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Original Research Article

THE PREVENTIVE STRATEGIES USED BY CRITICAL CARE NURSES REGARDING VENTILATOR ASSOCIATED PNEUMONIA AMONG PATIENTS WITH TRACHEOSTOMY TUBE

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ABSTRACT

Background: *Ventilator-associated pneumonia (VAP) is one of the most common healthcare-associated infections in intensive care units and is linked to prolonged mechanical ventilation, increased morbidity, and higher mortality. Patients with tracheostomy tubes remain at continued risk despite potential airway management benefits. Critical care nurses are central to implementing VAP prevention bundles; however, adherence to evidence-based practices varies across clinical settings.* ***Objective:*** *To evaluate the preventive strategies used by critical care nurses for ventilator-associated pneumonia among patients with tracheostomy tubes in a tertiary care hospital.* ***Study Design:*** *Descriptive cross-sectional study.* ***Setting:*** *Intensive care units of a tertiary care hospital in Lahore, Pakistan.* ***Duration of Study:*** *January 2025 to June 2025.* ***Methods:*** *A total of 153 registered nurses were recruited using purposive sampling from a population of 250 nurses, with sample size calculated using Slovin's formula. Data were collected using a structured questionnaire adopted to assess demographic characteristics and evidence-based VAP preventive practices, including humidifier care, ventilator circuit management, suctioning technique, head-of-bed elevation, cuff pressure monitoring, oral hygiene practices, sedation interruption, and spontaneous breathing trials. Data were analyzed using SPSS version 23. Descriptive statistics were presented as frequencies and percentages. Preventive practice levels were categorized as poor, moderate, or good based on composite practice scores.* ***Results:*** *Most participants were aged 21–25 years (47.7%), held BSN/Post-RN qualifications (63.4%), and had 1–5 years of professional experience (74.5%). High compliance was observed in infection control practices, including use of sterile water in humidifiers (98.0%), non-sharing of respiratory equipment (96.1%), aseptic tracheostomy care (96.1%), and ventilator tubing changes when indicated (96.1%). Head-of-bed elevation (89.5%), oral care every 4–8 hours (85.0%), chlorhexidine use (82.4%), and daily spontaneous breathing trials (86.9%) were also frequently reported. However, knowledge gaps were identified regarding correct suction duration (66.0%) and optimal cuff pressure range (68.0%). Overall, 42.5% of nurses demonstrated poor adherence to preventive strategies, 38.6% moderate adherence, and only 19.0% good adherence.* ***Conclusion:*** *While general infection control compliance was satisfactory, significant deficiencies were identified in specific technical aspects of VAP prevention among tracheostomized patients. Structured educational interventions, standardized clinical protocols, and regular competency-based evaluations are recommended to strengthen adherence to evidence-based practices and reduce VAP risk in critical care settings.*

Keywords: Ventilator-Associated Pneumonia; Tracheostomy; Critical Care Nurses; Infection Prevention; Intensive Care Unit; Preventive Strategies; Airway Management; Nursing Practice

INTRODUCTION

Ventilator-associated pneumonia (VAP) is defined as pneumonia that develops 48 hours or more after initiation of mechanical ventilation and remains one of the most frequent healthcare-associated infections in intensive care units (ICUs). It is associated with prolonged mechanical ventilation, extended ICU stay, increased antimicrobial exposure, higher healthcare costs, and increased mortality. Ranzani et al. described VAP as a major complication in critically ill ventilated patients and emphasized its ongoing clinical relevance despite advances in infection prevention strategies (1).

The pathogenesis of VAP primarily involves microaspiration of contaminated oropharyngeal and gastric secretions into the lower respiratory tract, facilitated by the presence of an artificial airway. Thakur et al. explained that bacterial colonization of the aerodigestive tract followed by aspiration is central to VAP development, rather than contamination of ventilator circuits alone (2). The insertion of an endotracheal or tracheostomy tube bypasses natural defense mechanisms such as coughing and mucociliary clearance, thereby increasing susceptibility to infection.

The global burden of VAP remains substantial. High et al. reported that VAP affects a considerable proportion of ventilated patients and continues to challenge antimicrobial stewardship and patient outcomes in critical care settings (3). Similarly, Mumtaz et al. highlighted that VAP significantly contributes to morbidity and mortality in ICU populations, particularly in resource-limited healthcare systems (4).

