Al-Razi University
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College of Medical Sciences
Applied Medical Sciences Department

Knowledge and Practice of Intensive Care Unit Nurses toward Prevention of Ventilator-Associated Pneumonia at Public Hospitals in Sana'a City-Yemen

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Thesis Submitted to the Applied Medical Sciences Department, College of Medical Sciences, AL-Razi University as Partial Fulfillment for MSc. in Critical Care Nursing

Researcher

Abdul Fattah Saleh Mohammed Al-jaradi
BSc. Nursing

Supervisor

Professor Dr. Nabil Ahmed Al-Rabeei
Professor of Public Health

Co-Supervisor

Dr. Sadek Al-Wesaby
Assistant Professor of Medical-Surgical Nursing

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جـامـــعـة الرازي
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معارف وممارسات ممرضي العناية المركزة تجاه الوقاية من الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي في المستشفيات العامة بمدينة صنعاء- اليمن

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الباحث

عبدالفتاح صالح محمد الجرادي

بكالوريوس تمريض

المشرف الرئيس

أ.د. نبيل أحمد أحمد الربيعي

استاذ الصحة العامة

المشرف المشارك

د. صادق عبده الوصابي

استاذ التمريض الباطني الجراحي المساعد

نوفمبر ٢٠١٨م

CERTIFICATE

This is to certify that the thesis entitled ***Knowledge and Practice of ICU Nurses' toward Prevention of Ventilator-Associated Pneumonia at Public Hospitals in Sana'a City-Yemen***; which submitted to the Department of Applied medical sciences, College of Medical Sciences, Al-Razi University for the award MSc. degree in ***Critical Care Nursing***. It is a recorded of the original and bona fide thesis work carried out by ***Abdul Fattah Saleh Mohammed Al-Jaradi*** under our guidance. Such material as has been obtained from other sources has been duly acknowledged in the research. This thesis embodies the work of the candidate herself and no part thereof has been submitted for any other degree.

Supervisor:

Professor Dr. Nabil Ahmed Al-Rabeei

Professor of Public Health

Dedication

This thesis is dedicated to

My great parents, who never stop giving of themselves in countless ways,

My dearest wife, who leads me through the valley of darkness with the light of hope and support,

My beloved brothers and sister,

My beloved kids: Doa'a, Rehab & Fatima whom I cannot force myself to stop loving. To all my family, the symbol of love and giving,

My friends who encourage and support me,

All the people in my life who touch my heart.

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LIST OF ABBREVIATION

AACCN	American Association of Critical Care Nurse
ABG	Arterial blood gazes
ARDS	Acute respiratory distress syndrome
BAL	Broncho-alveolar lavage
Bi- vent	Bi-level positive ventilation
BSCs	Bachelor of science
CACM	Combination (assist & control mode)
CCN	Critical care nursing
CDC	Center of communicable diseases control
C-ICU	Cardiac – intensive care unit
CM	Controlled mode
cmH_2O	Pressure measured in cm of water
CNS	Central nervous system
COPD	Chronic obstructive pulmonary disease
CO2	Carbon dioxide
CPIS	Clinical pulmonary infection score
C°	Centigrade
DRG	Dorsal respiratory group
E-ICU	Emergency – intensive care unit
ETT	Endotracheal tube
ETS	Endotracheal suction
F	Frequency
FIO2	Fractional concentration of inspired oxygen
G-ICU	General – intensive care unit
H	Hour
HAP	Hospital-acquired infection
HCWs	Health care workers
HCAP	Health care-associated pneumonia
HOB	Head of bed
H+	Hydrogen ions
H2	Histamine
ICU	Intensive care unit
I:E	inspiration to expiration
IPPV	Intermittent positive pressure ventilation
IVAC	Infection-related ventilation associated complications
Kg	Kilogram
MDR	Multi –drug resistant
M-ICU	Medical – intensive care unit
ML	Milliliters
MRSA	Methicillin-resistant Staphylococcus. aurous
MV	Mechanical ventilation
N	Numbers
NAVA	Neutrally adjusted ventilator assists
NIPPV	NON- invasive positive pressure breathing
NIV	NON- invasive ventilation

O_2	Oxygen
PaO2	Partial pressure of arterial oxygen
PaCO2	Partial pressure of carbon dioxide in arterial blood
PC	Pressure control
PEEP	Positive end expiratory pressure
P-ICU	Pediatric – intensive care unit
Blood PH	The acidity or alkalinity of the blood
PPI	Proton- pump inhibitors
PRVC	Pressure regulated volume control
PS	Pressure support
PTC	Protected telescoping catheter
PUD	Peptic ulcer disease
Q	Questions
RR	Respiratory rate
SaO_2	Saturation of hemoglobin
SD	Standard division
S-ICU	Surgical – intensive care unit
SIMV	Synchronized intermittent mandatory ventilation
SP	Spontaneous mode
SPSS	Statistical package for the social science
SSD	Suction system drainage
US	United State
USD	United State dollars
VAC	Ventilator – associated condition
VAP	Ventilator associated pneumonia
VAT	Ventilator- associated trachea bronchitis
VBS	Ventilator bundles strategies
VC	Volume control
VRG	Ventral respiratory group
VS	Volume support
VTE	Ventilator event
WBC	White blood cell
WOB	Work of breathing
ZEEP	Zero end expiratory pressure
µL	Microliters

ABSTRACT

Background of the study

Ventilator-associated pneumonia (VAP) is define as a type of pneumonia in a patient receiving mechanical ventilation that was not present at the time of admission to hospital or that occurs 48 hours after intubation and mechanical ventilation. The VAP is still an important cause of mortality and morbidity in mechanically ventilated patients. This can be primarily prevent by increase knowledge and practice of ICU nurses to improve nursing care that plays important role in outcomes.

Methods

A descriptive cross-sectional study was conducted among ICU nurses at public hospitals in Sana,a City-Yemen, to assess knowledge and practice of ICU nurses on prevention of Ventilator-Associated Pneumonia. The sample of the study consisted of 87 Yemeni nurses from different public hospitals were participated in this study. The sample size was determined using EpiCalc 2000. A stratified simple random sampling was applied to select the sample size from 4 major public hospitals. After official approvals were obtained from the previously selected settings, the researcher obtained lists of nurses' currently working in the study settings via random sampling methods. Data was collected using a close-ended questionnaire, 87 nurses were tested for knowledge and 50 nurses were tested for practice by using an observational checklist. Information letters, consent form, and questionnaires were handed to ICU nurses by the researcher. Data coded and entered into SPSS version 21.0 for descriptive and inferential statistics.

Results

The ICU nurses, (54%) were male, (52%) were unmarried with age mean ± SD, 28.40 ± 3.9 years. About (55.2 %) had working experience from 1-3 years. Two third (65.5 %) the nurses had a diploma degree, (51.7%) had courses training in ICU and (81.6%) had no training program on the prevention of VAP. Knowledge scored and their levels were as follows: (5.7%) scored 76%-100%, good, (36.8%) scored between 50%-75% and (57.5%) scored between 0% - 49%. poor knowledge. the overall level of practice, (52%). of nurses had a poor level, (42%) had a moderate level and (6%) that were had a good level of practice.

No association between knowledge and ICU training (P-value= 0.38), sex (P-value=0.41) and years of working experience (P-value= 0.37). A significant association between the knowledge toward prevention VAP and level of education (P-value=0.001). ICU nurses' practice on prevention of VAP was statistically associated with ICU training (P-value= 0.03) and years of work experience (p-value 0.64) but not associated between practice and educational level (P-value= 0.40).

On observation (28%) of nurses performed hands disinfect before oral care and before tracheal suction, before and after every patient care, most of the nurses (74%) were performed wear the gloves and gown before oral care and tracheal suction. (32%) of nurses were performed oral care with an antiseptic solution. Of ICU nurses (100%) of nurses not use the closed endotracheal suction system, (32%) performed sterilization

of suctioning equipment, (42%) used the sterile technique during tracheal suction and (54%) disposed of suction catheter immediately after one single use. Most nurses (78%) kept the patient in semi-sitting position, (88%) used the kinetic bed for the ventilated patient and (62%) of nurses were done respiratory chest physiotherapy. (54%) checked the nasogastric and (36%) used of protocol for weaning from mechanical ventilation.

Conclusion

ICU nurses' knowledge of VAP prevention was inadequate and their practice was found to be poor. No association between knowledge and ICU training, sex and years of work experience but significant association between the knowledge and level of education was found. ICU nurses' practice on prevention of VAP was statistically associated with ICU training and years of work experience but not associated with educational level.

Recommendations

We recommended increasing knowledge and practice of intensive care unit nursing staff through the courses training, workshop, and curriculums. In addition to similar studies with large sample size in other hospitals that provide critical care in Yemen are recommended.

ملخص الدراسة

- **خلفية الدراسة:**

يحدث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي بعد ٤٨ ساعة من وضع المريض على انبوب جهاز التنفس الاصطناعي، حيث يعرف بأنه من معظم العدوى المكتسبة في العناية المركزة، ويعتبر من الاسباب الرئيسية التي تؤدي الى زيادة معدل الوفيات والمراضة في العناية، وتبقى المسؤولية الاولية الوقاية من الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي هي مسؤولية الممرضين اعتمادا على المعارف والممارسات التي تلعب دورا مهماً في التأثير على مخرجات المرضى .

- **المنهجية:**

دراسة مقطعية عرضية وصفية اجريت على ممرضي العناية المركزة في المستشفيات العامة بمدينة صنعاء- اليمن لتقييم معارف وممارسات ممرضي العناية المركزة تجاه الوقاية من الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي. شملت عينة الدراسة على ٨٧ ممرض وممرضة من جميع المستشفيات المشاركين في الدراسة. تم تحديد حجم العينة باستخدام برنامج (Epical 2000) وتم اختيار حجم العينة من الاربعة المستشفيات العامة بواسطة طريقة العينة العشوائية الطبقية بعد الموافقة من مكان الدراسة. الباحث اخذ قائمة الممرضين العاملين في أماكن الدراسة بالطريقة العشوائية البسيطة، كذلك جمعت البيانات باستخدام الاستبيانات المكتوبة لعدد٨٧ ممرض وممرضة لتقييم المعارف ولعدد ٥٠ ممرض وممرضة لتقييم الممارسات باستخدام قائمة الملاحظة. المعلومات العامة وشكل الموافقة والاستبيان سلمت للممرضين بواسطة الباحث نفسة. تم ترميز وادخال البيانات الى برنامج الحزم الاحصائية للعلوم الاجتماعية النسخة ٢١ من اجل تحليل ومعالجة البيانات.

- **النتائج:**

اظهرت الدراسة ان نسبة ٤٥% من ممرضي العناية المركزة هم من الذكور ومنهم حوالي ٥٢% غير متزوجون ويتراوح متوسط اعمارهم والانحراف المعياري ٢٨,٤٠±٣,٩ سنة بينما نسبة ٥٢% عندهم سنوات خبرة من ١-٣ سنوات و حوالي ٢١,٧% حاصلين على كرس تدريبي في العناية المركزة وكذلك نسبة ٨١,٦% لم يحصلوا على برنامج تدريبي على الوقاية من الاتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي. ايضا اظهرت الدراسة ان نسبة ٥,٧% يملكون معارف جيدة وحوالي نسبة ٣٦,٨ % يملكون معارف متوسطة وايضا معظم ممرضي العناية المركزة بنسبة ٥٧,٥% يملكون معارف ضعيفة حول الوقاية من الاتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي. وكذلك مستوى الممارسات اكثر من نصف الكادر التمريضي ممارساتهم ضعيفة بنسبة ٥٢% وحوالي ٤٢% متوسط واخيرا فقط حوالي ٦% يؤدون ممارسات جيدة تجاه الوقاية من الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي. واظهرت الدراسة انه لا توجد دلالة احصائية بين مستوى المعارف والدوارات التدريبية في العناية المركزة (p- value= 0.38) وكذلك الجنس (p- value= 0.41) وسنوات الخبرة (p- value= 0.37). بينما توجد دلالة احصائية بين المعارف والمستوى التعليمي (p- value= 0.001). ايضا توجد دلالة احصائية بين مستوى الممارسات والدوارات التدريبية في العناية المركزة وسنوات الخبرة (p- value= 0.03). بينما لا توجد دلالة احصائية بين مستوى الممارسات والمستوى التعليمي (p- value= 0.40). اظهرت النتائج حول الممارسات أن حوالي ٢٨% يؤدون غسل اليدين قبل وبعد العناية بالفم والشفط من القصبة الهوائية وقبل وبعد العناية لكل مريض. ايضا معظم الممرضين بنسبة ٧٤%

يرتدون القفازات والجاونات قبل العناية بالفم والشفط من القصبة الهوائية وحوالي ٣٢% يؤدون العناية بالفم باستخدام محلول مضاد الاخماج (الكلورهيكسيديل). لاكن نسبة١٠٠% لا يعملون بنظام الشفط المغلق من القصية الهوائية وايضا حوالي ٣٢% يلتزمون بتعقيم ادوات الشفط ونسبة ٤٢% يستخدمون تقنية التعقيم خلال الشفط من القصبة الهوائية، وكذلك نسبة ٥٤% يتلفون قسطرة الشفط من القصبة الهوائية بعد استخدامها لمرة واحدة فقط، ايضا معظم الكادر التمريضي يضعون المريض في وضعية شبه جالس وحوالي نسبة ٨٨% يستخدمون الأسرة المتحركة للمرضى، واكثر من نصف الممرضين ٦٢% يأدون العلاج الطبيعي على الصدر للمرضى ، ايضا ٥٤% يشيكون على الارتجاع من الانبوب المعوي واخيرا حوالي ٣٦% يستخدمون برتوكول لعملية فطام المريض من جهاز التنفس الاصطناعي.

- **الاستنتاجات:**

استنتجت الدراسة ان معارف ممرضي العناية المركزة حول الوقاية من الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي غير كافية وكذلك مستوى ممارستهم ضعيفة. ايضا لا توجد دلالة احصائية بين المعارف والدورات التدريبية في العناية المركزة والجنس وسنوات الخبرة، لاكن توجد دلالة احصائية بين المعارف والمستوى التعليمي وتوجد دلالة احصائية بين الممارسات والدورات التدريبية في العناية المركزة وسنوات الخبرة وبينما لا توجد دلالة احصائية بين الممارسات والمستوى التعليمي للكادر التمريضي.

- **التوصيات**

نوصي برفع مستوى المعارف والممارسات للكادر التمريضي من خلال الدورات التدريبية وورش العمل والمناهج وكذلك نوصي بعمل دراسات مشابهة بحجم عينة اكبر في مستشفيات اخرى تعطي رعاية حرجة في اليمن.

CHAPTER 1: INTRODUCTION

1.1 Background of the study

Ventilator-associated pneumonia (VAP) defined as a type of pneumonia in a patient receiving mechanical ventilation that was not present at the time of admission to hospital or that occurs 48 hours after intubation and mechanical ventilation. It is characterized by a new or progressive pulmonary infiltrates, fever, leukocytosis and purulent trachea-bronchial secretions ***(Ismail and Zahran, 2015; Kalanuria, Zai and Mirski, 2014)***. VAP is a known serious health hazard among patients on mechanical ventilation with mortality rate ranges from 6- 60% and as high as 74% ***(Wami, Mengistu, and Gudisa, 2018).***

Intubation and mechanical ventilation both increase the risk of bacterial pulmonary infection because the invasive endotracheal tube allows direct entry of bacteria into the lower respiratory tract since the tube is located in the trachea. Bacterial colonization in the respiratory tract is further facilitated by the absence of the cough reflex and excessive mucus secretion in the mechanically ventilated patients ***(Khezri, et al., 2014).***

Mechanical ventilation (MV) is an essential, lifesaving therapy for patients with critical illness and respiratory failure; these patients are at high risk for complications such as VAP. Mechanical ventilation is an important part of advanced life support in the intensive care unit (ICU). ***(Aykac, Ozsurekci and Basaranoglu, 2017; Chen and Wang, 2017).*** The risks of VAP in a critical/intensive care unit patient are 6- 20 times higher since the intubation brings bacterial oropharyngeal colonization (Wami, Mengistu, and Gudisa, 2018)**.** VAP is a major complication of mechanical ventilation and is a recognized marker of quality of care in an intensive

care unit, VAP is a common infection in ICUs ***(Nora and Póvoa, 2017; Neuville, et al., 2017).*** VAP is a type of nosocomial pneumonia that occur in patients who receive more than 48 hours of mechanical ventilation, VAP is the second most common nosocomial infection and the leading cause of death from nosocomial infections in critically ill patients. VAP is defined as hospital-acquired pneumonia that develops in patients who have been treated with mechanical ventilation for 48 hours or longer who had no signs or symptoms of lower respiratory infection before they were intubated and treatment with mechanical ventilation began ***(Timsit, et al., 2017; Aferu, 2016).***

Most critically ill patients need a mechanical ventilator, which assists or replaces spontaneous breathing. Mechanically ventilated patients are more likely to develop pulmonary infection and VAP. Intubation bypasses the normal airway protective mechanisms and acts as a direct route for the bacterial invasion to the airway. Patients receiving invasive mechanical ventilation are at risk for numerous complications, including pneumonia. VAP results from the microbial invasion of the normally sterile lower respiratory tract VAP ***(Ismail and Zahran, 2015; Timsit, et al., 2017).***

1.2 Problem Statement

VAP is known to be one of the most serious infections acquired in ICUs, with an incidence of 6-60%, and a high morbidity-mortality rate and an increase in healthcare costs. VAP is a problem in ICU and dramatically increases morbidity and mortality rates on mechanically ventilated patients. It is among the most common infectious complication among patients admitted to ICU ***(Wami, Mengistu, and Gudisa, 2018).***

VAP increases the severity of illness as it elevates oxygen demands, sputum production, and produces alveolar collapse leading to impaired gas exchange. The patient might experience discomfort, agitation, delirium, immobility, and/or risk for impaired skin integrity, hemodynamic instability, as well as an increased stress response and malnutrition ***(Ismail and Zahran, 2015).***

When VAP occurs, it prolongs the ICU length of stay, ultimately increasing hospital stay and the risk of death in critically ill patients. VAP is also associated with an increased duration of mechanical ventilation and increased health care costs due to an increased ICU and hospital length of stay. VAP prolongs the length of stay by up to 50 days, and increase the duration of mechanical ventilation by 5 to 9 days which generates the substantial extra cost of care ***(Parisi, et al., 2016).***

The prevention and control of VAP in ICU said to depend on the education and sensitization of ICU staff members towards the problem and on the application of measures to prevent its occurrence. Similarly, since ventilator support directly related to critical care and its outcomes, improvements in ventilator support is required to be understood in order to improve emergency and critical care. ***(Said, 2012).***

VAP is still an important cause of morbidity and mortality in mechanically ventilated patients' event. VAP is incidence ranges from 5% to 67% depending on case mix and the diagnostic criteria used and the highest rates are in immune-compromised, surgical and elderly patients. In the United States (US); the incidence of VAP ranges from 2 to 16 episodes per 1,000 ventilator-days. The estimated risk of VAP is 1.5% per day and decreases to less than 0.5% per day after the 14^{th} day of mechanical ventilation. VAP increases the duration of hospitalization by 7 days and health-care costs by approximately $40,000 United States dollars (USD) ***(Weng, et***

al., 2017; Timsit, et al., 2017). Pneumonia rates are much higher in mechanically ventilated patients due to the artificial airway, which increases the opportunity for aspiration and colonization. Nosocomial infection still remains a challenging problem in ICUs, especially for pediatric populations ***(Jahansefat, et al., 2016; Aferu, 2016).***

In 2011, an estimated 157,000 healthcare-associated cases of pneumonia occurred in acute care hospitals in the U.S.; 39% of this pneumonia were VAP ***(CDC, 2017).*** Mortality in patients with acute lung injury on mechanical ventilation has been estimated to range from 24% in persons 15-19 years of age to 60% for patients 85 years and older. Studies have estimated that more than 300,000 patients receive mechanical ventilation in the United States each year. These patients are at high risk for complications and poor outcomes, including death ***(CDC. Module, 2017).***

The US national healthcare safety network claims that the incidence of VAP ranged from 0-4.4/1000 ventilation day.in Saudi Arabia, VAP was reported as a common device-associated infection with an overall rate of 4.52/1000 device days, with a higher incidence in medical and surgical ICU ***(Yaseen and Salameh, 2015).***

1.3 Significance of the study

The significance of this study, from a researcher's clinical experience it will provide baseline information on ICU nurses' knowledge level and practice on prevention of VAP. It will provide a strong body of scientific knowledge, which will ensure the highest standards of nursing care practice. This can be achieved through adherence to the evidence-based guidelines for the prevention of ventilator-associated pneumonia, ultimately improving patients' outcomes. Improved outcomes will shorten the patient's ICU length of stay, hospitalization as well as benefit the patient financially with decreased hospital costs. Hospitals also gain benefits as they are

continually faced with the challenge of providing cost-effective services to patients and communities ***(Ahmed and Abosamra, 2015).***.

