanns T., Welte T., Gastmeier P. (2006). Impact of the suctioning system (open vs. closed) on the incidence of ventilation-associated pneumonia: meta-analysis. *Intensive Care Medicine*, 32(9):1329-1335.

Topeli A, Harmancı A, Cetinkaya Y, Akdeniz S, Ünall S. (2004). Comparison of the effect of closed versus open endotracheal suction systems on the development of ventilator-associated pneumonia. *Journal of Hospital Infection*, 58(1):14-19.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Zeitoun SS, de Barros AL, Diccini S. (2003). A prospective, randomized study of ventilator-associated pneumonia in patients using a closed vs. open suction system. *Journal of Clinical Nursing*, 12(4):484-489.

Wong, W., & Wang, Y. (2021). Efficacy of closed and open tracheal suction systems for prevention of ventilator-associated pneumonia: A meta-analysis. *Chinese Journal of Evidence-Based Medicine*, 21(1), 21-27.

Lorente, L., Lecuona, M., Martín, M. M., García, C., Mora, M. L., & Sierra, A. (2005). Ventilator-associated pneumonia using a closed versus an open tracheal suction system. *Critical Care Medicine*, 33(1), 115–119.

Subirana, M., Solà, I., Benito, S., et al. (2007). Closed tracheal suction systems versus open tracheal suction systems for mechanically ventilated adult patients. *Cochrane Database of Systematic Reviews*.

Gahan, A. K., Jain, S., Khurana, S., Chawla, D., et al. (2023). Closed versus open endotracheal tube suction in mechanically ventilated neonates: a randomized controlled trial. *European Journal of Pediatrics*, 182(2), 785–793.

Siempos, I. I., Vardakas, K. Z., & Falagas, M. E. (2008). Closed tracheal suction systems for prevention of ventilator-associated pneumonia. *British Journal of Anaesthesia*, 100(3), 299-306.

Paymard, A., Khalafi, S., Abdi, S., & Bagheri-Nesami, M. (2020). Comparing the effects of open and closed suctioning methods on the incidence of ventilator-associated pneumonia in patients under mechanical ventilation. *Iranian Journal of Nursing and Midwifery Research*, 25(1), 50–54.

Bulut, D., & Sayar, M. S. (2023). Comparison of the effects of open and closed endotracheal suction systems on ventilator-associated pneumonia and mortality. *Asian Journal of Research in Infectious Diseases*, 14(3), 34-41.