Tracheostomy is frequently performed in patients requiring prolonged mechanical ventilation. Merola et al. demonstrated that tracheostomy is a common intervention in ICU practice and plays a central role in airway management strategies (5). Compared to translaryngeal intubation, tracheostomy may improve patient comfort, facilitate pulmonary hygiene, and reduce airway resistance. Alsunaid et al. discussed the clinical benefits of tracheostomy in wound care management and airway stabilization (6). However, the risk of VAP persists even after tracheostomy placement, necessitating consistent preventive measures. Evidence suggests that early tracheostomy may reduce the duration of mechanical ventilation and potentially decrease the incidence of VAP, although mortality benefits remain uncertain. Swain and Jena reviewed the role of early tracheostomy and noted its potential contribution to reducing ventilator-associated complications (7). Nonetheless, patients with tracheostomy tubes remain vulnerable to lower respiratory tract infections, particularly when preventive measures are inadequate.

Effective prevention of VAP requires strict adherence to evidence-based strategies. Klompas et al. provided updated recommendations

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for preventing ventilator-associated pneumonia in acute care hospitals, emphasizing head-of-bed elevation, oral hygiene, sedation management, and appropriate handling of ventilator circuits (8). Labeau et al. further highlighted that although preventive measures are well established, implementation remains challenging in clinical practice (9).

Critical care nurses play a pivotal role in implementing VAP prevention bundles. Their responsibilities include maintaining aseptic technique during airway care, performing regular oral hygiene, monitoring cuff pressure, conducting suctioning safely, promoting spontaneous breathing trials, and ensuring appropriate patient positioning. Jassim assessed preventive measures among ICU nurses and underscored variability in knowledge and adherence to recommended practices (10).

In many developing healthcare settings, gaps in training, inconsistent protocols, and limited monitoring systems may compromise compliance with infection prevention guidelines. Safavi et al. demonstrated that implementing structured infection-control guidelines can significantly reduce the incidence of VAP in ICU settings (11). These findings reinforce the need to evaluate current nursing practices in order to identify deficiencies and guide targeted interventions.

Despite growing international evidence, local data regarding preventive strategies used by critical care nurses for tracheostomized patients remain limited. Understanding current practice patterns is essential to strengthening training programs, improving compliance with VAP prevention bundles, and enhancing patient outcomes. Therefore, the present study was conducted to evaluate the preventive strategies used by critical care nurses regarding ventilator-associated pneumonia among patients with tracheostomy tubes in a tertiary care hospital setting.

METHODOLOGY

The study was conducted to evaluate the preventive strategies used by critical care nurses regarding ventilator-associated pneumonia (VAP) among patients with tracheostomy tubes in a tertiary care hospital in Lahore. A descriptive cross-sectional study design was employed to assess nurses' knowledge and reported preventive practices at a single point in time.

The study was conducted over six months in the intensive care units of the selected tertiary care hospital. The target population comprised registered staff nurses working in critical care units. Intern nurses were included, whereas student nurses and head nurses were excluded to ensure homogeneity of clinical responsibility and exposure to ventilated patients with tracheostomy tubes.

The sample size was calculated using Slovin's formula ($n = N / 1 + Ne^2$), where N represented the total population of nurses (250) and the margin of error (e) was set at 0.05. The calculated sample size was 153 participants. A purposive sampling technique was applied to recruit eligible nurses who met the inclusion criteria during the data collection period.

Data were collected using an adopted structured questionnaire developed by Jassim (2024) to assess preventive measures related to VAP in intensive care settings (10)

. The instrument consisted of two sections. The first section captured demographic characteristics, including age, educational qualification, and years of professional experience. The second section comprised structured items assessing knowledge and reported preventive strategies related to VAP among patients with tracheostomy tubes. These items covered key evidence-based practices such as humidifier care, ventilator circuit management, suctioning technique and duration, head-of-bed elevation, cuff pressure monitoring, oral care practices, sedation interruption, spontaneous breathing trials, and infection control measures.

Prior to data collection, formal administrative permission was obtained from the principal of the respective nursing institute and the administration of the tertiary care hospital. Ethical principles were observed throughout the study. Participants were informed about the purpose of the study, confidentiality of their responses was assured, and informed consent was obtained before participation. Participation was voluntary, and anonymity was maintained by not collecting identifying information.

Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 23.0. Descriptive statistics were applied to summarize the data. Categorical variables were presented as frequencies and percentages. Preventive strategy levels were categorized as poor, moderate, or good based on total scores from the questionnaire. Bar charts and tables were generated to present findings clearly. A p-value of ≤ 0.05 was considered statistically significant where applicable, although the primary analysis was descriptive in nature.