To ensure the highest standards of nursing care, the nursing practice must be based on a strong body of scientific knowledge. This can be achieved through adherence to the evidence-based guidelines for the prevention of ventilator-associated pneumonia ***(Ahmed and Abosamra, 2015).*** The prevention of VAP is primarily the responsibility of the bedside nurse whose knowledge, beliefs, and practice influence the health outcome of ICU patients; Critical care nurses play an important role in the identification of risk factors and prevention of ventilator-associated pneumonia. Critical care nurse has an important and crucial role in preventing VAP ***(Ismail and Zahran, 2015; Ahmed and Abosamra, 2015).***

This study underscores the importance of identifying the current knowledge and practice on the prevention of VAP among the ICU nurses and finds if there are factors that contribute to reducing the level of knowledge and practices toward prevention of VAP.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter begins with providing an insight about the theoretical part and empirical part that contain the anatomy and physiology of respiratory system and mechanical ventilation. Also pneumonia especially the VAP definition, pathogenesis, pathophysiology, incidence, etiological agents, risk factors, clinical manifestation, diagnosis, management of VAP: pharmacological interventions, non-pharmacological interventions.

2.2 Anatomy and Physiology of respiratory system

2.2.1 Anatomy of the respiratory system

The respiratory system can divided into two major parts: the upper airways part and the lower airways part. The upper respiratory tract includes the nose, with its nasal cavity, frontal sinuses, maxillary sinus, larynx, and trachea. The lower respiratory tract includes the lungs, bronchi and the alveoli ***(Ionescu, 2013).***

The upper respiratory system it is contain the following: the external nose is made of cartilage and skin and is lined with a mucous membrane. Openings to the exterior are the external nares. The internal nose communicates with the Para nasal sinuses and nasopharynx through the internal nares. The nasal cavity divided by a nasal septum. The anterior portion of the cavity is called the nasal vestibule. The nose warms, moistens, and filters air and functions in olfaction and speech. The main functions of upper respiratory system it is provides for gas exchange—intake of oxygen (O2) for delivery to body cells and removal of carbon dioxide (CO2) produced by body cells. Helps regulate blood acidity or alkalinity (pH). Contains

receptor for the sense of smell, filters inspired air, produces sounds (phonation), and excretes small amounts of water and heat ***(Tortora and Nielsen, 2017).***

The pharynx (throat) is a muscular tube lined by a mucous membrane. The anatomical regions of the pharynx are the nasopharynx, oropharynx, and laryngopharynx. The nasopharynx functions in respiration. The oropharynx and laryngopharynx function both in respiration and digestion ***(Tortora and Nielsen, 2017).***

The lower respiratory system it is contain the following: The larynx (voice box) is a passageway that connects the pharynx with the trachea. It contains the thyroid cartilage (Adam's apple); the epiglottis, which prevents food from entering the larynx; the cricoid cartilage, which connects the larynx and trachea; and the paired arytenoid, corniculate, and cuneiform cartilages. The vocal folds of the larynx produce sound as they vibrate; taut folds produce high pitches, and relaxed ones produce low pitches ***(Tortora and Nielsen, 2017).***

The trachea, commonly known as the windpipe, is a tube composed of connective tissue mucosa and smooth muscle supported by C-shaped rings of cartilage that extends into the bronchi ***(Tortora and Nielsen, 2017).*** The trachea is 2.0 to 2.5 cm wide (approximately 1 inch) and 10 to 12 cm long (approximately 4 to 6 inches). The trachea terminates by branching into two tubes: the right and left primary bronchi. The bronchi are somewhat smaller in diameter than the trachea, and each passes into its respective lung ***(White, etal, 2013).***

The right bronchus is wider and more vertically positioned than the left. This difference in positioning allows foreign matter to enter the right bronchus more easily than the left. Within the lungs, the bronchi branch off into increasingly smaller

diameter tubes until they become the terminal *bronchioles*. This branch further, forming alveolar ducts that end in numerous sac-like, thin-walled structures called the *alveoli*. Collectively, the alveoli and the alveolar ducts resemble a cluster of grapes. The branching makes this portion of the respiratory tract resemble an inverted tree, giving rise to the term bronchial tree ***(White, etal, 2013).***

The lungs are paired organs in the thoracic cavity enclosed by the pleural membrane. The parietal pleura is the superficial layer that lines the thoracic cavity; the visceral pleura is the deep layer that covers the lungs. The right lung has three lobes separated by two fissures; the left lung has two lobes separated by one fissure, along with a depression, the cardiac notch ***(Tortora and Nielsen, 2017).***

The lung is made up of about 300 million alveoli, which are arranged in clusters of 15 to 20. There are three types of alveolar cells. Type I alveolar cells are epithelial cells that form the alveolar walls. Type II alveolar cells are metabolically active. These cells secrete surfactant, a phospholipid that lines the inner surface and prevents alveolar collapse. Type III alveolar cell macrophages are large phagocytic cells that ingest foreign matter (e.g., mucus, bacteria) and act as an important defense mechanism **(Tortora and Nielsen, 2017).**

- ## Regulation of breathing

The respiratory center consists of a medullary respiratory center in the medulla oblongata and the pontine respiratory group in the pons. The medullary respiratory center is made up of a dorsal respiratory group (DRG), which controls normal quiet breathing, and a ventral respiratory group (VRG), which is used during forceful breathing and controls the rhythm of breathing. The pontine respiratory group may modify the rhythm of breathing during exercise, speaking, and sleep. The breathing

may be modified by a number of factors, including cortical influences; the inflation reflex; and chemical stimuli, such as O2, CO2, and hydrogen ions (H+) levels ***(Tortora and Nielsen, 2017).***

2.2.2 Physiology of respiratory system

- **Regulation of ventilation**

Successful ventilation depends upon neuroreceptors and chemoreceptors in the lungs and central nervous system (CNS), muscles that support inspiration and exhalation, and lung elasticity. Control of ventilation provides for adequate oxygen to meet metabolic demands, such as exercise, infection, or pregnancy. Ventilation promotes exhalation of diabolically produced carbon dioxide, which is a determinant of acid-base status. The CNS sends signals to the chest wall musculature to control ventilation rate, depth, and rhythm. Chemical regulation involves the influence of chemicals, such as carbon dioxide and hydrogen ions, which affect the rate and depth of ventilation ***(Potter, et al., 2011).***

- **Respiration**

After the tissues capillary exchanges, blood enter the systemic veins and travels to pulmonary circulation. The oxygen concentration in blood within the capillaries of the lungs is lower than in the lung' air sacs (alveoli). Because of this concentration gradient, oxygen diffuses from the alveoli to the blood. Carbon dioxide, which has a higher concentration in the blood than in the alveoli, diffuses from the blood into the alveoli. Movement of air in and out of the airways (ventilation) continually replenishes the oxygen and removes the carbon dioxide from the airways and lungs. This whole process of gas exchange between the atmospheric air and the

blood and between the blood and cells of the body is called respiration ***(Hinkle and Cheever, 2017).***

- **Gas exchange**

Occurs at the alveolar capillary membrane .Venous blood from the right ventricle is pumped into the pulmonary arteries and travels to the alveolar capillary network, where it is exposed to the inhaled air. Because of the higher concentration of oxygen in the alveoli, oxygen diffuses into the blood within the alveolar capillary network. The majority of oxygen binds to the iron atoms of the hemoglobin molecule in the red blood cells. The clinical measure of oxygen attached to hemoglobin is the oxygen saturation (SaO2, SpO2). Approximately 1% to 3% of oxygen dissolves into the blood plasma ***(White, etal, 2013).***

The exchange of carbon dioxide also occurs within the alveoli. Within the alveolar capillary network, the carbon dioxide detaches from hemoglobin and diffuses into the alveolar space. Carbon dioxide is removed from the alveolar space when exhalation occurs. The blood within the pulmonary capillary network is now oxygenated and travels to the heart via the pulmonary veins. Oxygenated blood is sent to the body via the aorta and the arterial network ***(White, etal, 2013).***

2.3 Mechanical ventilation

2.3.1 Concepts of mechanical ventilation

Mechanical ventilation is an essential, lifesaving therapy for patients with critical illness and respiratory failure ***(Aykac, Ozsurekci and Basaranoglu, 2017).*** Mechanical ventilation is an important part of advanced life support in the intensive care unit (ICU) and is essential in rescuing critically ill patients ***(Chen and Wang,***

2017). Mechanical ventilation is one of the indispensable tools in pediatric intensive care units ***(Meligy, et al., 2017).***

A mechanical ventilation: is ventilation of the lunge by artificial means usually by a ventilator once a patient's partial pressure of arterial oxygen (PaO2) cannot be maintained by the basic methods of oxygen delivery systems i.e. masks ,cannula; endotracheal intubation and mechanical ventilation (MV) are instituted A. ventilator delivers gas to the lungs with either negative or positive pressure. It is used in acute setting such as in the ICU for a short period of time during a serious illness. It may be used at home or in a nursing or in the rehabilitation institution if the patient have chronic illnesses that require long-time ventilation assistance. Caring for a patient on mechanical ventilation has become an integral part of nursing care in critical care or general medical-surgical units, extended care facilities, and the home. Nurses, physicians, and respiratory therapists must understand each patient's specific pulmonary needs and work together to set realistic goals ***(Goldsworthy and Graham, 2014).***

Patients receiving invasive mechanical ventilation are at risk for numerous complications, including pneumonia ***(CDC. Control, 2017).*** More than 300,000 patients receive mechanical ventilation in the United States each year. These patients are at high risk for complications and poor outcomes, including death ***(CDC. Module, 2017).*** Positive patient outcomes depend on an understanding of the principles of mechanical ventilation and the patient's care needs as well as open communication among members of the health care team about the goals of therapy, weaning plans, and the patient's tolerance of changes in ventilator settings ***(Goldsworthy and Graham, 2014).***

2.3.2 Classification of ventilators

Mechanical ventilators are classified according to the method by which they support ventilation. The two general categories are negative-pressure ventilators and positive-pressure ventilators ***(Goldsworthy and Graham, 2014).***

2.3.2.1 Negative-pressure ventilators

Exert a negative pressure on the external chest. Decreasing the intra thoracic pressure during inspiration allows air to flow into the lung, filling its volume. Physiologically, this type of assisted ventilation is similar to spontaneous ventilation. It is used mainly in chronic respiratory failure associated with neuromuscular conditions, such as poliomyelitis, muscular dystrophy, amyotrophic lateral sclerosis, and myasthenia gravis. It is inappropriate for the patient whose condition is unstable or complex or who requires frequent ventilator changes. Negative- pressure ventilators are simple to use and do not require intubation of the airway; consequently, they are especially adaptable for home use. There are several types of negative-pressure ventilators. (Iron lung, body wrap and chest cuirass) ***(Goldsworthy and Graham, 2014).***

- **Iron lung (Drinker Respirator Tank)**

The iron lung is a negative-pressure chamber used for ventilation. It was used extensively during polio epidemics in the past and currently is used by a few polio survivors and patients with other neuromuscular disorders (e.g. amyotrophic lateral sclerosis, muscular dystrophy) ***(Goldsworthy, Graham, 2014; Suddarths, 2010).***

- **Body Wrap (Pneumo-Wrap) and Chest Cuirass (Tortoise Shell)**

The body wraps and chest cuirass are portable devices that require a rigid cage or shell to create a negative-pressure chamber around the thorax and abdomen. Because of problems with proper fit and system leaks, these types of ventilators are used only with carefully selected patients ***(Goldsworthy and Graham, 2014).***

2.3.2.2 Positive-pressure ventilators

Today, the most common ventilators use positive pressure. Positive pressure ventilators inflate the lungs by exerting positive pressure on the airway, pushing air in, similar to a bellows mechanism, forcing the alveoli to expand during inspiration. Expiration occurs passively. Endotracheal intubation or tracheostomy is usually necessary. These ventilators are widely used in the hospital setting and are increasingly used in the home for patients with primary lung disease. Three types of invasive positive-pressure ventilators are classified by the method of ending the inspiratory phase of respiration. (Pressure-cycled, time-cycled and volume-cycled-flow cycled). The fourth type, noninvasive positive-pressure ventilation, does not require intubation ***(Montgomery, et al., 2015;*** **Goldsworthy and Graham, 2014).**

- **Pressure-cycled ventilators**

When the pressure-cycled ventilator cycles on, it delivers a flow of air (inspiration) until it reaches a preset pressure, and then cycles off, and expiration occurs passively. Its major limitation is that the volume of air or oxygen can vary as the patient's airway resistance or compliance changes. As a result, the tidal volume delivered may be inconsistent, possibly compromising ventilation. Consequently, in adults, pressure cycled ventilators are intended only for short-term use. The most

common type is the intermittent positive pressure breathing (IPPB) machine ***(Goldsworthy and Graham, 2014).***

- **Time-cycled ventilators**

Time-cycled ventilators terminate or control inspiration after a preset time. The volume of air the patient receives is regulated by the length of inspiration and the flow rate of the air. Most ventilators have a rate control that determines the respiratory rate, but pure time cycling is rarely used for adults. These ventilators are used in newborns and infants ***(Goldsworthy and Graham, 2014).***

- **Volume-cycled ventilators**

Volume-cycled ventilators are by far the most commonly used positive-pressure ventilators today the volume of air delivered with each inspiration is preset. Once this preset volume is delivered to the patient, the ventilator cycles off and exhalation occurs passively ***(Goldsworthy and Graham, 2014).***

- **Flow-cycled ventilators**

Flow cycling the inspiratory phase switches when the gas flow falls below a certain level (i.e. once the breath is complete)***(Montgomery, et al., 2015).***

- **Noninvasive Positive-Pressure Ventilation**

Noninvasive positive-pressure ventilation (NIPPV) is a method of positive-pressure ventilation that can be given via face masks that cover the nose and mouth, nasal masks, or other oral or nasal devices such as the nasal pillow (a small nasal cannula that seals around the nares to maintain the prescribed pressure). It eliminates

the need for endotracheal intubation or tracheostomy and decreases the risk of nosocomial infections such as pneumonia ***(Goldsworthy and Graham, 2014).***

2.3.3 Goals of mechanical ventilation

The main of mechanical ventilation to improve gas exchange (reverse hypoxemia relieve acute respiratory acidosis), to relieve respiratory distress (reduce oxygen cost of breathing reverse respiratory muscle fatigue), to improve pulmonary mechanics (prevent and reverse atelectasis, improve compliance, prevent lung injury), to permit lung and airway healing (maintain lung and airway Functions), to avoid complications (protect lung and airway, prevent disuse respiratory muscle dystrophy) ***(David W. Chang, James H. Hiers, 2014).***

2.3.4 Components of mechanical ventilation

The mechanical ventilators are comprised of four main elements: 1. A source of pressurized gas including a blender for air and O2. 2.An inspiratory valve, expiratory valve and ventilator circuit. 3. A control system, including control panel, monitoring and alarms. 4. A system to sense when the patient is trying to take breath ***(Hugh Montgomery, Luigi Camporota, 2015).***

2.3.5 Indications for mechanical ventilation

The mean indication for mechanical ventilation can be determined in the three indications to support acute ventilator failure, to reverse life-threatening hypoxemia and to decrease the work of breathing ***(Baid.H, Creed.F, 2016).***

Another study showed the Indications for use the mechanical ventilation in an acute respiratory failure. Unable to stabilize the chest wall (i.e., trauma, flail chest, penetrating injuries), after major surgery to maintain oxygenation. Cardiogenic or

septic shock to decrease myocardial workload and maintain oxygenation, Severe asthma/anaphylaxis, Acute respiratory distress syndrome (ARDS), Pneumonia, Burns and smoke inhalation, neuromuscular disease (i.e., Guillain-Barre, amyotrophic lateral sclerosis, overdose, brainstem injury, chronic obstructive pulmonary disease (COPD) (i.e., emphysema, cystic fibrosis). PaO 2 < 50 mmHg with an fractional concentration of inspired oxygen (FiO2) of >.60 (oxygenation issue). pH < 7.25 (ventilation issue) and Arterial PaCO 2 < 30 or > 50 ***(Goldsworthy and Graham, 2014; David W. Chang, James H. Hiers, 2014).***

2.3.6 Ventilator settings

The ventilator should be checked according to agency policy, as well as whenever changes are noted to the patient's condition. This is performed as often as every 1 to 4 hours. Depending on the jurisdiction, this duty may be shared between the registered nurse and the registered respiratory therapist. The nurse responsible for the patient needs to be aware of the alarm-level settings. The settings the nurse needs to be familiar with:

Adjust the ventilator mode according to patient case. Tidal volume (VT) is the volume of gas delivered with each breath. Usually this is set at 6 to 8 mL/kg ideal body weight for normal lungs, Fractional concentration of inspired oxygen (FiO2) is set from 0.21 to 1.0 to maintain the patient's PaO2 greater than 60 mmHg and a SaO2 of at least 90%, according to the arterial blood gas (ABG) values or start high, and reduce depending on monitored SaO2. In a severely hypoxic patient, start with 100% to be safe. Respiratory rate (RR) is the frequency of breath delivered by the ventilator the normal range from 14-16 per minute; this may be changed frequently, depending on the patient's work of breathing (WOB), comfort level, pH, and PaCO2. Positive

end expiratory pressure (PEEP): 5 cmH2O. (In severe asthma, perhaps ‘ZEEP’ or zero PEEP, to start with. In pulmonary edema / ARDS, much higher start at 8-10 cmH2O). Sensitivity is set to make the ventilator sensitive to the patient’s inspiratory effort. If set too high, patient–ventilator dyssynchrony may occur. If set too low, this will increase the work of breathing when the patient attempts to initiate a breath the normal Sensitivity / trigger : - 0.5 cm. Inspiratory-to-expiratory ratio (I:E) ratio needs to be set to Time the respiratory cycle at 1:2. This can be altered to prolong the expiratory phase for patients with COPD, pressure limit : - 10 – 25 cmH2O ***(Goldsworthy and Graham, 2014; Montgomer, et al., 2015).***

2.3.7 Modes of ventilator support

ICU ventilators can be very confusing because of the array of different modes. Unfortunately there is no standard nomenclature in use and modes that are essentially the same can have quite different names according to the ventilator manufacturer. However most modes can be classified according to the following questions: 1. How is the breath delivered: a preset pressure, or a preset volume? 2 Are the breaths delivered at a set frequency (controlled mode), in response to patient’s respiratory efforts spontaneous mode (SM) or a combination of both assist-control or spontaneous-assisted (CACM) ***(Montgomery, et al., 2015).***

The modes that are in common use are outlined in three Maine modes (Controlled mode, Supported (spontaneous) mode, Combination mode).

- **Controlled modes**

Every breath delivered to patient is a mechanical breath (breath may be triggered by a timing mechanism or patient effort). Volume Control mode (VCM): A minute or tidal volume is preset and is delivered by the ventilator until the preset

volume is reached, breaths are delivered at a preset frequency/rate, pressure is variable throughout the delivered breath, and flow is constant throughout the breath. Pressure control mode (PCM): A pressure level is preset in which the volume of gas is delivered until the preset pressure has been reached, breaths are delivered at a preset frequency/ rate, pressure is constant throughout the delivered breath, tidal and minute volume are variable, flow is variable throughout the breath. In pressure regulated volume control (PRVC): An alternative to straight pressure control and/or volume control, in this mode we attempt to obtain best of both volume and pressure control, PRVC regulates pressure to changing compliance of lungs to adjust inspiratory flow and pressure to maintain a set tidal volume, breaths are delivered at a preset frequency (timing mechanism) and may also be patient-triggered ***(Goldsworthy and Graham, 2014; Montgomery, et al., 2015).***

- **Supported (spontaneous) modes**

Every breath is spontaneous (i.e., patient triggered and patient cycled) but supported by ventilator. Pressure support / contenous positive airway pressure (CPAP): Pressure Support is a patient-initiated breathing mode in which ventilator supports patient effort, provides a small amount of pressure during inspiration to help patient draw in a spontaneous breath, reduces work of breathing. Volume support mode (VSM): A patient-adapted constant inspiratory support is supplied when activated by patient effort, Volume is continuously monitored and inspiratory pressure automatically adjusts to maintain targeted tidal volume, patient determines frequency, pressure pattern constant, and flow pattern decelerating. Neutrally adjusted ventilator assists (NAVA): Patient-initiated synchronized breathing mode**,** breathing support is triggered by the electrical activity of the diaphragm (Edi)**,** patient controls the respiratory rate, inspiratory time, and the tidal volume with assist from the ventilator**,**

NAVA level is multiplied by the measured signal to provide a pressure which is proportional and synchronized to the patient's effort ***(Goldsworthy and Graham, 2014; Montgomery, et al., 2015).***

- **Combination modes**

it is combination of both controlled and supported. Synchronized Intermittent Mandatory Ventilation (Volume Control) + Pressure Support SIMV (VC+ PS): mandatory breaths are volume Control breaths (controlled)**,** spontaneous breaths are pressure support (supported) and ventilator provides mandatory breaths which are synchronized with patient's spontaneous efforts at a preset rate**.** SIMV (PC + PS): Synchronized intermittent mandatory ventilation (Pressure Control) + Pressure support, mandatory breaths are pressure control breaths (controlled)**,** spontaneous breaths are pressure support (supported), and ventilator provides mandatory breaths which are synchronized with patient's spontaneous efforts at a preset rate. SIMV (PRVC) + PS: Synchronized intermittent mandatory ventilation (Pressure Regulated Volume Control) + Pressure support, mandatory breaths are PRVC breaths (controlled)**,** spontaneous breaths are pressure support (supported) and ventilator provides mandatory breaths**,** which are synchronized with patient's spontaneous efforts at a preset rate**.** Bi-level positive airway pressure (Bi-vent): Pressure controlled breathing that allows the patient the opportunity of unrestricted spontaneous breathing**,** two pressure levels are set together with the individually set duration of each level**,** spontaneous breathing efforts can be assisted by pressure support**,** decelerating flow pattern, constant pressure patter***n (Goldsworthy and Graham, 2014; Montgomery, et al., 2015).***

2.3.8 Complications of mechanical ventilation

Airway complications such as (aspiration, decreased clearance of secretions, ventilator-acquired pneumonia). Endotracheal tube complications such as (tube kinked or plugged, rupture of piriform sinus, tracheal stenosis or tracheomalacia, mainstem intubation with contralateral lung atelectasis, cuff failure, sinusitis, otitis media, laryngeal edema). Mechanical complications such as (hypoventilation with atelectasis, hyperventilation with hypocapnia and respiratory alkalosis, barotrauma (pneumothorax or tension pneumothorax, pneumomediastinum, subcutaneous emphysema), alarm "turned off", failure of alarms or ventilator, inadequate nebulization or humidification, overheated inspired air resulting in hyperthermia). Physiological complications such as (fluid overload with humidified air and sodium chloride retention, depressed cardiac function and hypotension, stress ulcers, paralytic ileus, gastric distention, starvation, dyes-synchronous breathing pattern ***(Yaseen and Salameh, 2015).***

2.3.9 Weaning from mechanical Ventilation

Weaning is the process of withdrawing mechanical ventilatory support and transferring the work of breathing from the ventilator to the patient. In most cases, weaning may be accomplished rapidly from full ventilatory support to unassisted spontaneous breathing. Many patients can tolerate an abrupt termination of ventilatory support; this would include those who have been on the ventilator for a relatively short time (usually no more than 1 to 2 days) and who have also regained normal cardiopulmonary function. Examples include patients recovering from post anesthesia, drug overdose, and status asthmaticus. For other patients, successful weaning requires a more gradual withdrawal of mechanical ventilatory support.

Generally, the longer the patient has been on mechanical ventilation, the more gradual the weaning process should be. The process of gradually reducing mechanical ventilatory support must be individualized and the weaning process may take from days to weeks or even months. Indeed, some patients become ventilator-dependent and may not be able to maintain adequate ventilation without mechanical assistance. Examples of these patients include high cervical spine injury, traumatic brain injury, and some neuromuscular diseases ***(David, James, 2014).***

Table 1: Guidelines for weaning from short-term ventilation

Readiness Criteria

- Hemodynamically stable, adequately resuscitated, and not requiring vasoactive support
- SaO2 greater than 90% on FiO2 40% or less, PEEP 5 cm H2O or less
- Chest radiograph reviewed for correctable factors; treated as indicated
- Metabolic indicators (serum pH, major electrolytes) within normal range
- Hematocrit more than 25%
- Core temperature more than 36°C and less than 39°C
- Adequate management of pain/anxiety/agitation
- No residual neuromuscular blockade
- ABG values normalized or at patient's baseline
- Weaning Intervention
- Reduce ventilator rate, then convert to pressure-support ventilation (PSV) only.
- Wean PSV as tolerated to 10 cm H2O or less.
- If patient meets tolerance criteria for at least 2 hours on this level of support and meets extubation criteria (see later), may extubate.
- If patient fails tolerance criteria, increase PSV or add ventilator rate as needed to achieve "rest" settings (consistent respiratory rate <20 breaths/min) and review weaning criteria for correctable factors.
- Repeat wean attempt on PSV 10 cm after rest period (minimum, 2 hours). If patient fails second wean trial, return to rest settings and use "long-term" ventilation weaning approach.

Tolerance Criteria:

- If the patient displays any of the following, the weaning trial should be stopped and the patient returned to "rest" settings.
- Sustained respiratory rate greater than 35 breaths/min
- SaO2 less than 90%
- Tidal volume 5 mL/kg or less
- Sustained minute ventilation greater than 200 mL/kg/min
- Evidence of respiratory or hemodynamic distress: (Labored respiratory pattern, increased anxiety, diaphoresis, or both, sustained heart rate greater than 20% higher or lower than baseline, systolic blood pressure exceeding 180 mm Hg or less than 90 mm Hg

Extubation Criteria

- Mental status: alert and able to respond to commands.
- Good cough and gag reflex and able to protect airway and clear secretions
- Able to move air around the endotracheal tube (ETT) with cuff deflated and end of tube occluded

Guidelines for weaning from short-term ventilation adapted from (Yaseen and Salameh, 2015).

2.4 Pneumonia

Pneumonia is an infection that involves a complex set of steps, beginning with initial contact with a pathogenic microorganism and culminating in the invasion of the lower respiratory tract. This infection can be acquired in the community or within the hospital setting, and can be transmitted by aspirated or inhaled microorganisms Pneumonia is a severe health problem and a significant cause of mortality and

morbidity worldwide. In 2013, pneumonia was the eighth most common cause of death in the United States .In the US alone it is responsible for approximately 1.1 million hospital admissions, 50,000 deaths, and close to 14,000 hospital readmissions per year . Pneumonia can be bacterial, viral, or fungal (but most commonly bacterial). It is important to understand the role of the different pathogens in the microbial etiology of pneumonia to effectively manage and guide appropriate to diagnostic testing, management issues, and antimicrobial treatment and prevention ***(Bin, et al., 2017).***

Pneumonia is an inflammation of the lung, which is characterized by exudation into the alveoli. It can be classified anatomically as lobar or by a etiology. Community acquired—not hospitalized or residing in a long-term care facility for ≥ 14 days prior to onset of symptoms. Hospital acquired—more than 48 h between admission and onset of symptoms. Ventilator associated—more than 48–72 h between intubation and onset of symptoms. Aspiration—micro-aspiration of bacteria colonizing the upper respiratory tract, macro-aspiration of gastric contents, indirect transmission from staff, inhaled aerosols ***(Badoor, 2014).***

Pneumonia is infection of the lung. Depending on the type and severity of the infection and the overall health of the person, it may result in acute respiratory failure. Pneumonia can be caused by most types of microorganisms, but is most commonly a result of bacterial or viral infection. Pneumonia remains a common infection found in both the community and hospital, even though there have been advances in identifying people at risk and implementing preventive measures specialist of the Critical care nurses. In the United States, pneumonia is the leading cause of death from infectious disease, the second most common nosocomial (hospital-acquired) infection, and the eighth leading cause of death ***(Yaseen and Salameh, 2015).***

Pneumonia is one of the most common precipitating causes for ICU admission. It is a frequent cause of hemodynamic compromise and septic shock. Pneumonia is also one of the most common causes for the acute respiratory distress syndrome. Pneumonia on admission to the intensive care unit presents in three different forms: traditional community-acquired pneumonia, hospital-acquired pneumonia (HAP), and the controversial entity of health care–associated pneumonia (HCAP). HCAP is a community-onset pneumonia but with risk factors for pathogens more typical of HAP. In addition, presence of any number of immunocompromised states within each of these entities raises concern for a broader spectrum of potential etiologies, especially opportunistic pathogens. While VAP is technically a subgroup of HAP, this type of pneumonia occurs as a complication of critical illness, rather than the precipitating cause of critical illness. As such, VAP ***(Aelami, Lotfi and Zingg, 2014).***

2.5 Ventilator associated pneumonia

Ventilator-associated pneumonia (VAP) is one of the most frequent hospital-acquired infections occurring in mechanically ventilated patients and is associated with increased mortality, ICU stay, and health-related costs. VAP occurrence is closely related to intubation and the presence of the endotracheal tube (ETT) itself. Thus, effective preventive strategies are of pivotal importance and a major concern in ventilated patients ***(Frca et al., 2018; Mietto, et al., 2013).***

2.5.1 Definition of VAP

Ventilator associated pneumonia (VAP) is the most common nosocomial infection acquired in the intensive care unit (ICU). It is defined as an inflammation of the lung parenchyma occurring 48 to 72 hours or more following endotracheal

intubation, and is characterized by the presence of either new or progressive infiltrates, signs of systemic infection, changes in sputum characteristics and detection of an organism not present at the time mechanical ventilation (MV) was begun ***(Morgan, 2017).***

VAP is one of the most frequent hospital-acquired infections encountered in critically ill patients receiving mechanical ventilation. VAP is defined as pneumonia that develops 48 hours after a patient has been placed on mechanical ventilation. It is an important subset of hospital-acquired pneumonia, which is pneumonia that occurs 48 hours or longer after admission to the hospital and results from an infection that was not incubating at the time of admission ***(Cairo, 2016).***

According the criteria defined by the American Thoracic Society/Infectious Disease Society of America there are three types of pneumonia related with healthcare: Hospital acquired (or nosocomial) pneumonia is pneumonia that occurs 48 hours or more after admission and did not appear to be incubating at the time of admission. VAP is a type of hospital- acquired pneumonia that occurs more than 48 to 72 hours after endotracheal intubation ***(Eno, 2014).***

2.5.2 Pathogenesis of VAP

The pathogenesis of VAP is mainly two main subsequent mechanisms: colonization of the respiratory tract and aspiration of colonized secretions. The presence of the ETT is considered a foreign body that contributes to VAP, as its surface gets colonized by bacteria that then contaminate secretions. This is related to biofilm formation, which is characterized by aggregation of microorganisms on the ETT within hours of intubation, and acts as a reservoir for bacteria that create resistance against antimicrobial agents. Endotracheal intubation also violates natural

defence mechanisms, including cough reflex and mucociliary clearance of secretions, and facilitates a direct connection between the upper and the lower respiratory tract ***(Folos, et al., 2017).*** This causes the secretions to accumulate in the upper respiratory tract and become colonized by pathogenic virulent organisms, as well as translocate into the lower airways. ***(Blot, Poelaert and Kollef, 2014).***

During critical illnesses, particularly in patients with an endotracheal tube and receiving mechanical ventilation, there is a dramatic shift in the flora of the oropharyngeal tract to gram-negative bacilli and S. aureus. This shift in flora may be attributed to a number of factors that compromise host defense mechanisms, including comorbidities, malnutrition, reduced levels of mucosal immunoglobulin A, increased production of proteases, exposed and denuded mucous membranes, elevated airway pH, and an increased number of airway receptors for bacteria as a result of acute illness and prior antimicrobial use ***(Cairo, 2016).*** Following bacterial aspiration and colonization of the proximal airways, the occurrence of VAP mainly depends on the size of the inoculum, functional status, exposure to antibiotics, and potential host defenses **(Cal, *et al.*, 2012).**

Tracheal intubated patients can be colonized via exogenous and endogenous bacterial sources. Patients are colonized from exogenous bacterial sources via the hands and apparel of healthcare personnel, contaminated aerosols, and invasive devices such as tracheal aspiration catheters and fiberoptic bronchoscopes. Pathogens are also acquired from the patient's endogenous flora, though there is still controversy regarding the primary source of infection (oropharynx, stomach). It is well acknowledged, however, that in critically ill patients, oral flora quickly shifts to a predominance of aerobic Gram-negative pathogens pseudomonas aeruginosa and methicillin-resistant staphylococcus aureus. Following bacterial aspiration and

colonization of the proximal airways, the occurrence of VAP mainly depends on the size of the inoculum, functional status, exposure to antibiotics, and potential host defenses ***(Cal, et al., 2012).***

2.5.3 Incidence of VAP

Ventilator associated pneumonia incidence is 1–4/1000 ventilator days, but it can be high as 10/1000 ventilator days ***(Akdogana, et al., 2017).*** VAP is estimated to occur in 9 to 28 percent of all patients who are mechanically ventilated for more than 24 hours, but this incidence depends on case mix and diagnostic criteria used. It accounts for almost 50 per cent of ICU acquired infection. More severely ill patients and those with significant co-morbidities have a higher mortality and are especially prone to VAP, making it difficult to determine the independent contribution VAP makes to mortality. Recent studies suggest that the attributable mortality is estimated at 4.4 to 9 percent. It is associated with a prolonged duration of mechanical ventilation, increased ICU, hospital length of stay and healthcare costs ***(Morgan, 2017).***

VAP represents approximately 80% of hospital acquired infection, the incidence of VAP is variable but is thought to sit between 1 - 4 cases per 1000 ventilator-case days in medical patients, and up to 10 cases per 1000 ventilator-case days in surgical patients, In general, this equates to between 8% and 28% of ICU patients ***(Dinko. Tonković, 2014).*** Mean incidence of the VAP in internal and surgery ICUs has been reported as 3.6 per 1000 days of ventilation, and it varies in developing countries from 10 to 41.7 per 1000 days ***(Yaghoubinia, et al., 2017).***

Studies have estimated that each year more than 300 000 patients receive mechanical ventilation in the United States, whereas in Europe there is a lack of

reliable data, because of a paucity of funding in this field of epidemiology ***(Martin-loeches, et al., 2018).***

VAP is common in critical care patients and is responsible for around half of all antibiotics given to patients in ICUs. The International Nosocomial Infection Control Consortium suggest that the overall rate of VAP is 13.6 per 1000 ventilator days. However, the individual rate varies according to patient group, risk factors, and hospital setting. The average time taken to develop VAP from the initiation of MV is around 5 to 7 days, with a mortality rate quoted as between 24% and 76% ***(Miller, 2018).***

The mortality rate of VAP generally ranges between 25% to 50%; however, it may increase to 70% in some cases. According to the data of the National Nosocomial Infections Surveillance System, approximately 2.4–14.7 of pneumonia cases develop in 1000 ventilator days ***(Karakuzu, et al., 2018).***

VAP occurs in 28% of patients who receive mechanical ventilation, where its rate of occurrence varies with the duration of mechanical ventilation. Estimated rates are 3% per day for the first 5 days, 2% per day for days 6–10, and 1% per day after day 10. The mortality rate for VAP ranges between 27 and 76%. Pseudomonas or Acinetobacter pneumonia is associated with higher mortality rates than those associated with other organisms ***(Abdelrazik and Salah, 2017).***

VAP is a life-threatening complication with mortality rates of 33% to 50%. It is reported to occur in 10–25% of patients given mechanical ventilation. The risk of VAP is highest immediately after intubation. VAP is estimated to occur at a rate of 3% per day for the first 5 days, 2% per day for next 5 days, and 1% per day thereafter. VAP occurs more frequently in trauma, neurosurgical, or burn units than in respiratory units and medical intensive care units ***(Sachdeva, et al., 2015).***

2.5.4 Etiologic agents of VAP

- **Ventilator circuit versus the artificial airway**

VAP is the result of organisms introduced into the respiratory tract during mechanical ventilation. This can arise from the ventilator circuit or by aspiration of contaminated secretions from above the cuff of the artificial airway. If a clean circuit is used and the patient is never disconnected, the organisms that accumulate in the circuit arise from the patient. However, if the circuit is disconnected and care is not taken to avoid contamination, the circuit could potentially cause VAP. This, however, is less likely to occur than the aspiration of contaminated Oropharyngeal secretions. The primary source of VAP is the aspiration of contaminated oropharyngeal secretions around the airway cuff. This occurs because oflongitudinal folds that develop in inflated cuffs. To minimize this leakage, it is important to avoid accumulation of secretions above the cuff and to ensure that gastric contents do not move into the pharynx ***(Hess and Kacmarek, 2014).***

The causative microbial agents of VAP mostly include two common aerobic organisms, gram-negative bacilli and gram-positive organisms**.** Early-onset VAP is caused by pathogens that are sensitive to antimicrobial agents and occurs within the first 4 days post-intubation and is usually due to antibiotic sensitive bacteria, including gram-positive organisms such as Staphylococcus aureus, and gram-negative bacilli such as Klebsiella pneumonia and Escherichia coli. In contrast, Late VAP infection is caused by multi-drug resistant (MDR) gram-negative bacilli develops five or more days after intubation including the methicillin-resistant S. aureus (MRSA), Pseudomonas aeruginosa, and Acinetobacter spp, and is mostly accompanied by with poor prognosis ***(Folos, et al., 2017; Morgan, 2017).***

2.5.5 Risk factors of VAP

Risk factors that lead to nosocomial pneumonia are oropharyngeal colonization, gastric colonization, aspiration, and compromised lung defenses. Mechanical ventilation, re-intubation, self-extubation, presence of a nasogastric tube, and supine position are a few of the associated risk factors for VAP. Maintenance of the natural gastric acid barrier in the stomach plays a major role in decreasing incidence and mortality from nosocomial pneumonia. The widespread use of antacids or histamine (H2) blockers can predispose the patient to nosocomial infections because they decrease gastric acidity (increase alkalinity). These medications are used to guard against stress bleeding and may increase colonization of the upper gastrointestinal tract by bacteria that thrive in a more alkaline environment ***(Morton and Fontaine, 2017).***

The existence of definite host, pharmacological or environmental factors can lead to increase propensity of VAP in critical care patients. Risk factors identified from literature for the development of VAP have been detailed in Table 2. These factors can be distinguished into non-modifiable and modifiable risk factors ***(Zubair, et al., 2017).***

Table 2: Risk factors for VAP.

Host associated	**Non-modifiable risk factors**	• Age • Sex • Medical conditions (Underlying) • ARDS, COPD • Head trauma
	Modifiable risk factor	• Intubations (number and frequency) • Time comparisons for circuit change (24 h vs. 48 h) • Body position of patient • Consciousness scale • Use of medications/antibiotic
Device associated		• Endotracheal tubing • Ventilator circuit • Orogastric or Nasogastric tubes
Personnel related		• Inappropriate hand washing practice • Poor gloves changing protocol during patients contact • Lack of use of personal protective utensils when antibiotic resistant pathogens have been recognized.

Risk factors for VAP adopted from (Zubair *et al.*, 2017) .

Lower respiratory tract infections in intubated patients include ventilator-associated tracheobronchitis (VAT) and VAP. Both are hospital-acquired infections that occur within 48 h after intubation. VAP that occurs during the first 4 days of MV is defined as early onset in order to differentiate it from late-onset VAP, which develops thereafter the term ventilator-associated pneumonia, however, is a misnomer, as the MV is not the main risk factor for lung colonization and pneumonia ***(Cal , et al., 2012).***

Endotracheal intubation followed by prolonged MV remains the main risk factor for VAP development ***(Folos, et al., 2017).*** Patients at increased risk include those who are immunocompromised, the elderly, and those with chronic illnesses (e.g. lung disease, malnutrition, obesity) ***(Baid, et al., 2016).***

VAP develops 48h or later after commencement of mechanical ventilation via endotracheal tube or tracheostomy. It develops as a result of colonization of the lower respiratory tract and lung tissue by pathogens. Intubation compromises the integrity of the oropharynx and trachea, allowing oral and gastric secretions to enter the airways. VAP is the most frequent post-admission infection in critical care patients, and significantly increases the number of mechanical ventilation days, the length of critical care stay, and the length of hospital stay overall ***(Baid, et al., 2016).***

Some of these risk factors may already be present at admission to the intensive care unit (ICU), such as advanced age, presence of a respiratory or cardiovascular system disease, organ failure, burns, trauma, acute respiratory distress syndrome, gastric colonization, sinusitis, high-volume gastric aspiration, and seasonal changes. Others include the risk factors that develop and can be changed during the diagnosis and treatment processes in the ICU. These risk factors influence development by impairing the defense mechanisms of the host ***(Karakuzu, et al., 2018).***

2.5.6 Pathophysiology of VAP

The pathophysiology of VAP involves 2 main routes: colonization of the respiratory and digestive tracts and secreted micro aspiration of superior and inferior segments of airway. Initiation of VAP is categorized into two forms: a) Rapid onset: VAP associated with antibiotic-susceptible species and occurs within 48-96 h after intubation. b) Late-onset: It is connected with resistant organisms and occurs more than 96 h after intubation ***(Zubair, et al., 2017).***

VAP is the presence of an ETT or tracheostomy, both of which interfere with the normal anatomy and physiology of the respiratory tract, specifically the functional mechanisms involved in clearing secretions (cough and mucociliary action). Intubated

patients have a reduced level of consciousness that impairs voluntary clearance of secretions, which may then pool in the oropharynx. This leads to the macroaspiration and microaspiration of contaminated oropharyngeal secretions that are rich in harmful pathogens ***(Miller, 2018).***

Normal oral flora start to proliferate and are able to pass along the tracheal tube, forming an antibiotic-resistant biofilm which eventually reaches the lower airways. Critically unwell patients exhibit an impaired ability to mount an immune response to these pathogens, leading to the development of a pneumonia ***(Miller, 2018).***

Bacterial migration of the lungs can be caused by spread of organisms from many different sources including the oropharynx, sinus cavities, nares, dental plaque, gastrointestinal tract, patient-to-patient contact, and the ventilator circuit. Inhalation of colonized bacteria from any of these sources can cause an active host response and, finally, VAP ***(Khezri, et al., 2014).***

Aspiration of the contaminated oropharyngeal secretions and, in some cases, gastroesophageal contents can occur because the patient is unable to protect the lower airways. Impaired level of consciousness, gastroesophageal reflux, a blunted gag reflex, and abnormal swallowing can all contribute to the risk of aspiration. After these offending organisms penetrate and colonize the lower airways, they can overwhelm already compromised pulmonary cellular and humoral immune defense mechanisms and eventually lead to VAP ***(Cairo, 2016).***

2.5.7 Clinical manifestation of VAP

- **Ventilator-associated condition (VAC)**

is greater than or equal to 2 days of stable or decreasing daily minimum positive end expiratory pressure (PEEP) or daily minimum fraction of inspired oxygen (Fio2) followed by an increase in daily minimum PEEP greater than or equal to 3 cm of H2O or daily minimum Fio2 greater than or equal to 0.20 points sustained for greater than or equal to 2 calendar days ***(Wiener-Kronish, 2016).***

- **Infection-related ventilator-associated complication (IVAC)**

is triggered by the presence of possible infection indicators concurrent with VAC onset, namely, an abnormal temperature (below 36°C or above 38°C) or white blood cell count (less than or equal to 4,000 or greater than or equal to 12,000 cells/mm3) and 1 or more new antibiotic starts that continue for greater than or equal to 4 days ***(Wiener-Kronish, 2016).***

Possible VAP and probable VAP. Possible VAP is defined as Gram stain evidence of purulent pulmonary secretions or a pathogenic pulmonary culture in a patient with infection – related ventilation associated complication (IVAC). Probable VAP is defined as Gram stain evidence of purulence plus quantitative or semi-quantitative growth of a pathogenic organism beyond specified thresholds. Probable VAP can also be triggered by positive tests for respiratory viruses, *Legionella* species, pleural fluid cultures, and suggestive histopathology with or without an abnormal Gram stain result ***(Klompas, et al., 2014).***

2.5.8 Diagnosis of VAP

The clinical criteria to diagnose VAP include the presence of new or progressive radiographic infiltrates in addition to one or more of the following: fever,

purulent secretions, leukocytosis, tachypnea, diminished tidal volume, and hypoxemia. Radiographic signs alone are too nonspecific (Wiener-Kronish, 2016). Analytical determinations and the scores from various rating scales such as the clinical pulmonary infection score (CPIS). It is also known that the clinical criteria for the diagnosis of VAP have high sensitivity but low specificity; other complications in critically ill ventilated patients such as atelectasis, pulmonary oedema, pulmonary embolism and pulmonary trauma may closely resemble VAP ***(Torres, et al., 2018)***.