RESULTS

The majority of participants were aged 21–25 years (73; 47.7%), followed by 26–30 years (56; 36.6%), 31–35 years (18; 11.8%), and 36–40 years (6; 3.9%). Most nurses held a BSN/Post-RN qualification (97; 63.4%), while 38 (24.8%) had a diploma and 18 (11.8%) had specialization. Regarding professional experience, 114 (74.5%) had 1–5 years of experience, 22 (14.4%) had 6–10 years, 11 (7.2%) had 11–15 years, and 6 (3.9%) had 16–20 years (Table 1).

Table 1: Demographic characteristics of participants (n = 153)

Variable	Category	n	%
Age (years)	21–25	73	47.7
	26–30	56	36.6
	31–35	18	11.8
	36–40	6	3.9
Educational qualification	Diploma	38	24.8
	Specialization	18	11.8
	BSN/Post-RN	97	63.4
Professional experience	1–5 years	114	74.5
	6–10 years	22	14.4
	11–15 years	11	7.2
	16–20 years	6	3.9

High compliance was observed in several infection control measures. 150 (98.0%) participants reported use of sterile water in humidifiers. Changing ventilator tubing when soiled or malfunctioning was reported by 147 (96.1%). The same proportion (96.1%) stated that oxygen masks, tubing, and Ambu bags were not shared between patients. Elevation of the head of bed to 30–45 degrees was reported by 137 (89.5%). Aseptic technique during tracheostomy tube replacement was reported by 147 (96.1%). Use of a single-use suction catheter with sterile water in open suction systems was reported by 138 (90.2%). Regular verification of nasogastric tube position was reported by 144 (94.1%). Knowledge gaps were identified in specific technical aspects. Correct suction duration (15 seconds) was identified by 101 (66.0%). Appropriate endotracheal cuff pressure range (20–30 cmH_2O) was identified by 104 (68.0%). Daily sedation interruption was reported by 120 (78.4%). Oral care every 4–8 hours was reported by 130 (85.0%), and chlorhexidine use (0.12–0.125%) was reported by 126 (82.4%). Closed suction catheter use for each new patient was reported by 140 (91.5%). Safe disposal of condensed ventilator water was reported by 136 (88.9%). Daily spontaneous breathing trials were performed by 133 (86.9%) (Table 2).

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Table 2: Preventive strategy practices related to VAP among tracheostomized patients (n = 153)

Preventive Strategy	Correct Response (n)	%
Use sterile water in humidifiers	150	98.0
Change ventilator tubing when soiled	147	96.1
Do not share oxygen mask/tubing/Ambu bag	147	96.1
Suction duration 15 seconds	101	66.0
Elevate head 30–45 degrees	137	89.5
Aseptic technique during tracheostomy replacement	147	96.1
Single-use catheter in open suction	138	90.2
Regular NG tube position check	144	94.1
Maintain cuff pressure 20–30 cmH_2O	104	68.0
Reposition before cuff deflation	130	85.0
Manual cuff pressure monitoring	142	92.8
Daily sedation interruption	120	78.4
Oral care every 4–8 hours	130	85.0
Closed suction catheter for a new patient	140	91.5
Do not pour ventilator condensate onto the patient.	136	88.9
Daily spontaneous breathing trial	133	86.9
Oral care with chlorhexidine	126	82.4

Based on total practice scores, 65 (42.5%) nurses demonstrated poor preventive strategies, 59 (38.6%) demonstrated moderate preventive strategies, and only 29 (19.0%) demonstrated good preventive strategies (Table 3).

Table 3: Overall level of preventive strategies (n = 153)

Preventive Strategy Level	n	%
Poor	65	42.5
Moderate	59	38.6
Good	29	19.0

DISCUSSION

TThe present study evaluated the preventive strategies adopted by critical care nurses to reduce ventilator-associated pneumonia (VAP) among patients with tracheostomy tubes. The findings demonstrate satisfactory compliance in several core infection control practices; however, important deficiencies were observed in selected technical and bundle-related components.

Nearly all participants reported using sterile water in humidifiers and avoiding the sharing of respiratory equipment between patients. These findings are consistent with the emphasis on strict infection prevention measures in critical care settings. Vallecoccia et al. described ventilator-associated lower respiratory infections as closely linked to lapses in ventilator circuit and equipment management, underscoring the importance of proper device handling and hygiene practices (12).

A high proportion of nurses reported changing ventilator tubing when it was visibly soiled or malfunctioning, and maintaining aseptic technique during tracheostomy care. Bryant noted that improper airway device handling increases the risk of respiratory infections, particularly in mechanically ventilated patients, underscoring the importance of strict aseptic precautions (13).