Diagnosis of VAP is difficult due to the number of differential diagnoses that present with the same signs and symptoms (e.g. sepsis, acute respiratory distress syndrome (ARDS), cardiac failure, lung atelectasis). Radiological changes include consolidation and new or progressive infiltrates. Clinical signs include pyrexia > 38°C, raised or reduced white blood cell (WBC) count, new-onset purulent sputum, increased respiratory secretions/suctioning requirements, and worsening gas exchange. Microbiology criteria include a positive blood culture growth not related to any other source, and positive cultures from bronchoalveolar lavage ***(Baid, et al., 2016).***

- ## Clinical Pulmonary Infection Score

The Clinical Pulmonary Infection (CPIS) score is calculated on the basis of points assigned for various signs and symptoms of VAP. Scores can range between 0 and 12 with a score greater than 6 suggestive of a diagnosis of VAP. It is poorly predictive in trauma and burns patients ***(Ding, et al., 2017).***

Table 3: Clinical criteria used in the diagnosis of VAP

Criterion	Points		
	0	**1**	**2**
Temperature	≥ 36.5C to ≤ 38.4C	≥ 38.5C to ≤ 38.9C	≤ 36 C to ≤ 39C
Blood leukocytes(/µL	≥ 4000 to ≤ 11 000	< 4000 or >11000	<4000 or >11000 + bands (>500)
Tracheal secretions	Rare	Abundant	Abundant and purulent
Chest X ray infiltrates	None	Diffuse	Localized
PaO2 /FiO2	>240 or ARDS		<240 and no ARDS
Microbiology	Negative		Positive

Clinical criteria used in the diagnosis of VAP adopted from (Cunha, 2009).

It is generally accepted that measurements of CPIS should be performed at the beginning of antibiotic therapy and after 2 to 3 days to evaluate the effectiveness of the treatment course. Although some investigators have found considerable inter-observer variability and a lack of specificity to guide antibiotic therapy, a case can be made that measurement of the CPIS may reduce the mortality rate associated with VAP. The measurement of CPIS may also provide information that can allow the clinician to aggressively treat patients with VAP while limiting the course of antibiotic therapy and thus controlling for the development of bacterial resistance ***(Cairo, 2016).***

- ## Microbiological diagnosis

Microbiological diagnosis in VAP includes qualitative and quantitative analysis of the respiratory secretions obtained using bronchoscopic (directed) or nonbronchoscopic (blind) techniques, or by taking tracheal aspiration samples. The first two can be done by broncho-alveolar lavage (BAL) and protected telescoping catheter (PTC), while the latter consists of taking secretions directly through the endotracheal tube ***(Antoni. Torres, 2015).***

The presence of purulent respiratory secretions, defined as secretions from the lungs, bronchi, or trachea that contain >25 neutrophils and <10 squamous epithelial

cells per low-power field, and positive culture (qualitative, semiquantitative, or quantitative) of sputum, endotracheal aspirate, BAL, lung tissue, or PTC is considered indicative of possible HAP/VAP ***(Torres & Cillniz 2015).***

- **Blood cultures**

Blood cultures are indicated in patients suspected to have HAP/VAP as it has prognostic implications and positive blood cultures are more frequently associated with methicillin-resistant *Staphylococcus aureus* (MRSA) ***(Torres & Cillniz, 2015).***

2.5.9 Management of VAP

They are mainly categorised into pharmacological interventions (prophylactic antimicrobial therapy, and oral chlorhexidine), and non-pharmacological interventions (body positioning, ETT cuff pressure control, silver- coated ETT, and ETT with suction system drainage (SSD) ***(Folos, et al., 2017).***

2.5.9.1 Pharmacologic Interventions

Treatment of VAP relies on knowledge of common pathogens, patient risk factors (for example immunosuppression and underlying respiratory condition), and previous microbiology specimens. Empirical treatment for VAP should include antibiotics with cover against Pseudomonas aeruginosa, Staphylococcus aureus, and gram-negative bacilli, with antibiotics administered in a timely fashion. Delaying treatment and failing to select a suitable antibiotic regimen in accordance with local policy has been shown to result in higher mortality rates. Antibiotics should be safely de-escalated once microbiology results are available, with cessation after 7 days based on improving clinical and biochemical markers ***(Miller, 2018).***

- **Oropharyngeal Decontamination**

The CDC currently recommends the development and implementation of an oral hygiene program for patients in acute care and long-term care facilities that are at high risk for nosocomial pneumonias. Although there has been a debate regarding the benefits of oral hygiene in preventing VAP, studies have demonstrated that using an oral cleansing agent like chlorhexidine can modulate oropharyngeal colonization and ultimately decrease the incidence of VAP ***(Cairo, 2016).***

- **Stress ulcer prophylaxis**

Gastrointestinal bleeding and stress ulcers in critically ill patients are associated with increased morbidity and mortality. Use of prophylactic treatment, such as H2-antagonists and antacids, may reduce the risk of stress ulcers. However, as the acidity of gastric contents decreases, gastric colonization by potentially pathogenic organisms increases ***(Cairo, 2016).***

To reduce peptic ulcer diseases (PUD) risk, mechanically-ventilated patients should receive PUD prophylaxis. Histamine 2 (H2) blockers are preferred over sucralfate. Proton-pump inhibitors (PPI) may be efficacious, and serve as an alternative to sucralfate or an H2 blockers. Requiring PUD prophylaxis on both ICU admission and ventilator order sets will standardize the treatment. Furthermore, include PUD prophylaxis in charge nurse rounds. A charge nurse can provide "just-in-time" training and assist bedside nurses in obtaining orders for PUD prophylaxis***(HR, 2017).***

The use of sucralfate may be beneficial in reducing gastric colonization. Sucralfate is a prophylactic agent that does not affect gastric pH. Current findings are controversial, and the use of sucralfate is not recommended at this time for patients at

high risk for gastrointestinal bleeding. In patients with ARDS, sucralfate was associated with an increased risk of VAP. The CDC currently has no specific recommendations about the use of sucralfate, H2 receptor antagonists, or antacids for stress-bleeding prophylaxis ***(Cairo, 2016).***

- **Venous thromboembolism prophylaxis**

Mechanically-ventilated patients are at high risk for ventilator associated event (VTE). Risk factors include immobility and a stress inflammatory response resulting in hypercoagulation. Although there is no evidence to suggest VTE prophylaxis reduces VAP risk, it is appropriate to include VTE prophylaxis in a bundle that promotes improved care of mechanically ventilated patients due to their high risk for VTE ***(Eno, 2014).***

Deep venous thrombosis prevention: for acutely ill hospitalized medical patients at increased risk of thrombosis, the American College of Chest Physicians recommend anticoagulant thromboprophylaxis with low-molecular-weight heparin, low-dose unfractionated heparin bid, or fondaparinux. In acutely ill hospitalized medical patients who receive an initial course of thromboprophylaxis, guidelines suggest against extending the duration of thromboprophylaxis beyond the period of patient immobilization or acute hospital stay. For critically ill patients who are bleeding, or are at high risk for major bleeding, the recommendation is to use mechanical thromboprophylaxis with graduated compression stockings or intermittent pneumatic compression until the bleeding risk decreases, rather than no mechanical thromboprophylaxis ***(Eno, 2014).***

- **Prophylactic antibiotics**

The guidelines for antibiotic use have two major goals: to provide therapy with an appropriate and adequate empirical antibiotic regimen, and to achieve the first goal without overusing and abusing antibiotics. The initial antibiotic therapy algorithm includes two groups of patients: Patients with early-onset VAP without any risk factors for multi drugs resistant (MDR) may be placed on narrow-spectrum monotherapy based on knowledge of local microbiological data. Patients with late-onset VAP or risk factors for MDR pathogens require broad-spectrum therapy based on knowledge of the local hospital antibiogram. When the patient is at high risk for MDR, three antibiotics are prescribed: two drugs of different classes active against Pseudomonas aeruginosa and a third drug to treat methicillin resistant S. aureus. Clinical improvement takes about 3 days. If clinical improvement does not occur within 72 hours, the patient should be evaluated for noninfectious causes of the symptoms or extrapulmonarv infections, If a patient receives an appropriate antibiotic regimen, the duration of therapy can be reduced to 7 to 8 days versus the traditional 14 to 21 days ***(Sole, Klein and Moseley, 2017).***

Systematic antibiotic therapy remains the mainstay for treating VAP, and a broad-spectrum antibiotic is primarily chosen for all potential gram- positive and gram-negative bacteria. Microbiology confirmation can assist in selecting the best antibiotic for the identified infectious agents, and checking the CPIS score while undergoing treatment is recommended to track the effectiveness of antibiotic therapy ***(Folos, et al., 2017).***

There are currently no recommendations from the CDC regarding the routine use of systemic antimicrobial agents to prevent VAP or nosocomial pneumonias. On the other hand, judicious use of appropriate antibiotics may reduce patient

colonization and subsequent infections with multidrug-resistant bacteria ***(Cairo, 2016).***

2.5.9.2 Non-pharmacologic Interventions

Many non-pharmacological evidence-based strategies aimed at preventing VAP can be seen as part of basic and routine nursing care, direct responsibility of the bedside intensive care nurse, and can easily be instituted at minimal costs; and neglecting any of these could put the patient at risk for infection. Nevertheless, nurses need to have an awareness of the problem as well as evidence-based preventive strategies to adhere to such practice and integrate them into their nursing care. Nurses' knowledge would facilitate optimal delivery of patient care, bring confidence to make appropriate decisions, and prevent poor outcomes in the recovery of mechanically ventilated patients ***(Al-Sayaghi, 2014).***

The role of the critical care nurse in preventing VAP is crucial. Most of the measures included in VAP prevention bundle guidelines are largely related to the daily nursing care activities. The key concepts of the VAP Prevention Bundle are five concepts. These concepts include; head of bed (HOB) elevation 30 degrees or more, use of thromboembolic prophylaxis, use of peptic ulcer disease prophylaxis, daily interruption of sedative drug infusions with a constant assessment of readiness to extubate and providing oral care **(Ismail and Zahran, 2015).** Many hospitals have developed and implemented evidence-based prevention protocols and educational programs for physicians and nurses ***(Cal, et al., 2012).***

- **Ventilator bundles prevention strategies (VBS)**

The institute for healthcare improvement developed the concept of "bundles" to help health-care providers more reliably deliver the best possible care for patients

undergoing particular treatments with inherent risks. VBS are considered as a "package" of evidence-based guidelines, designed to help reduce VAP and promote adherence to evidence-based protocols and guidelines in order to improve clinical outcomes. These include combinations of sedation vacation and use of weaning protocols, elevation of the head of the bed between 30° and 45°, daily oral care with chlorhexidine, adequate hand hygiene, and ulcer and deep vein thrombosis prophylaxis ***(Jansson, 2014).***

Bundled strategies for preventing VAP were developed in order to promote the delivery of evidence-based care in a more standardized and deliberated fashion. A bundle of care is defined as "individual interventions or best practice for a specific disease process that when grouped together have an even greater positive impact on the patient outcome" A bundled practice correlate with a significant reduction in VAP ***(Musvosvi, 2013).***

A large number of preventive measures and strategies have been proposed with variable degrees of effectiveness. Consequently, physicians should first consider preventive measures with a demonstrated impact on patient outcomes, such as optimal infection control practice (particularly, hand hygiene), NIPPV, sedation and winning protocols, oral hygiene care, and endotracheal tube with drainage of subglottic secretions. Clearly, there is no single preventive mechanism that will completely avert this complication, and patients at risk of VAP must be approached with a package or bundle of preventive measures ***(Eno, 2014).***

There are numerous strategies for preventing VAP. The first step is to prevent colonization by pathogens of the oropharynx and gastrointestinal tract. Basic nursing care principles, such as meticulous hand washing and wearing gloves when suctioning

patients orally or through the ETT, are essential. Gloves should also be worn when suctioning through closed-suction devices ***(Morton and Fontaine, 2017).***

- **Hand washing**

The basic tenant of infection control is to ensure that organisms are not transferred from one patient to another. This dictates proper hand hygiene before and after all patient contacts. Gloves should be worn during the patient interaction if there is potential for contact with body secretions. Depending on the infectious condition of the patient, additional precautions such as gown, gloves, and/or a mask may be necessary. Reusable equipment must be cleaned and disinfected appropriately before it is used on another patient ***(Hess and Kacmarek, 2014).***

Health provider are the first line of protection in preventing bacterial colonization of the oropharynx and the gastrointestinal tract. Scrupulous hand washing for 10 seconds should be performed before and after all contacts with patients. In addition, gloves should be worn when contact with oral or endotracheal secretions is probable ***(Khezri, et al., 2014).***

Perform appropriate hand hygiene. Hands should be disinfected with a sanitizer (e.g., Cal-Stat hand sanitizer) before entering any patient's room regardless of the reason and when leaving the patient's room regardless of the activities that occurred in the room ***(Kacmarek, et al., 2017).***

- **Semi recumbent patient positioning and enteral feeding**

Enteral feeding may predispose a patient to VAP by elevating the gastric pH, which can lead to gastric colonization with pathogenic bacteria and cause gastric distention. This in turn can lead to an increased risk of reflux and aspiration of gastric contents. Routine verification of the proper placement of the enteral feed tube is

important. Intermittent feedings may also be preferable to continuously feeding because preventing over distention of the stomach can limit gastro-pulmonary colonization ***(Cairo, 2016).***

In patients receiving enteral feedings, the HOB should be elevated 30 to 45 degrees (unless contraindicated) to decrease the risk for aspiration (Morton and Fontaine, 2017). Appropriate semi-recumbent positioning of patients, with a 30- to 45-degree head-up approach, reduces the incidence of micro-aspiration of gastric contents when compared with patients nursed in a supine position ***(Miller, 2018).***

- **Noninvasive ventilation (NIV)**

Since VAP is connected with intubation, avoidance of intubation is the most effective non- pharmacological preventive measure. Rates of nosocomial pneumonia and all nosocomial infections were much less in patients supported with noninvasive ventilation than those intubated and ventilated mechanically ***(Khezri, et al., 2014).***

Using NIV is also associated with a lower rate of other nosocomial infections such as urinary tract infections and catheter-related infections. When it is clinically appropriate, noninvasive ventilation should be preferentially used over invasive ventilation ***(Cairo, 2016).***

- **Selection, changing, and suctioning of the endotracheal tube**

The ETT can cause mucosal injuries and reduce mucociliary function, in addition to worsening upper airway defenses. Furthermore, the ETT create binding sites for bacteria in the bronchial tree and increases mucus secretion and accumulation of secretions, thereby promoting the adherence of bacteria. Thus, ETT increases the entry of bacteria into the lung, which serves as an inaccessible reservoir to host

defenses. The movement of secretions from the oral cavity into the subglottic space and into lung increase the risk of VAP ***(Alanazi, et al., 2014).***

The use of oral rather than nasal intubation is recommended because sinusitis is a particular concern in nasally intubated patients and is associated with VAP. Furthermore, there is an increased risk of VAP when patients are reintubated. The risk and benefits of reintubation should be considered before changing an ETT. If the tube is changed, it is important to avoid contamination of the lower airways with oropharyngeal secretions by properly suctioning around the ET cuff before deflating the cuff or replacing the ET ***(Cairo, 2016).***

The cuff on the artificial airway should be inflated to 20 to 30 cm H20 during exhalation to minimize aspiration of secretions and to minimize tracheal injury. However, even at this pressure, micro-aspiration can occur through the longitudinal folds in the cuff. To minimize pooling of secretions above the cuff, deep pharyngeal suctioning should be performed on a regular basis and before movement of the patient ***(Hess and Kacmarek, 2014).***

The Centers for Disease Control recommends using a new suction catheter with each open-suction procedure and using sterile water to rinse the catheter when suctioning is performed. The use of sterile gloves is also appropriate for this procedure ***(Cairo, 2016).***

- **Continuous aspiration of subglottic secretions**

Subglottic suction ports have been shown to reduce the incidence of VAP and to significantly reduce the use of antibiotics. If it is anticipated that a patient wasmechanically ventilated for more than 72 hours, consideration for insertion of a tube with subglottic drainage should be made ***(Miller, 2018).***

The accumulation of respiratory secretions in the subglottic space is a well-proven cause of VAP. Therefore, prevention should include the aspiration of secretions from the subglottic space, and techniques to avoid leakage between the tube and the tracheal wall. A conventional endotracheal tube permits only intermittent aspiration of secretions through the central lumen, distal to the tracheal cuff, while new tubes with an independent dorsal lumen permit the continuous aspiration of secretions in the subglottic space ***(Bouza, et al., 2008).***

- ## Kinetic therapy

Immobility in critically ill patients can lead to atelectasis and reduced bronchopulmonary secretion clearance. Several investigators have suggested that kinetic therapy or the use of automated rotating beds may be effective in reducing the incidence of VAP, particularly in surgical patients or patients with neurologic problems. Whether kinetic beds offer significant advantages over standard ICU patient-turning strategies will require additional studies. At present, the CDC has no recommendation regarding "kinetic" therapy or continuous lateral rotational therapy ***(Cairo, 2016).***

- ## Oral care

Critically ill patients have an increased risk for colonization by the microorganisms associated with poor oral hygiene. Oral care for a mechanically ventilated patient involves brushing the patient's teeth (at least every 8 hours), using antimicrobial solutions and alcohol-free mouthwash to cleanse the mouth, applying a water-based mouth moisturizer to maintain the integrity of the oral mucosa, and thoroughly suctioning oral and subglottic secretions. Chlorhexidine oral rinse is one agent that provides antimicrobial action and is used in many institutions. An oral care

protocol should be in place for every adult critical care unit using the current evidence-based research and practice ***(Morton and Fontaine, 2017).***

- **Minimize the duration of mechanical ventilation**

The shorter the time that a patient remains intubated, the lower the risk of VAP. Thus, daily spontaneous awaking trials and spontaneous breathing t rials should be used to identify extubation readiness. Re-intubation is also associated with VAP risk, so efforts should be used to minimize extubation failure such as the use of NIV in patients at risk ***(Hess and Kacmarek, 2014).***

- **Stress ulcer prophylaxis**

Stress ulcer prophylaxis raises gastric pH, which is detrimental to the innate immunological protection provided by gastric acid. Stopping stress ulcer prophylaxis in low-risk patients (those patients absorbing feed without a history of gastrointestinal bleeding) is recommended ***(Miller, 2018).***

The advent of the ventilator bundle of standard orders, which incorporates gastrointestinal and deep venous thrombosis prophylaxis, along with getting the patient out of bed, oral care, and keeping the HOB elevated 30 to 45 degrees, has reduced the incidence of VAP in many institutions ***(Morton and Fontaine, 2017).***

- **Body positioning**

Body positioning in intubated patients has a noteworthy importance on VAP prevention. Current guidelines recommend the semi-recumbent position (head of bed elevated 30–45°) to reduce gastric reflux. This recommendation is based upon the results of a randomized clinical trial showing the superiority of 45° head elevation compared to supine 0° positioning in VAP prevention, especially in enteral feeding

patients. Oropharyngeal colonization and lung secretions clearance impairment play a greater role in VAP development than does the gastro-pulmonary route of bacterial translocation ***(Morton and Fontaine, 2017; Hess and Kacmarek, 2014; Mietto, et al., 2013).***

- ## Care of the tracheostomy tube

Tracheostomy tubes placed by the percutaneous route can predispose the patient to the development of pneumonia, possibly from contamination during the insertion procedure. In cases where the patient has a tracheostomy tube, the nurse should wear a gown, use aseptic technique, and replace the tube with one that has been sterilized or given high-level disinfection. These types of pneumonia are associated with prolonged ventilation and ICU stay but not with increased mortality. A common pathogen associated with percutaneous tracheotomy is *Pseudomonas* spp. ***(Cairo, 2016).***

- ## Ventilator circuit management strategies

Most clinicians agree that reducing ventilator circuit's changes is cost-effective and, more important, lessens the risk of VAP ***(Cairo, 2016).*** Ventilator circuits do not need to be changed on a routine basis. Not breaking the circuit is important so that the interior of the circuit is not contaminated. An important part of this practice is use of inline suction catheters. Inline catheters become part of the circuit and do not need to be changed routinely. Any condensate that accumulates in the circuit should be removed away from the patient and from the circuit aseptically. The type of humidification, whether active or passive, does not affect VAP rates. If aerosolized medications are delivered, a device that remains in the ventilator circuit should be used (spacer for metered-dose inhaler, mesh nebulizer, or T-connector with a valve

for jet nebulizers). Reusable nebulizers should be rinsed with sterile water (or saline) between treatments and allowed to air dry ***(Hess and Kacmarek, 2014).***

Drain and discard inspiratory tube condensate away from the patient, or prevent its formation by using heated wire circuits or heat and moisture exchangers ***(Kacmarek, et al., 2017).***

CHAPTER 3: OBJECTIVES AND HYPOTHESIS OF THE STUDY

3.1 General objective

To assess the knowledge and practice of ICU nurses towards prevention of ventilator-associated pneumonia at public hospitals in Sana'a City, Yemen.

2.2 Specific objectives

1. To identify the knowledge of ICU nurses towards prevention of ventilator-associated pneumonia.
2. To determine the existing practice of ICU nurses towards prevention of ventilator-associated pneumonia.
3. To examine the level of overall knowledge of nurses toward prevention of ventilator-associated pneumonia.
4. To explore the level of overall practice of nurses toward prevention of ventilator-associated pneumonia.
5. To find out if there is any association between sex, education level, years of working experience, ICU training, training program and level of knowledge of nurses on the prevention of VAP.
6. To verify if there is an association between sex, marital status, and education level, years of working experience, ICU training, training program and level of practice of nurses on the prevention of VAP.

2.3 Hypothesis

1. There is no significant association between sex, educational level, years of working experience, ICU training, training program and level of knowledge of nurses on the prevention of VAP at the public hospitals in Sana'a City.

2. There is no significant association between sex, marital status, educational level, years of working experience, ICU training, training program and level of practice of nurses on prevention of VAP at the public hospitals in Sana'a City.

CHAPTER 4: RESEARCH METHODOLOGY

4.1. Study Setting

This study conducted in four public hospitals in Sana'a City, Yemen that include (Al-Thowrah, Al-Sabeen, Al-Kuwait, and Al- Jomhury hospitals). All Hospitals provide primary, secondary and tertiary healthcare and referee hospitals to all Yemeni people.

The reasons for choosing these hospitals because each hospital has intensive care units and patients under of the mechanical ventilation and they are referral hospitals and most community go to these hospitals. In addition, these hospitals are matched in history and they are selected in (2012) by the ministry of public health and population to prepare it for accreditation. There are 2083 nurses in these hospitals, which represent 63.32 % of the total healthcare workers. Based on Yemeni annual statistical health report (2001). There are three nurses' categories working in these hospitals; registered nurse, practical nurse, and patient care assistants nurse.

4.2. Study Design

A descriptive, cross-sectional study carried out to assess knowledge and practice of ICU nurses toward prevention of VAP at public hospitals in Sana'a city – Yemen. This study conducted from October 2017 to October 2018. A descriptive cross-sectional this design was used. where more information required in a particular field through the provision of a picture of the phenomenon as it occurs naturally ***(Polit,et al., 2001).*** Knowledge and practice of ICU nurses on VAP prevention were assessed. Each subject was assessed at a single time in the study period.

The observational method was used to gain insight into what was happening in practice. Observational study involved the collection of data that specify the behaviors/ practice or events selected for observation and was conducted in participants' natural environments ***(Kelleher S, Andrews, T, 2008).*** Direct observation was potentially a more comprehensive method to ascertain how nurses performed in real situations and to identify differences, if any, in practice

4.3 Population of the Study

All nurses with various educational backgrounds and working in ICU at public hospitals in Sana'a City, Yemen during the data collection period were invited to participate in the study.

4.4 Sample Size Determination

The sample size was determined through use EpiCalc program, 2000 taking into consideration the following;

The sample size to knowledge was calculated as a follows: the population of the study were all nurses working in ICU at four public hospitals (Al-Thowrah hospital, Al-Sabeen, Al-Kuwait, and Al- Jomhury hospital) was 205 nurse, precision (3%), and 95% confidence level. The final sample size was 87 Yemeni nurses.

The sample size to practice was calculated as a follows: the population of the study were all nurses working in ICU at four public hospitals (Al-Thowrah hospital, Al-Sabeen, Al-Kuwait, and Al- Jomhury hospital) was 205 nurses, Precision (4%), and 95% confidence level. The final sample size was 50 Yemeni nurses.

4.5 Sampling Technique

A stratified simple random sampling was applied to select the sample size from 4 major public hospitals. After official approvals obtained from the previously selected settings, the researcher obtained lists of nurses' currently working in the study settings via random sampling methods . The list was reviewed and nurses meeting the inclusion criteria were included in the study to select from the total population (N)= 205 nurses were subdivided according to hospitals (Al-Thowrah hospital n= 98, Al-Jomhury hospital n= 42, Al-Kuwait hospital n= 35 and Al-Sabeen hospital n= 30).

Calculation the sample size from each stratum in the hospital was prepared by the following formula:

$$\frac{n}{N} * K = sample\ size\ \text{to}\ each\ hospital$$

- n = (sample size)
- N= (study population)
- k= (population of each hospital)

The table 4: shows a stratified simple random sampling method to selected sample size from each stratum:

Study setting	Total of Population	The study sample of knowledge	The study sample of practice
Al-Thowrah hospital	98	41	24
Al- Jomhury hospital	42	18	10
Al-Kuwait hospital	35	15	9
Al-Sabeen hospital	30	13	7
Total	**205**	**87**	**50**

4.6 Inclusion and exclusion criteria

4.6.1 The inclusion criteria were included:

- All Yemeni male and female nurses working in the ICU who had an educational certificate that volunteers to participate in this study during the study period were included.

- Nurses who had a duration of working 1 year and more.

4.6.2 The exclusion criteria were included:

All nurses who are not fulfilled the above inclusion criteria.

4.7 Data Collection Methods and Tools

4.7.1 Data collection methods

The demographic characteristics of ICU nurses and knowledge toward the prevention of VAP were collected through a self-administered questionnaire and Practice of ICU nurses toward prevention VAP was collected through observation. Data was collected through the three months from 1st March to 30th May 2018 where good rapport was maintained in the whole period of data collection.

4.7.2 Data collection tools

1. The questionnaire tool

A structured questionnaire was administered to assess the knowledge of ICU nurses (Appendix- A). A close-ended questionnaire with an information letter and consent form attached and handed to ICU nurses by the researcher. A code number was applied. Nurses were told to sign the consent form. The questionnaire consisted of twenty-eight questions and nurses' informed consent. The questionnaire divided into the following parts:

- **Part I:** nurses informed consent.
- **Part II:** Demographic characteristics of nurses; this part contains the following:(hospital name, intensive care unit types, sex, marital status, age in year, level of education, duration of working in year, degree or courses training in ICU, attending training programs on prevention of VAP, diploma in respiratory therapy. This included ten questions. The questions number from (Q1 to Q10).

- **Part III:** knowledge of ICU nurses toward prevention ventilator-associated pneumonia, which included eighteen questions. This part was comprised of the following sections:
- **Section I:** Knowledge of ICU nurses about general information on VAP. The questions number from (Q11 to Q12).
- **Section II:** Knowledge of ICU nurses about ETT tube strategies toward the prevention of VAP. The questions number from (Q13 to Q16).
- **Section I11:** Knowledge of ICU nurses about position strategies toward the prevention of VAP. The questions number from (Q17 to Q19).
- **Section IV:** Knowledge of ICU nurses about suction strategies toward prevention of VAP. The questions number from (Q20 to Q22).
- **Section V:** Knowledge of ICU nurses about common prevention strategies toward the prevention of VAP. The questions number from (Q23 to Q25).
- **Section VI:** Knowledge about other strategies toward prevention of VAP. The questions number from (Q26 to Q28).

The questionnaire prepared in English language and translated from English into Arabic using translation and back-translation techniques by two specialists, all nurses were received an Arabic version questionnaire. If some of the items in the questionnaire were not clear to a few participants. The questionnaires were filled in the presence of the researcher and participants were free to ask for any questions or clarifications.

The questionnaire was filled during working hours; consent forms and filled questionnaires were placed into sealed by the researcher and taken from each unit daily. All of the collected data has checked by the researcher daily for completeness and finally.

2. The observation checklist tool

Observation checklist was applied to assess the actual nurses' practice. During the three shifts, each nurse attended mechanically ventilated patients was observed by the researcher for about 1-2 hours, the time is selected randomly whereby the researcher stays around ICU. Within these hours, the nurses were occupied with patients care practice. Observed nurses' time was conveniently selected and were not aware that they were being observed.

The observation checklist was included the twenty observe. The observation checklist divided into the following parts:

- **Part I:** Practice of ICU nurses about common prevention practice toward the prevention of VAP. The checklist questions number from (Q1 to Q5).
- **Part II:** Practice of ICU nurses about suction practice toward the prevention of VAP. The checklist questions number from (Q6 to Q11).
- **Part III:** Practice about position and ventilator equipment's change toward the prevention of VAP. The checklist questions number from (Q12 to Q15).
- **Part IV:** Practice about other nursing care practice toward prevention of VAP. The checklist questions number from (Q16 to Q20).

4.8 Validity and reliability of the tools

The questionnaire and an observation checklist were adopted from previously validated and reliable studies by **(*Burja, et al., 2017; Said, 2012; Aferu, 2016; al-sayaghi 2014; Neuville, et al., 2017; Labeau , et al., 2007;and alshameri, Faroq, 2012).*** and from prevention of VAP guidelines ***(HR, 2017; Cynosure Health, 2013).***

The validity of the English and Arabic version of the questionnaire and an observation checklist reviewed by five experts in order to determine if all questions and observes were clearly worded and would not be misinterpreted. Experts included

two academic staff in critical and medical-surgical nursing and three ICU nurse specialist, the ICU respiratory therapist, and a registered nurse who has worked in the ICU for 6 years and more.

As a result, some questions were omitted, some added and others rephrased. Other questions added were formulated by the researcher with the help of literature supervisor and experts was make modified to add or omit to clearly and correct misinterpreted and doubtlessness from credence and completeness of study tools.

The reliability of the questionnaire was tested by using Cronbach's Alpha So, the tool was found to be highly reliable for data collection coefficient was (0.73).

All items on the data collection tools (questionnaire and observational checklist) were weighted with the digits 0 and 1. Weighting (1) represented adherence to accepted ICU nurse knowledge and practice employed to prevent VAP. While (0) represented non adherence to accepted ICU nurse knowledge and practice employed to prevent VAP. The above weight was converted into percentage ranging from (0 – 100 %.

4.9 Pilot Study

The piloted of the questionnaire and the observational checklist was performed before data collection. A pilot study was done on ten nurses working in the ICU on items in a questionnaire and observational checklist to assess the clarity, feasibility of the study and drawbacks of the questionnaire. Following the pilot study, minimal modifications to the layout and presentation of the instrument were made. The pretest nurses were excluded from the final study sample.

4.10 Data Processing and Statistical Analysis

Once the questionnaires were collected, a codebook was developed to provide numerical results for analysis. Information from the tool was original data. All

available data organized into pie chart and cross-tables were used to provide an overall and coherent presentation and description of data. A packaged computer analysis program, statistical package for the social science (SPSS 21.0) was used for statistical analysis of this data. Descriptive statistics were used to interpret the demographic data: age, sex, working experiences in ICU and training and types of ICU. Descriptive measures, including frequency, the percentage for categorical variables, and the mean and standard deviation for numerical variables. To find the association between knowledge and practice and demographic characteristics was used chi-square test for categorical data, and P-value ≤ 0.05 was considered significant.

- ***Scoring system***

Each correct responses to the items in the questionnaire or checklist was given (1score), and (0score) was given to either wrong or don't know responses.

The levels of knowledge and practice were classified as follows: good level was assigned to nurses who got 76%-100%, moderate 50%-75% and poor 0% - 49%.

4.11 Study Variables/ Operational Definition

4.11.1 Study variables:

- Dependent variables: knowledge and practice of ICU nurses toward the prevention of VAP.
- Independent variables: ventilator associated pneumonia VAP.

4.11.2 Operational definition:

- **Intensive care unit:** A special area in a hospital, where critically ill patients or highly dependent patient, who need close and frequent observation, can be cared for by qualified and special trained staff working under the best possible condition.

- **Intensive care nurse:** Any nurse working in general ICU, cardiac ICU, surgical ICU, medical ICU, neuro ICU, and pediatric ICU at public hospitals who is able to work in ICU.
- **Knowledge:** refers to the correct level of response of the subject regarding the prevention of ventilator-associated pneumonia elicited through structured questionnaire participants who selected a correct choice from a certain item and above mean score value were considered to be knowledgeable.
- **Practice:** refers to the nursing actions done by the nurses on the subject regarding the prevention of ventilator-associated pneumonia such as hand washing, suctioning from the ETT/tracheotomy and oral care, Participants who adhere to accepted ICU nurse practice to prevent VAP and above mean score value were considered to have good practice on that item.
- **Ventilator-associated pneumonia (VAP):** refers as a type of pneumonia in a patient receiving mechanical ventilation that was not present at the time of admission to hospital or that occurs 48 hours after intubation and mechanical ventilation.
- **ICU training:** this is a specialized/formal ICU training for nurses working under the best possible condition to a care-dependent patient who needs close and frequent observation.

4.12 Ethical Considerations

Approval of the study was obtained prior to carrying out this study from the ethical committee of the college of medical sciences of Al-Razi University. A cover letter was sent to principles of hospitals to obtain approval to conduct this study (Appendix -B). The purpose and benefits of the study was explained to participants. The consent was taken from all participated nurses in the study. All nurses also have

the right to refuse to participate or to withdraw from the study without any effect on their working.

CHAPTER 5: RESULTS

5.1 Demographic Characteristics of ICU Nurses

5.1.1 Demographic characteristics

Table 5 shows the demographic characteristics of the ICU nurses. The results of the study showed that more than the half (54%) of ICU nurses were males and (52%) were unmarried. Most of the nurses (71.3%) were in the age group ranged from 20-30 year with mean ± SD, 28.40 ± 3.9 years. More than the half (55.2 %) of the participants had working experience from 1-3 years with mean ± SD, 4.70 ± 4.2 years, and two thirds (65.5 %) of them had a diploma degree.

Table 5: Demographic characteristics of ICU nurses (N=87)

Demographic data	**F**	**%**
Sex		
• Male	47	54
• Female	40	46
Marital status		
• Married	42	48
• Unmarried	45	52
Age (years)		
• 20 - 30 years	62	71.3
• 31 - 40 years	24	27.6
• 41 - 50 years	1	1.1
Working experience (years)		
• 1 - 3 years	48	55.2
• 4 - 6 years	19	21.8
• 7 - 9 years	8	9.2
• ≥ 10 years	12	13.8
Level of education		
• Diploma degree	57	65.5
• Bachelor degree	29	33.3
• Master degree	1	1.1

5.1.2 Distribution of nurses according to ICU specialities

Figure 1 reveals the distribution of nurses according to ICU specialities. The majority of nurses were working in general ICU (32.2%) followed by (21.8%) were working in other ICU (neurology, nephrology and cardiology), whereas (14.9%) of nurses were working in pediatric intensive care unit (PICU) and followed by (12.6%, 10.3%, and 8% respectively) in surgical intensive care unit (SICU) emergency intensive care unit (EICU) and medical intensive care unit (MICU).

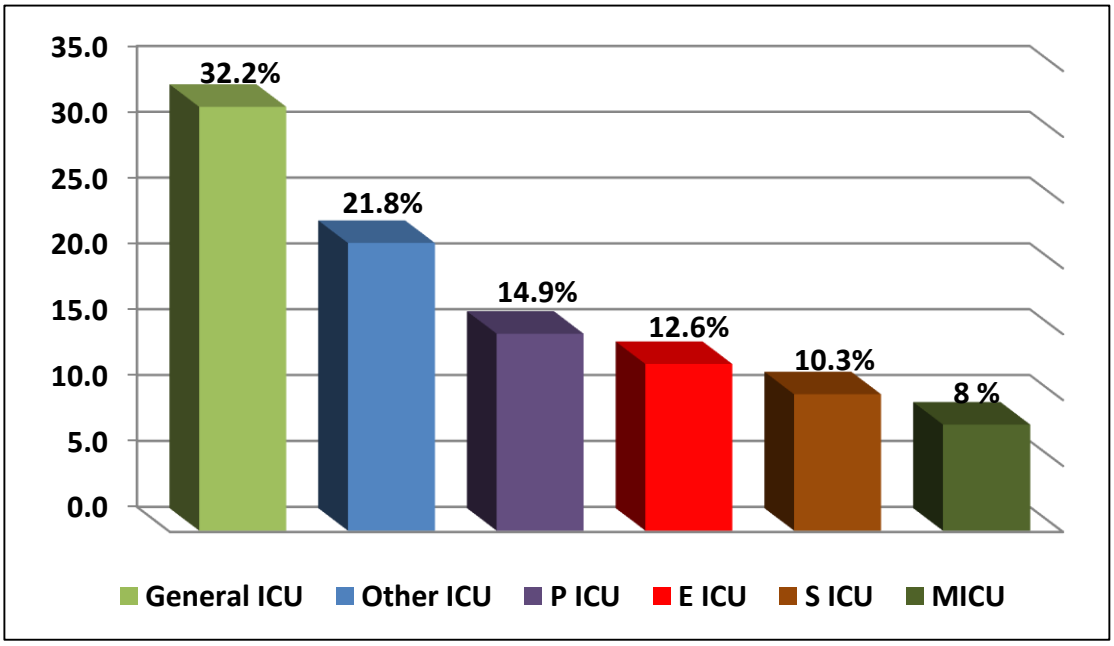

Figure 1: Distribution of ICU nurses according to workplace types (N= 87).

5.1.3 Distribution of ICU nurses according to course training

As regarding, the response of ICU nurses toward courses training. About the half of the nurses (51.7%) had training courses in ICU and the majority of nurses (81.6%) were had no training program on the prevention of VAP. Whereas only (10.3%) from participants were had a diploma in respiratory therapy table 6.

Table 6: Distribution of ICU nurses according to course training (N=87)

Statement	Responses			
	Yes		No	
	F	%	F	%
Do you have a degree or courses training in ICU?	45	51.7	42	48.3
Do you attend a training program on the prevention of VAP?	16	18.4	71	81.6
Do you have a diploma in respiratory therapy?	9	10.3	78	89.7

5.2 Knowledge of nurses toward prevention of VAP

5.2.1 Knowledge of ICU nurses about general information toward the prevention of VAP

Table 7 presents the responses of ICU nurses about general information about the prevention of VAP. Nearly two thirds of the nurses (65.5%) knew that ventilator-associated pneumonia it occurs after 48 hours after intubation and mechanical ventilation. Regarding the best strategies to the prevention of VAP, about (52.9%) of the participated nurses reported an education program, reduce colonization and prevent aspiration as the beast strategy.

Table 7: Knowledge of ICU nurses about general information on the prevention of VAP (N=87).

Statement	Options	Responses	
		F	%
Ventilator-associated pneumonia as Pneumonia in a patient receiving mechanical ventilation that occurs.	• Was present at the time of admission to the hospital.	3	3.4
	• Occur in 24 hours after intubation and mechanical ventilation.	16	18.4
	• Occur after 48 hours after intubation and mechanical ventilation.	**57**	**65.5**
	• Don't know.	11	12.6
Which the following is the best strategies for the prevention of VAP?	• Prevent colonization and aggressive antibiotics use	13	14.9
	• Prevent aspiration and use non-invasive ventilation.	26	29.9
	• Education program, reduce colonization and prevent aspiration.	**46**	**52.9**
	• Don't know.	2	2.3

5.2.2 Total knowledge of ICU nurses about general information toward prevention of VAP.

On the other hand, the totally correct answer of ICU nurses on general information toward the prevention of VAP was (59.2%) correct answer and (40.8%) incorrect answer or don't know. Figure 2.