Head-of-bed elevation to 30–45 degrees was reported by most participants, indicating reasonable adherence to aspiration-prevention strategies. Degroote et al. highlighted that microaspiration remains a key contributor to pulmonary infection in intubated patients and that preventive positioning strategies are clinically important in minimizing aspiration risk (14). However, knowledge regarding suction duration and cuff pressure management was comparatively weaker. Only two-thirds of participants correctly identified the recommended suction duration, and a similar proportion correctly reported the optimal cuff pressure range. Smith and Spivey emphasized that inadequate subglottic secretion management and improper cuff practices may compromise airway protection and facilitate bacterial entry into the lower respiratory tract (15). These gaps suggest that while general infection control measures are well recognized, more technical aspects of airway management require further reinforcement.

Monitoring and controlling endotracheal cuff pressure was widely reported, yet manual examination remains subject to inaccuracy. Seo et al. noted that sedation and airway management practices in ICU settings require structured protocols and regular evaluation to optimize patient outcomes and minimize complications (16). This supports the need for standardized cuff pressure-monitoring tools rather than relying solely on manual assessment.

Daily sedation interruption and spontaneous breathing trials were reported by most nurses, although not universally practiced. Strehlow demonstrated that structured quality improvement initiatives can significantly enhance compliance with spontaneous awakening and breathing trial protocols (17). These practices are essential for reducing ventilation duration, which, in turn, may decrease VAP risk.

Oral care practices showed relatively good adherence, including regular oral hygiene and the use of chlorhexidine. Huang et al. reviewed oral care interventions in ICU settings and confirmed their role in reducing microbial colonization associated with ventilator-associated pneumonia (18). Despite favorable self-reported compliance in the present study, the effectiveness of oral care depends on consistent technique and protocol-driven application.

Structured infection-control interventions have been shown to reduce the incidence of VAP significantly. Safavi et al. demonstrated that implementation of evidence-based infection control guidelines resulted in measurable reductions in VAP rates in ICU patients (19). This suggests that institutional reinforcement, monitoring systems, and continuous professional development are critical to sustaining high levels of compliance.

The overall distribution of preventive strategy levels in this study indicated that only a minority of nurses achieved a “good” level of adherence. At the same time, a substantial proportion fell into poor or moderate categories. SK et al. reported similar findings in a tertiary care teaching hospital, where variability in adherence to preventive bundles influenced VAP incidence (20). These parallels indicate that knowledge-practice gaps may persist even in structured ICU environments.

Furthermore, tracheostomized patients often require prolonged critical care support, and long-term airway management increases vulnerability to complications. McMahon et al. emphasized the importance of patient-centered outcomes and comprehensive airway management in critical care, including coordinated nursing care to prevent secondary complications (21).

Although compliance was strong in general infection control measures, inconsistencies in suction practices, cuff pressure management, and sedation interruption highlight areas for targeted intervention. Multidisciplinary protocols, simulation-based training, regular audits, and performance feedback may enhance adherence to VAP prevention bundles.

The cross-sectional design and reliance on self-reported data limit the ability to assess the accuracy of actual clinical practice. Future multicenter studies incorporating direct observational audits and outcome-based measures, such as VAP incidence rates, may provide more robust evidence regarding the effectiveness of preventive strategies in tracheostomized ICU patients.

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CONCLUSION

Preventive practices against ventilator-associated pneumonia among tracheostomized patients demonstrated acceptable adherence to basic infection control measures but insufficient consistency in key technical components, such as suctioning and cuff pressure management. Strengthening structured training, protocol enforcement, and ongoing monitoring may improve overall compliance and contribute to safer airway management in intensive care units.

DECLARATIONS

Data Availability Statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department Concerned. (IRBEC-ICN-55/25)
Consent for publication
Approved
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Not applicable

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION

MAHA ARSHAD (Student)
Conceived the study, coordinated data collection, performed analysis, and prepared the first draft of the manuscript
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Assisted in data collection, literature review, and manuscript preparation
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TABASSUM KHURSHID (Student)
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RABIA BIBI (Student)
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GHUZALA ANWAR (Assistant Professor)
Provided academic supervision, contributed to study design and critically reviewed the manuscript
HUMAIRA SADDIQUE (Assistant Professor)
Guided methodology development, supervised data analysis and reviewed the manuscript
IQRA YASIN (Principal)
Provided institutional support, oversight and final approval of the manuscript

All authors read and approved the final version of the manuscript.

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