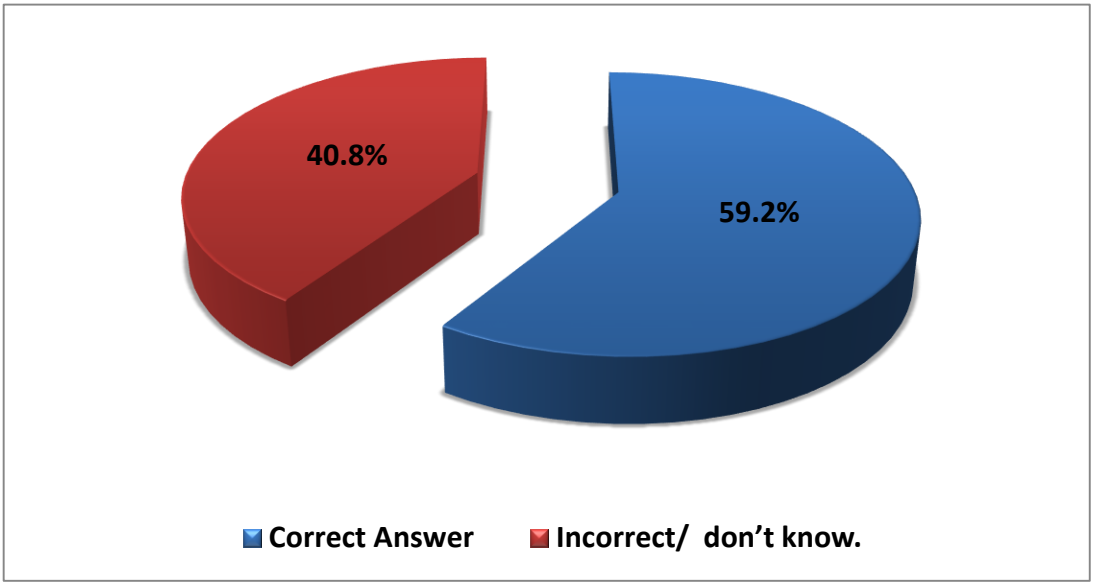

Figure 2: Total knowledge of ICU nurses about general information toward prevention of VAP (N=87)

5.2.3 Knowledge of ICU nurses about ETT tube strategies toward prevention of VAP

More than half of nurses (58.6%) knew that oral intubation is recommended when intubating patients, and (63.2%) of them mentioned that endotracheal tubes with the extra lumen to drainage of subglottic secretions it reduces the risk for VAP. Whereas (42.5%) knew that accidental extubation and re-intubation for endotracheal tube are increasing the risk for VAP. Furthermore, the correct recommendations to the maintenance of adequate pressure inside of the tracheal balloon should be between 20 and 30cmH2O, only was mentioned by (12.6%). More details presenting in table 8.

Table 8: Knowledge of ICU nurses about ETT tube strategies toward prevention of VAP (N=87)

Statement	Options	Responses	
		F	%
Which the way is a best recommended when intubating a patient?	• Oral intubation is recommended.	**51**	**58.6**
	• Nasal intubation is recommended.	8	9.2
	• Both routes of intubation are recommended.	27	31.0
	• Do not know.	1	1.1
Endotracheal tubes with the extra lumen for drainage of subglottic secretions.	• Reduce the risk of VAP.	**55**	**63.2**
	• Increase the risk for VAP.	15	17.2
	• Does not influence the risk of VAP.	7	8.0
	• Do not know.	10	11.5
Accidental extubation and re-intubation for endotracheal tube are.	• Slightly influence the risk for VAP.	41	47.1
	• Increase the risk for VAP.	**37**	**42.5**
	• Do not influence the risk of VAP.	6	6.9
	• Do not know.	3	3.4
The recommendation to the maintenance of adequate pressure inside of the tracheal balloon should be:	• Recommend to be between 20 and 30cmH2O.	**11**	**12.6**
	• Recommend to be between 10 and 20cmH2O.	21	24.1
	• Recommend to be between 0 and 10cmH2O.	28	32.2
	• Do not know.	27	31.0

5.2.4 Total Knowledge of ICU nurses about ETT tube strategies toward prevention of VAP

As regards to the total knowledge of ICU nurses about ETT tube strategies toward prevention of VAP showed that (44.3%) of the nurses were answered correctly while (55.7%) incorrect answer or don't know. Figure 3.

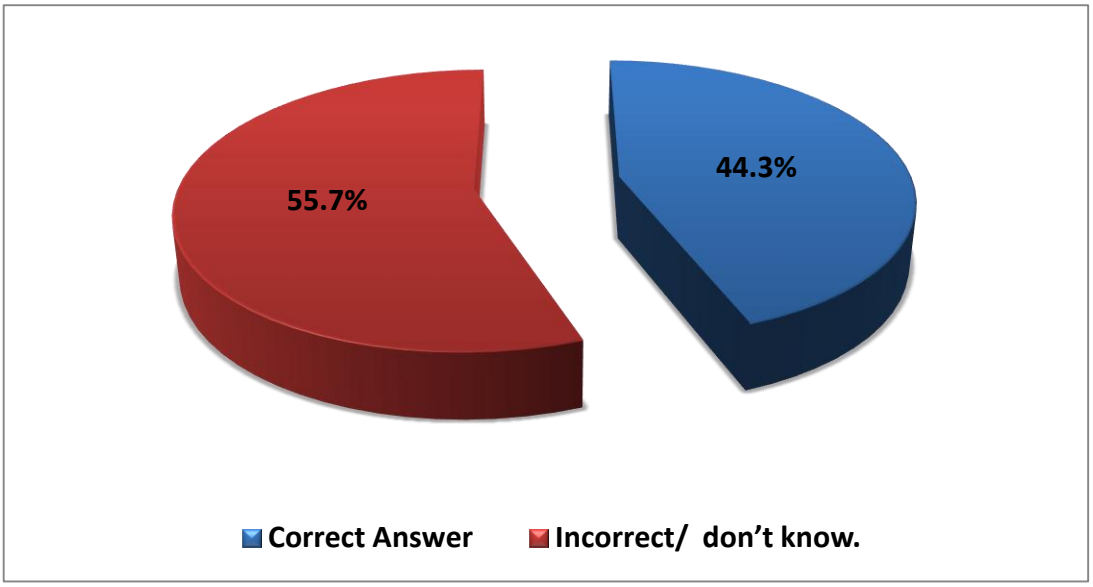

Figure 3: Total knowledge of ICU nurses about ETT tube strategies toward prevention of VAP (N=87).

5.2.5 Knowledge of ICU nurses about position strategies toward prevention of VAP

Table 9 shows the knowledge of ICU nurses about elevation of the bed position and chest physiotherapy strategies toward prevention of VAP. The findings of this study showed that more than half of nurses (57.5%) knew that head of bed if there is no contraindication should be elevated from (30-45º) angle, while (54%) of them said that the use of kinetic bed was reduced the risk for VAP. Finally the majority of respondents (86.2%) understood that chest physiotherapy was reduced the risk of VAP.

Table 9: Knowledge of ICU nurses about position strategies toward prevention of VAP (N=87)

Statement	Options	Responses	
		F	%
The beat recommended to a patient position on the bed if there is no contraindication.	• Elevate the head of the bed from (5 - 15o) angle.	7	8.0
	• Elevate the head of the bed from (15 - 30o) angle.	27	31.0
	• Elevate the head of the bed from (30 - 45o) angle.	**50**	**57.5**
	• Do not know.	3	3.4
Use kinetic (automatically bed) standard beds?	• Reduce the risk of VAP.	**47**	**54.0**
	• Increase the risk for VAP.	5	5.7
	• Does not influence the risk of VAP.	28	32.2
	• Do not know.	7	8.0
Chest physiotherapy is recommended due to the following reason.	• Reduces the risk for VAP.	**75**	**86.2**
	• increases the risk for VAP	3	3.4
	• Does not influence the risk of VAP.	8	9.2
	• Do not know.	1	1.1

5.2.6 Total knowledge of ICU nurses about position strategies toward prevention of VAP

Figure 4 reveals the total knowledge of ICU nurses about bed position and chest physiotherapy strategies toward prevention of VAP. The findings of the study showed that there was (65.9%) of the nurses were answered correctly and (34.1%) of them there answers were either answered incorrect or they don't know.

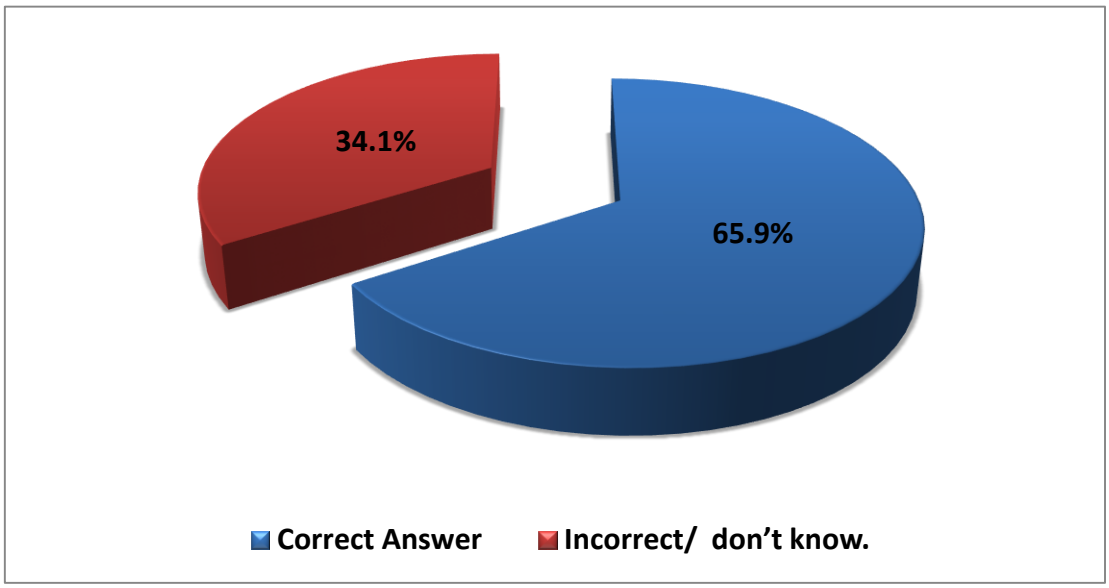

Figure 4: Total knowledge of ICU nurses about position strategies toward prevention of VAP (N=87).

5.2.7 Knowledge of ICU nurses about suction strategies toward prevention of VAP

Knowledge of ICU nurses related to the suction strategies to prevention of VAP. The results of the study showed that, most of the nurses (71.3%) were know the regular subglottic suction should be done before deflating tube cuff and before repositioning the tube, whereas the best type of endotracheal suction was closed suction systems (34.5%) and the nurse is required to dispose a suction catheter immediately after one single use (86.2%). More details presenting in table 10.

Table 10: Knowledge of nurses about suction strategies toward prevention of VAP (N=87)

Statement	Options	Responses	
		F	%
The regular subglottic suction should be done.	• Before deflating tube cuff or before reposition the tube	**62**	**71.3**
	• After deflating tube cuff or after repositioning the tube	9	10.3
	• Does not influence the risk of VAP.	6	6.9
	• Don't know.	10	11.5
The best type of endotracheal suction is (open or closed systems).	• Open suction systems are recommended.	7	8.0
	• Closed suction systems are recommended.	**30**	**34.5**
	• Both systems can be recommended.	31	35.6
	• Don't know.	19	21.8
A nurse is required to dispose of a suction catheter.	• Immediately after one single use.	**75**	**86.2**
	• Can be clean and used twice.	8	9.2
	• Can be used more than one without cleaning.	2	2.3
	• Don't know.	2	2.3

5.2.8 Total knowledge of ICU nurses about suction strategies toward prevention of VAP

The total knowledge of ICU nurses about suction strategies toward prevention of VAP showed that (64%) of the nurses were answered correct and (36%) were answered incorrect or don't know.

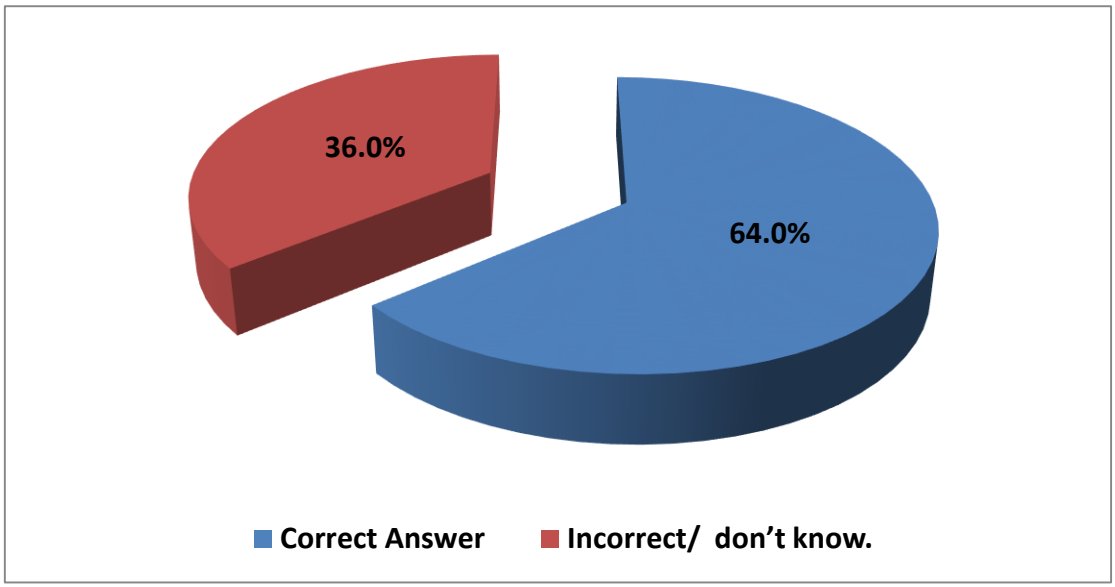

Figure 5: Total knowledge of ICU nurses about suction strategies toward prevention of VAP (N=87).

5.2.9 Knowledge of ICU nurses about common strategies toward prevention of VAP

Table 11 reveals the responses of ICU nurses knowledge about (oral and hand care) & (humidifiers, filters and ventilator circuit) strategies toward prevention of VAP. 35.6% from nurses knew the best solutions that used with comprehensive and regular oral care it is cholerihyxidine solution, (42.5%) of nurses were know the true recommendation to disinfect the hands and wear gloves it is before oral care and before ETT suctioning. Whereas the correct recommendation to changes of the humidifiers filters and ventilator circuit should be every new patient (or when clinically indicated) were about (52.9%).

Table 11: Knowledge of ICU nurses about common strategies toward prevention of VAP (N=87)

Statement	Options	Responses	
		F	%
Which the best of solutions that used with Comprehensive and regular oral care?	• Normal saline solution.	49	56.3
	• Cholerihyxidine solution.	**31**	**35.6**
	• Sterile water solution.	6	6.9
	• Don't know	1	1.1
When caring for a ventilated patient is required to disinfect hand and wear gloves.	• Before oral care and before ETT suctioning.	**37**	**42.5**
	• After oral and ETT suctioning.	0	0.0
	• Before and after oral / ETT suctioning.	49	55.2
	• Don't know	1	1.1
Correct recommendation to changes of the humidifiers filters and ventilator circuit should be changed.	• Every 48 hours (or when clinically indicated).	29	33.3
	• Every week (or when clinically indicated).	8	9.2
	• Every new patient (or when clinically indicated).	**46**	**52.9**
	• Don't know	4	4.6

5.2.10 Total knowledge of ICU nurses about common strategies toward prevention of VAP

Figure 6 presents the total knowledge of ICU nurses about oral, hands care and humidifiers, filters, and ventilator circuit strategies toward prevention of VAP. 43.7% of the nurses were answered correct and (56.3%) were answered incorrect or don't know.

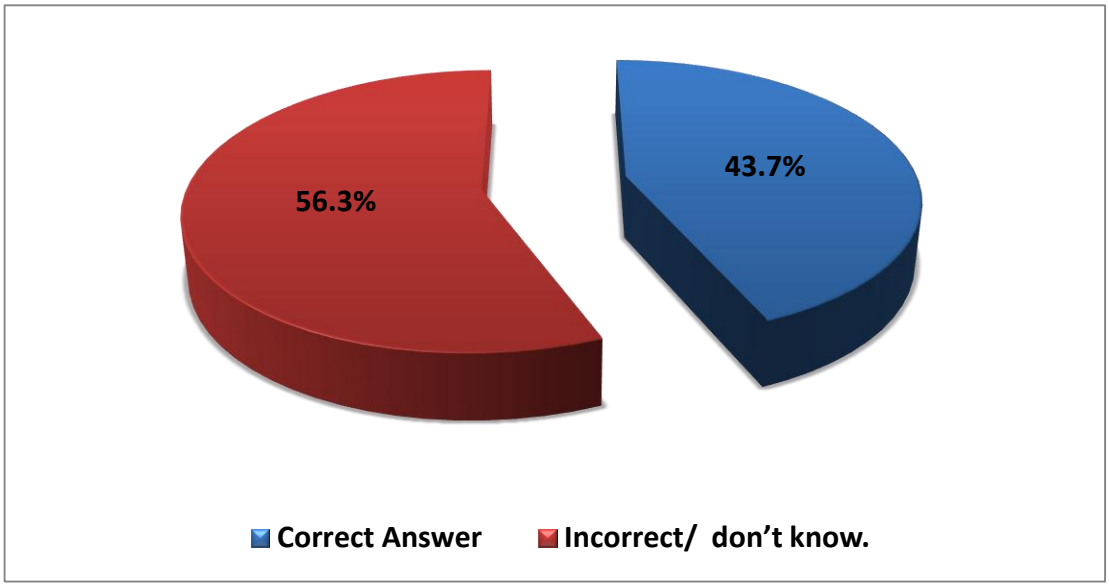

Figure 6: Total knowledge of ICU nurses about common strategies toward prevention of VAP (N=87).

5.2.11 Knowledge of ICU nurses about other strategies toward prevention of VAP

Table 12 describes the responses of ICU nurses about (prophylaxis) & sedation and weaning protocol strategies toward the prevention of VAP. Only (3.4%) of nurses that knew the best type of prophylaxis drugs to peptic ulcer for decreased the risk of VAP it uses the sucralfate only, and (16.1%) were know the prophylaxis from DVT such as anticoagulant and elastic stoking it reduces the risk for VAP. Whereas the Implementation of ICU protocol for sedation and the weaning from mechanical ventilation it reduces the risk for VAP were (59.8%).

Table 12: Knowledge of ICU nurses about other strategies toward prevention of VAP (N=87)

Statement	Options	Responses	
		F	%
The best type of prophylaxis drugs to peptic ulcer for decreased the risk of VAP.	• Use the anti-acids and histamine type2 antagonist.	42	48.3
	• Use the sucralfate only.	**3**	**3.4**
	• Use all the above	28	32.2
	• Don't know	14	16.1
Give the patient a prophylaxis from DVT such as anticoagulant and elastic stocking.	• Reduce the risk of VAP.	**14**	**16.1**
	• Increase the risk for VAP.	5	5.7
	• Do not influence the risk of VAP.	61	70.1
	• Don't know	7	8.0
Implementation of ICU protocol for sedation and weaning from mechanical ventilation.	• Reduce the risk of VAP.	**52**	**59.8**
	• Increase the risk for VAP.	3	3.4
	• Do not influence the risk of VAP.	21	24.1
	• Don't know	11	12.6

5.2.12 Total of knowledge of ICU nurses about other strategies toward prevention of VAP

On the other hand, the total knowledge of ICU nurses about (prophylaxis) and (sedation and the weaning protocol) strategies toward prevention of VAP showed that (26.4%) of the nurses were answered correct and (73.6%) were answered incorrect or don't know.

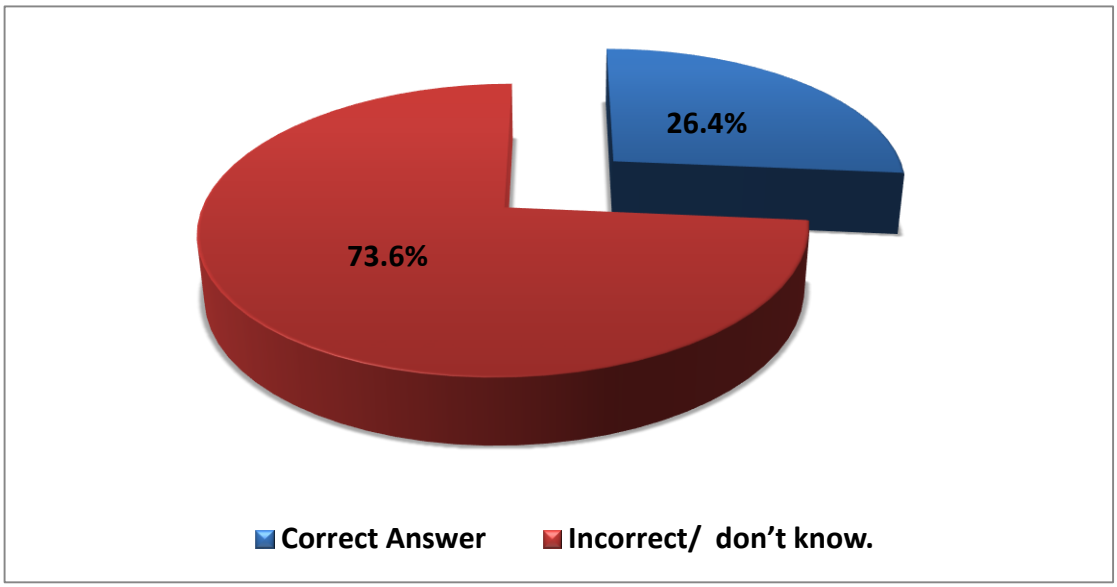

Figure 7: Total of knowledge of ICU nurses about other strategies toward prevention of VAP (N=87)

5.2.13 Overall knowledge of ICU nurses toward prevention of VAP

As regards to the overall knowledge of ICU nurses about prevention of VAP showed that the overall correct answers about prevention of VAP among ICU nurses were (49.7%), whereas (50.3%) they answered incorrectly or don't know.

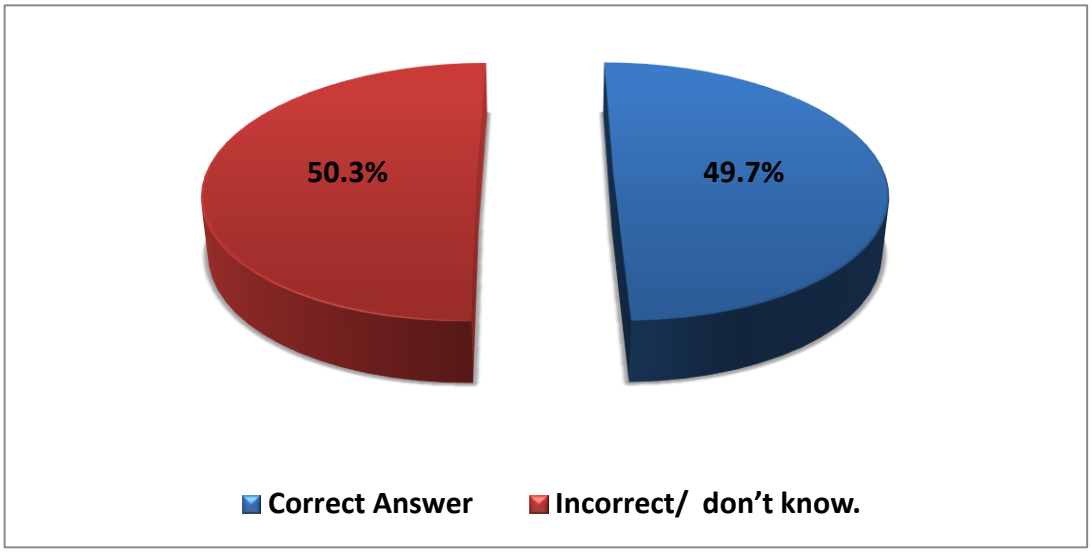

Figure 8: Overall knowledge of ICU nurses toward prevention of VAP (N=87)

5.2.14 Level of overall knowledge of ICU nurses toward the prevention of VAP.

Figure 9 shows the level of overall ICU nurses knowledge toward the prevention of VAP. There were more than half (57.5%) of ICU nurses had poor knowledge, (36.8%) were had moderate knowledge. Whereas only (5.7%) of the nurses were had good knowledge toward prevention of VAP.

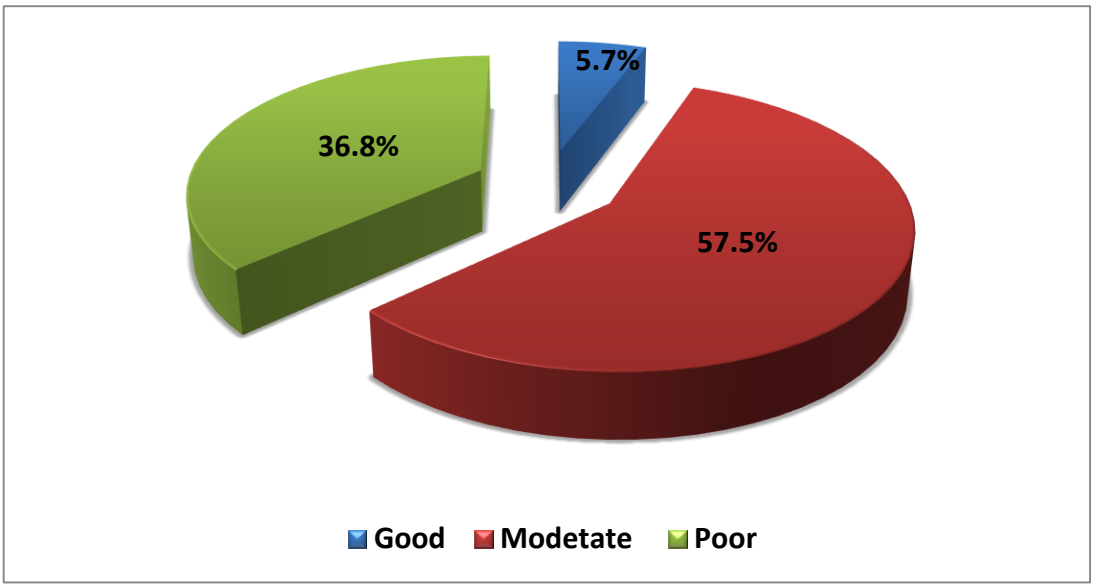

Figure 9: Level of overall knowledge of ICU nurses toward prevention of VAP (N=87).

5.3 The practice of ICU nurses toward prevention of VAP

5.3.1 Practice of ICU nurses about common nursing care toward prevention of VAP

As regards to the practice of ICU nurses toward oral and hand care & and environmental care toward prevention of VAP. About (28%) of nurses were applied hands washing/disinfect before oral care and before tracheal suction, before and after every patient care. Most nurses (74%) were wearing the gloves and gown before oral care and tracheal suction. About (32%) of nurses were cleaned mouth using gauze and antiseptic solution (chlorhexidine), (30%) were applied water-soluble jelly to patient lips after oral care and (60%) were maintained patient environmental cleanness and sterilization. More details are describing in table 13.

Table 13: Practice of ICU nurses about common nursing care toward prevention of VAP (N=50)

Practice	Outcomes			
	Yes		No	
	F	%	F	%
• Hand washing before oral care, tracheal suction, before, and after every patient care.	14	28	36	72
• Wear sterile gloves before oral care and tracheal suction	37	74	13	26
• Clean mouth using gauze and antiseptic solution (chlorhexidine).	16	32	34	68
• Apply water-soluble jelly to patient lips after oral care.	15	30	35	70
• Ensuring environmental cleanness and sterilization	30	60	20	30

5.3.2 Total practice of ICU nurses about common nursing care toward prevention of VAP.

The total practice toward oral, hand care and environmental care toward prevention of VAP showed that (44.8%) of the ICU, nurses were correctly practiced and (55.2%) were not correctly practiced of all items related to oral, hand and environmental care toward prevention of VAP.

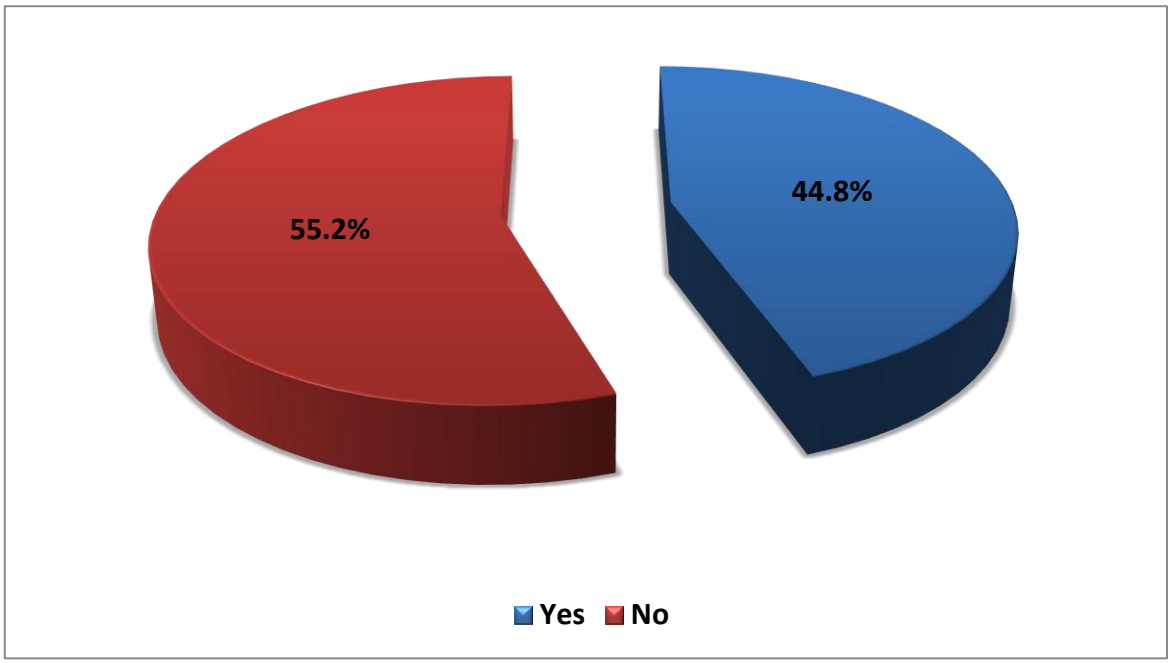

Figure 10: Total practice of ICU nurses about common nursing care toward prevention of VAP (N=50)

5.3.3 Practice of ICU nurses about suction strategies toward prevention of VAP

Table 14 shows the practice of ICU nurses toward suction & cuff pressure strategies toward prevention of VAP. The results of the study showed that all of the nurses were not applied closed endotracheal suction system and only (32%) of nurses sterilized or disinfected of suctioning equipment. Whereas (42%) of nurse used sterile technique during tracheal suction and (54%) discard suction catheter immediately after one single use. 20% applied subglottic suctioning before deflating cuff or repositioning the tub, and (30%) were control and maintenance of cuff pressure.

Table 14: Practice of ICU nurses about suction strategies toward prevention of VAP (N=50)

Practice	Outcomes			
	Yes		No	
	F	%	F	%
• Apply closed endotracheal suction system.	0	0	50	100
• Sterilized/disinfected of suctioning equipment	16	32	34	68
• Using sterile technique during tracheal suction	21	42	29	58
• Discard suction catheter immediately after one single use.	27	54	23	48
• Apply subglottic suctioning before deflating cuff or repositioning the tube.	10	20	40	80
• Control and maintenance of cuff pressure.	15	30	35	70

5.3.4 Total practice of ICU nurses about suction strategies toward prevention of VAP

The total practice toward suction and cuff pressure strategies toward prevention of VAP showed that (29.6%) of the ICU nurses were done practice correct and (70.4%) were not done correct practice toward prevention of VAP.

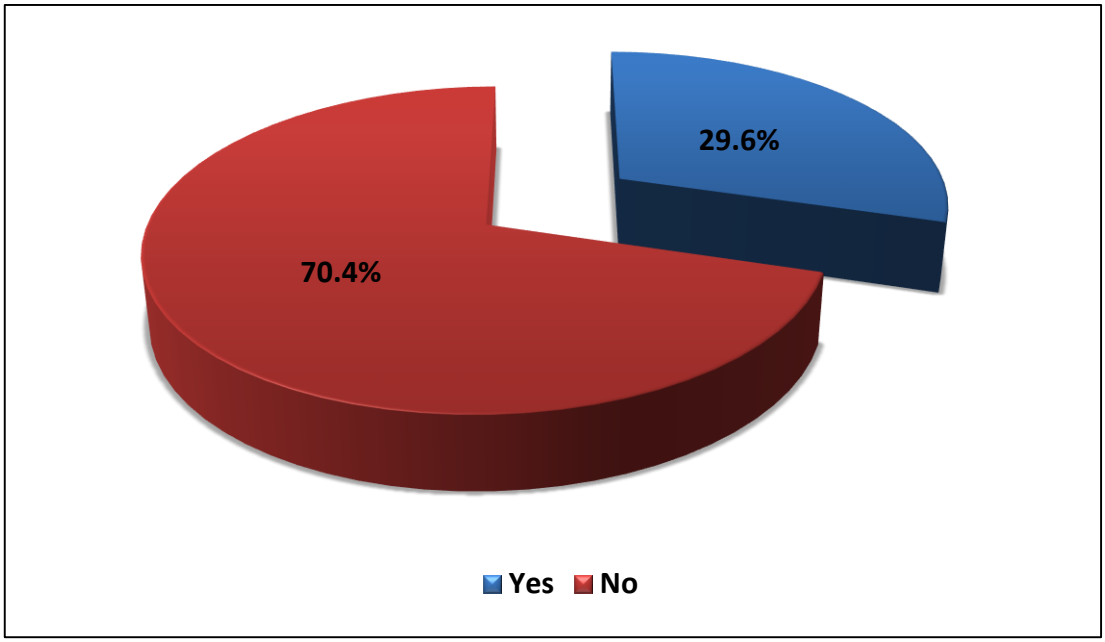

Figure 11: Total practice of ICU nurses about suction strategies toward prevention of VAP (N=50)

5.3.5 Practice of ICU nurses about position and ventilator equipments care toward prevention of VAP

The practice of ICU nurse toward position, chest physiotherapy & (humidifier, circuit, filters & ETT tube) strategies toward prevention of VAP. Most of the nurses (78%) kept the patient in a semi-sitting position at (30˚ to45˚), (88%) used the kinetic bed for a ventilated patient. Whereas about (62%) of nurses were applied chest physiotherapy and (58%) were avoidance of elective change of ventilator circuit, filters, humidifier, and endotracheal tubes only with a new patient or when clinically indicated. Table 15.

Table 15: Practice of ICU nurses about position and ventilator equipment's toward prevention of VAP (N=50)

Practice	Outcomes			
	Yes		No	
	F	%	F	%
• Position a patient in a semi recumbent at (30˚ to45˚)	39	78	11	22
• Use the kinetic bed for a ventilated patient.	44	88	6	12
• Apply chest physiotherapy	31	62	19	38
• Avoidance of elective change of ventilator circuit, filters, humidifier and endotracheal tubes only with a new patient or when clinically indicated	29	58	21	42

5.3.6 Total practice of ICU nurses about position and ventilator equipment's toward prevention of VAP

The total practice of ICU nurses toward position, chest physiotherapy and (humidifier, circuit, filters & ETT tube) strategies toward prevention of VAP. Showed that (71.5%) of the ICU nurses were done practice correct and (28.5%) were not done correct practice toward prevention of VAP.

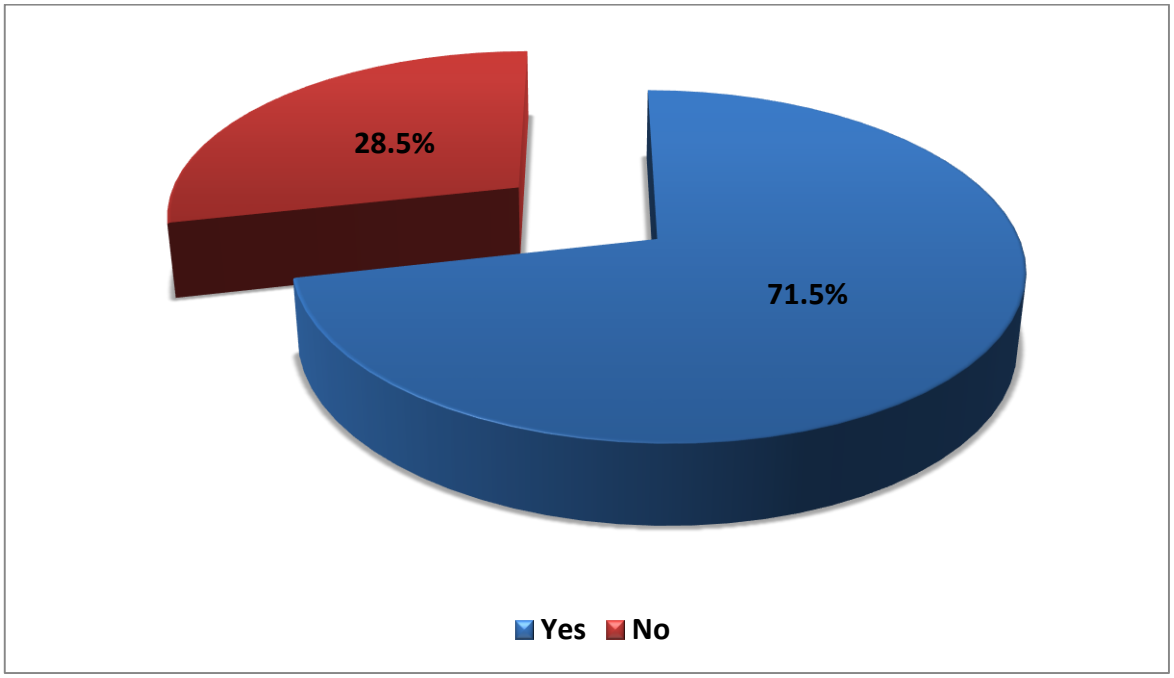

Figure 12: Total practice of ICU nurses about position and ventilator equipment's toward prevention of VAP (N=50)

5.3.7 Practice of ICU nurses about other nursing care toward prevention of VAP.

Table 16 describes the practice of nurses toward assessment, documentation, sedation and weaning protocol strategies toward the prevention of VAP. More than half of ICU nurses (54%) were checked the nasogastric tube for residual volume through the esophagus and (36%) used of protocol for weaning from mechanical ventilation. (32%) of nurses were applied sedation interruption. Whereas (66%) applied an assessment of readiness to weaning and extubation and (68%) were documented all the procedures.

Table 16: Practice of ICU nurses about other nursing care toward the prevention of VAP. (N=50)

Practice	Outcomes			
	Yes		No	
	F	%	F	%
• Checking the nasogastric tube for residual volume through the esophagus	27	54	23	46
• Use of protocol for weaning from mechanical ventilation.	18	36	32	64
• Apply sedation interruption	16	32	34	68
• Apply assessment of readiness to weaning and extubation	33	66	17	34
• Documentation	34	68	16	32

5.3.8 Total practice of ICU nurses about other nursing care toward prevention of VAP.

The total practice of ICU nurses toward assessment, documentation, sedation and weaning protocol strategies toward prevention of VAP showed that (51.2%) of the ICU nurses were correctly practiced and (48.8%) were not correctly practiced assessment, documentation, sedation and weaning protocol strategies toward prevention of VAP.

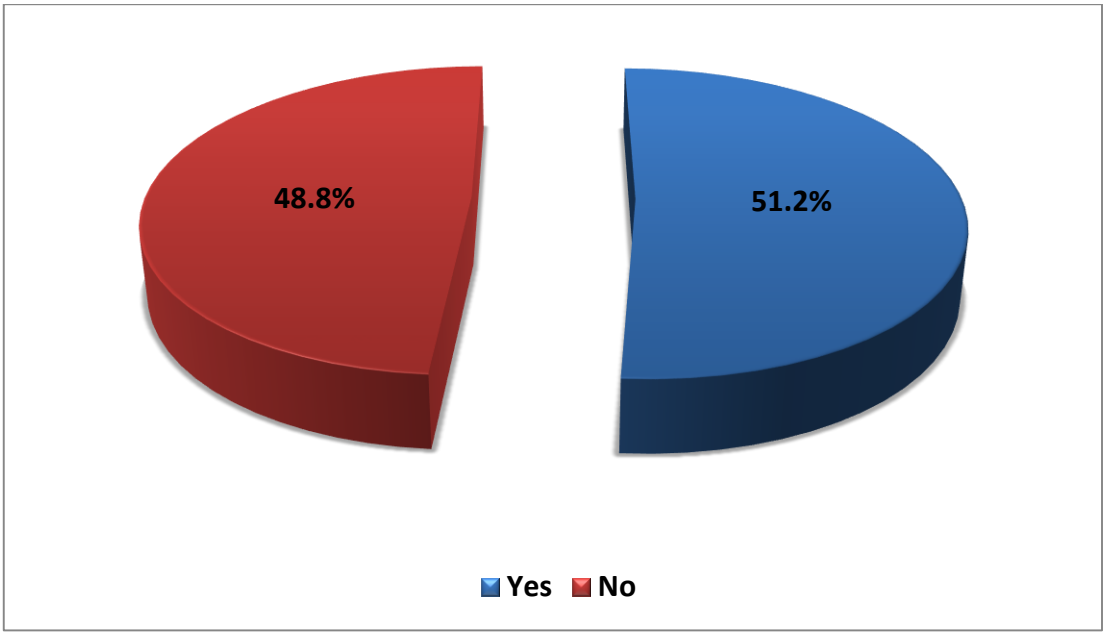

Figure 13: The Total practice of ICU nurses about other nursing care toward prevention of VAP (N=50)

5.3.9 Overall practice of ICU nurses toward prevention of VAP

Figure 14 describes the overall practice of ICU nurses toward the prevention of VAP. The finding of this study showed that less than half of ICU nurses were correctly practiced all items related to prevention of VAP (47.2%), whereas the (52.8%) of ICU nurses were not correctly practiced all items related to prevention of VAP.

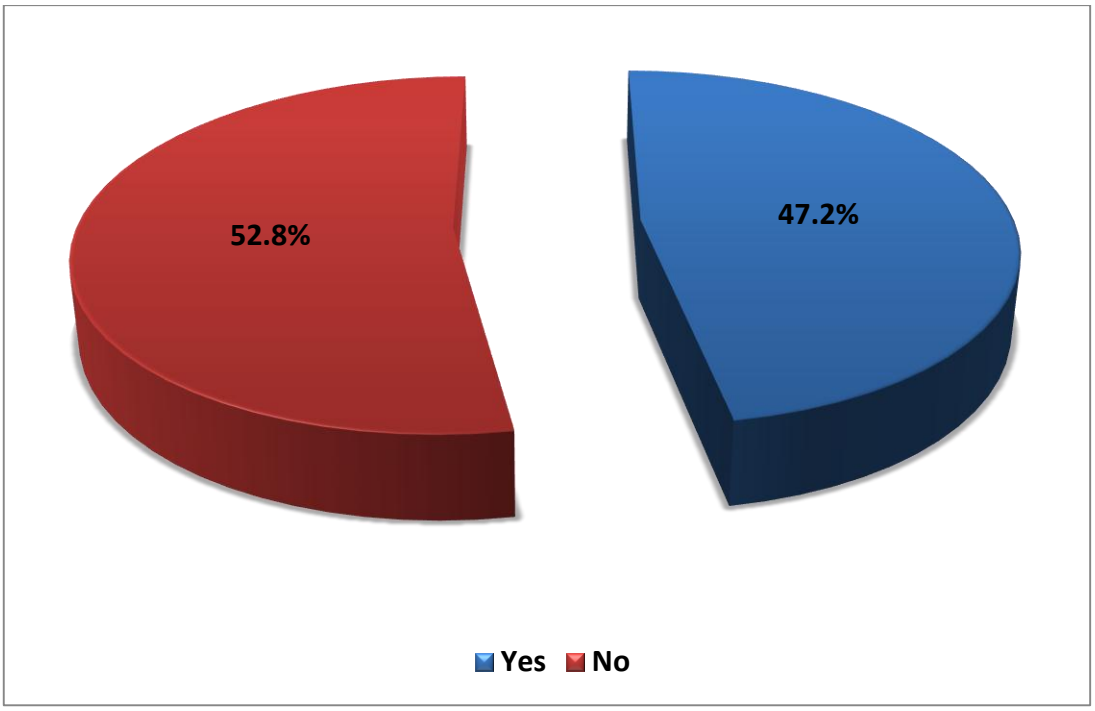

Figure 14: Overall practice of ICU nurses toward prevention of VAP (N=50)

5.3.10 Overall level of practice of ICU nurses toward prevention of VAP

Figure 15 presents the overall level of practice of ICU nurses toward the prevention of VAP. There were more than half (52%). of ICU nurses had a poor level of practice whereas (42%) had a moderate level of practice and only (6%) that were had a good level of practice.

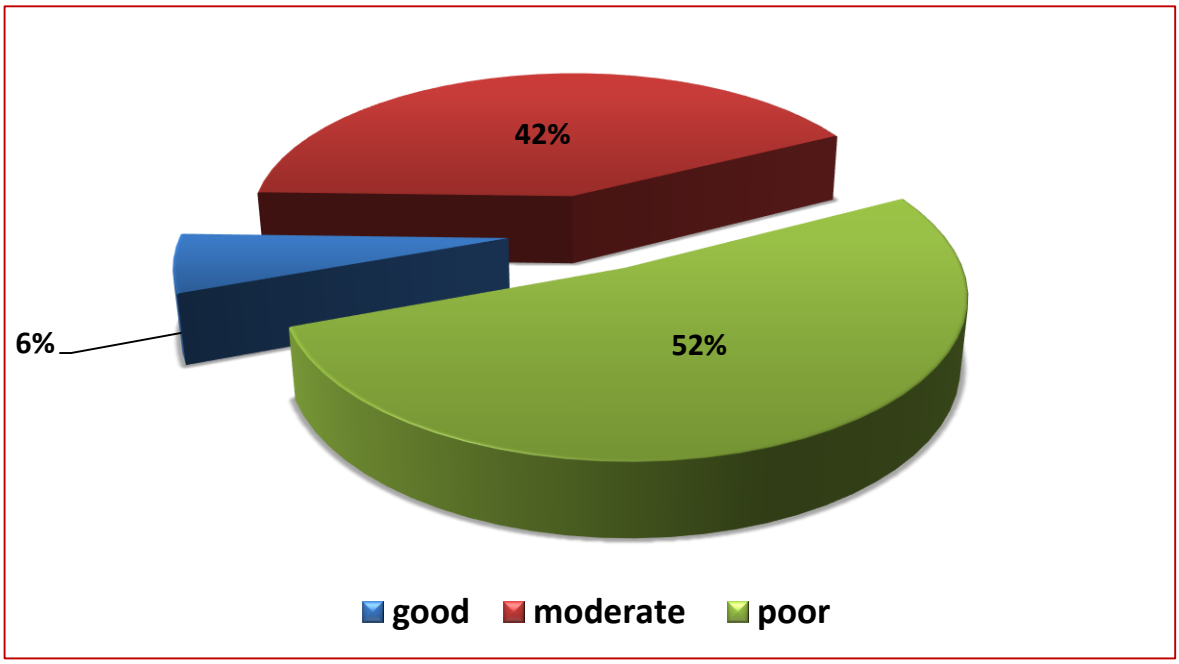

Figure 15: Overall level of practice among ICU nurses toward prevention of VAP (N=50).

5.4Association between the level of knowledge and demographic characteristics of ICU nurses toward prevention VAP

Table 17 shows there was no significant association between the overall level of knowledge toward prevention VAP and courses training in ICU among nurses (P-value= 0.38). A statistically significant association between the overall level of knowledge toward prevention VAP and attended training programs on the prevention of VAP, (P-value= 0.02). There was no significant association between the overall level of knowledge toward prevention VAP and sex (P-value=0.41). Therese was a highly significant association between the overall level of knowledge toward prevention VAP and level of education of nurses (P-value=0.001). Also no significant association between the overall level of knowledge toward prevention VAP and working experience of ICU nurses (P-value= 0.37).

Table 17: Association between the level of knowledge and demographic characteristics of nurses toward prevention VAP (N=87)

Items	Level of knowledge on prevention of VAP			p-value
	Good	Moderate	Poor	
Attended courses training in ICU				0.38
• Yes	4	24	17	
• No	1	26	15	
Attended training programs on prevention of VAP				0.02
• Yes	3	10	3	
• No	2	40	29	
Sex				0.41
• Male	1	25	14	
• Female	4	25	18	
Educational level				0.001
• Diploma degree	2	30	25	
• Bachelor degree	2	20	7	
• Master degree	1	0	0	
Work experiences				
• 1 to 3 years	1	28	19	0.37
• 4 to 6 years	1	10	8	
• 7 to 9 years	1	6	1	
• ≥10 years	2	6	4	

5.5 Association between the level of practice and demographic characteristics of nurses toward prevention VAP

Table 18 shows a significant association between the overall level of practice toward prevention VAP and courses training in ICU (P-value= 0.03). No statistically significant association between the overall level of practice and training programs on prevention of VAP (P-value= 0.42). Also showed there was no significant association between the overall level of practice and marital status (P value= 0.23). No significant association between the overall level of practice and educational level (P-value= 0.40), whereas the statistically significant association between the level of practice and experiences (P-value= 0.03).

Table 18: Association between the level of practice and demographic characteristics of nurses toward prevention VAP (N=50)

Items	Level of practice on prevention of VAP			p-value
	Good	Moderate	Poor	
Attended course training in ICU				
• Yes	2	14	8	0.03
• No	1	7	18	
Attended training programs on prevention of VAP				
• Yes	1	5	3	0.42
• No	2	16	23	
Sex				
• Male	1	8	11	0.93
• Female	2	13	15	
Marital status				
• Unmarried	1	8	16	0.23
• Married	2	13	10	
Educational level				
• Diploma degree	3	13	17	0.40
• Bachelor degree	0	8	8	
• Master degree	0	0	1	
Work experiences				
• 1 to 3 years	3	7	17	0.03
• 4 to 6 years	0	8	3	
• 7 to 9 years	0	1	4	
• ≥10 years	0	5	2	

CHAPTER 6: DISCUSSION

6.1 Introduction

The objective of this study was to assess knowledge and practice levels of intensive care unit nurses toward prevention of ventilator-associated pneumonia (VAP) at public hospitals in Sana'a city Yemen. The results of this study were based on the primary data gathered from eighty-seven ICU nurses to assess the knowledge and fifty ICU nurses to assess the practice. All the participants in the current study were working in the ICUs at the four major public hospitals in Sana'a city Yemen. The prevention of VAP is primarily the responsibility of the nurse whose knowledge and practice influence the health outcome of ICU patients. Critical care nurses play an important role in the prevention of ventilator-associated pneumonia.

This chapter presents the major findings of the study and discusses them in relation to similar studies conducted by other researchers; this helped the investigator to prove that the findings were true about knowledge and practice of ICU nurses regarding prevention of ventilator-associated pneumonia. Those can be categorized into the following:

6.2 Demographical characteristics of ICU nurses

Eighty-seven ICU nurses were recruited and all completed the study, about (54%) of ICU nurses were males, and (52%) were unmarried. The mean and ± SD of age were by 28.40 ± 3.9 years. In addition, about 71.3% the age of them ranged from 20 - 30 years. Also about (65.5 %) had a diploma in nursing, the majority of ICU nurses (51.7%) had courses training in ICU and the high of them (81.6%) had not received any training program on the prevention of VAP, and (55.2 %) were working in ICU for 1-3 years.

This finding agrees with a study was conducted in Sana'a, Yemen for (Al-Sayaghi, 2014)**,** who found that nearly two third (65.4 %) of ICU nurses had diploma degree (2 or 3 years) after secondary school. Also these our results are in agreement with the study was conducted in Sree Chitra by ***(Report et al., 2011).*** Who found that more than half (53.33%) of ICU nurses had (1 to 5 years) experience.

Also ***(Shaaban, 2013).*** Who reported in his study to age nurses that ranged between 20 to more than 30 years with a mean of 27.26 ± 5.69 years. In reference to the level of education, the subjects were mostly internship (44.4%), related to the years of experience. Whereas this finding disagrees with the study conducted in Saudi Arabia by ***(Meherali et al., 2010).*** Regarding of nurses' knowledge of evidence-based guidelines for the prevention of ventilator-associated pneumonia in critical care areas. Who is found about (42.5%) of ICU nurses had (2 to 5) years' experience.

Our results this disagreement with other results reported by ***(Passang, et al., 2014).*** Who found about (71%) were female critical care providers. As regards to age group our result agrees with his results that reported about 89.1% of participants belonged to the age group of 20-29 years, furthermore, 63% were unmarried and 51.4% had done a diploma.

6.3 Nurses knowledge toward prevention of VAP

The prevention of VAP is primarily the responsibility of the bedside nurse whose knowledge and practice influence the health outcome of ICU patients; Critical care nurses play an important role in the prevention of ventilator-associated pneumonia. Critical care nurse has an important and crucial role in preventing VAP ***(Ismail and Zahran, 2015)*.**

To ensure the highest standards of nursing care, the nursing practice must base on a strong body of scientific knowledge. This can be achieved through adherence to the evidence-based guidelines for the prevention of ventilator-associated pneumonia, ultimately improving patients' outcomes. Improved outcomes will shorten the patient's ICU length of stay, hospitalization as well as benefit the patient financially with decreased hospital costs***(Ahmed and Abosamra, 2015).***

Lack of knowledge is said to be a barrier to practice ***(Dia, 2008).*** The knowledge scored and their levels were as follows: about (57.5%) of the ICU nurses had poor knowledge, (36.8%) were had moderate knowledge and only (5.7%) of the nurses were had good knowledge score toward the prevention of VAP. Level of knowledge was observed to be inadequate therefore knowledge of the ICU nurses on VAP preventive strategies does not necessarily reflect adequate practical skills, but knowledge remains the first step toward the implementation of the VAP preventive strategies.

The results of this study are similar to another study was conducted by ***(Passang, et al., 2014).*** Who found that 55.8% of participants had adequate knowledge and 44.2% had inadequate knowledge on the prevention of VAP. Thus it is inferred that a high proportion of the critical care providers have inadequate knowledge on prevention of VAP which can be improved by many strategies. These findings were support by a study conducted in American University of Beirut by ***(Mohamad et al., 2010).*** Who reported on the 69 of critical care providers in 2010, and study by ***(Omrane et al., 2007).*** The study findings showed adequate knowledge on the prevention of VAP.

6.3.1 General knowledge toward prevention of VAP

The results related to the occurrence of the ventilator-associated pneumonia showed that about two-thirds (65.5%) of the nurses were know the ventilator-associated pneumonia that occurs after 48 hours after intubation and mechanical ventilation.

This finding agrees with the study was conducted in Saudi, Arabia. by ***(Yaseen and Salameh, 2015).*** Who found that the majority (70.2%) of ICU nurses were know the VAP that occurs more than or equals 48 hours after endotracheal intubation.

6.3.2 ETT tube strategies toward prevention of VAP

This study showed that more than half of nurses (58.6%) know that oral intubation and the endotracheal tubes with the extra lumen that used for drainage of subglottic secretions and it is reduces the risk for VAP about (63.2%). whereas about (42.5%) of them that know the accidental extubation and re-intubation of endotracheal tube are increasing the risk for VAP. Also, the correct recommendation to the maintenance of adequate pressure inside of the tracheal balloon should be keeped between 20 and 30 cmH2O only about (12.6%).

On the other hand, the total knowledge of ICU nurses toward intubation & cuff pressure strategies toward prevention of VAP was poor (44.3%). The result was agree with the study conducted by ***(Paula and Gomes, 2010),*** they recommended route of patient intubation is oral intubation about (69.88%), and the endotracheal tubes with extra lumen for drainage of subglottic secretions of the 83 participants, (60.24%) answered that these endotracheal tubes reduce the risk for VAP. Also disagreed with another study that conducted by ***(Aferu, 2016).*** Who reported that the unplanned extubation could be increased risk of aspiration lead to increased risk of VAP about

(70.9%) and the ETT with well-maintained pressure cuff to decrease the risk for VAP about (61.5%).

6.3.3 Position strategies toward prevention of VAP

This study showed. There were more than half of the nurses (57.5%) that know the head of bed should be elevated if there is no contraindication about (30 - 45˚) angle, also the use of kinetic bed it reduces the risk for VAP about (54%). Whereas the majority (86.2%) of the nurses were reported the chest physiotherapy it reduces the risk for VAP.

On the other hand, the total knowledge of ICU nurses about bed position and chest physiotherapy strategies toward prevention of VAP was moderate (65.9%). this result was agreement with another study was conducted by ***(Ahmed and Abosamra, 2015)***. To assess knowledge of pediatric critical care nurses regarding evidence-based guidelines to the prevention of VAP, they found more than half (67.3%) of ICU nurses were maintained the patients in semi-recumbent position, and about (73.5%) of them toward kinetic versus standard beds it reduce the risk for VAP.

This finding disagrees with other study conducted in Beirut, Lebanon. toward the knowledge of nurses related to the VAP prevention ***(Ismail and Zahran, 2015).*** they reported that only (25%) of the nurses knew the best recommended to a patient position on the bed should be elevation from (30- 45˚) degrees.

6.3.4 Suction strategies toward prevention of VAP

Our study showed that most of the ICU nurses (71.3%) knew the regular subglottic suction was should done before deflating tube cuff and before repositioning the tube. Whereas the best type of endotracheal suction, it is the closed suction

systems about (34.5%), and in finally the nurse is required to dispose of a suction catheter immediately after one single use about (86.2%) of them. On the other hand, the total level of ICU nurses knowledge about suction strategies toward the prevention of VAP it is moderate about (64%).

this findings are agreed with the study conducted by ***(Pauline, (2015).*** Who found that more than half (67.1%) of ICU nurses were had knowledge on the subglottic suctioning is reduce the risk of VAE but this finding disagrees with study was conducted in Addis Ababa, Ethiopia to assess knowledge, practice and associated factors of intensive care nurses on prevention of ventilator-associated pneumonia ***(Wami.G, 2014).*** The findings of this study showed that (49.6%) of ICU nurses knew the nurse is required to dispose a suction catheter immediately after one single use.

6.3.5 Oral, hands care and (humidifiers, filters and ventilator circuit) strategies toward prevention of VAP

The results of the present study showed that (35.6%) of ICU nurses knew the best solutions that used with comprehensive and regular oral care is Cholerihyxidine solution, also (42.5%) were know the true recommendation to disinfect the hands and wear gloves it is before oral care and before ETT suctioning. Whereas the correct recommendation to changes of the humidifiers filters and ventilator circuit should be every new patient (or when clinically indicated) about (52.9%).

This finding is agreed with the study was conducted in Catarina, Brazil. on the evaluation of a bundle to prevent ventilator-associated pneumonia in an intensive care unit ***(Guterres et al., 2013).*** they found that (38.8%) of ICU nurses knew the best solutions for oral care is Cholerihyxidine solution.

This finding disagrees with the study was conducted in Sari, Iran. About the nurses' knowledge of evidence-based guidelines for preventing ventilator-associated

pneumonia in intensive care units was done by ***Bagheri-nesami and Amiri, 2014).*** they reported that there was (17.3%) of ICU nurses were know the frequency of ventilator circuit changes is recommended to change circuits for every new patient.

6.3.6 Overall knowledge of ICU nurses toward prevention of VAP

The overall correct answers about knowledge of ICU nurses toward prevention of VAP was (49.7%). This finding is relative agree with the study was conducted in Egypt. By ***(Ahmed and Abosamra, 2015).*** regarding knowledge of pediatric critical care Nurses regarding evidence-based guidelines for prevention of ventilator-associated pneumonia, they found that there was (34.7%) of ICU nurses have had a satisfactory level of knowledge regarding evidence-based guidelines for preventing ventilator-associated pneumonia.

6.4 Nurses practice toward prevention of VAP

6.4.1 Oral and hand care practice toward prevention of VAP

The current study report no nurse observed to wash hands before entering ICU. While it is recommended for healthcare workers including nurses to wash hands before entering the intensive care unit ***(Boyce, Pittet, 2002).*** The observer associate absence of a tap and reagent for hand rub in the inlet door as a factor, which hinders hand washing before entering ICU**;** researcher perceives that dryness, irritation, and fissures caused by soap or alcohol-based products may contribute to poor compliance to hand washing. It, therefore, suggested that the use of waterless alcohol gels may improve the hand hygiene of healthcare workers because these gels are less damaging to the skin and they efficiently and effectively remove transient flora from the hands ***(Boyce, Pittet, 2002).*** Hands should be wash in contact with patients, the materials around them and the secretions from the patient, and before and after invasive

procedures, whether or not gloves used or changed.

Our study showed that only (28%) of nurses were performed regular hands disinfect before oral care and before tracheal suction, before and after every patient care. In ICU infections are among the most common complications affecting ICU patients due to poor adherence to an aseptic procedure like endotracheal suctioning (ETS) ***(Burk, 2003)***. Application of aseptic technique in suctioning practice and hand washing before and after such procedures strongly emphasized in the literature ***(Thompson, 2000).*** Nurses observed not wash their hands before ETS as expected because of the time it takes out of a busy work schedule particularly, in high-demand situations, such as emergency, under busy working conditions and at times of overcrowding or understaffing.

With the application of multimodal intervention practice on the nosocomial infection to the health workers, hand hygiene compliance reported to increase from 40% to 53% before patient contact and from 39% to 59% after patient contact ***(Lam et al., 2004).*** In another study, it was reported that hand washing rates were only 23% before patient contact and 48% after patient contact ***(Bischoff et al., 2000).*** Similar findings of a study done to HCW found that among HCWs, hand hygiene applications before patient contact were significantly worse than hand hygiene applications after patient contact ***(Lankford et al., 2003).***

Notably, however, a large number (74%) of participants in our study were observed to wear sterile gloves and gown before oral care and tracheal suction. This may suggest a perception among nurses that wearing gloves and using a ‘non-touch’ aseptic technique when inserting the suction catheter negates the need for frequent hand washing yet the literature clearly suggests that gloves do not replace the need for hand washing ***(Pratt et al., 2001).*** These findings support earlier studies that report

moderate and even low levels of adherence to recommended ETS procedure ***(Polit 2001; Thompson 2000; Boyce and Pittet, 2002).***

This finding is similar to study conducted in Addis Ababa, Ethiopia. ***By Perez-Granda, et al., (2013)***. toward prevention of Ventilator-Associated Pneumonia: Can Knowledge and Clinical Practice Be Simply Assessed in a Large Institution, they reported that (35.2%) of ICU nurses were performed regularly disinfect hands and wear gloves before tracheal suctioning but disagreed with a study conducted in Isfahan, Iran. Was done by ***(Adib-Hajbaghery, Ansari and Azizi-Fini, 2013)***. About the intensive care nurses practice for oral care of mechanically ventilated patients**,** who is reported there were (53.8%) of ICU nurses were used oral care with Chlorhexidine to patients.

Hand washing hygiene is a cheap and primary infection control procedure, therefore, the researcher is suggesting the measure for improvement by continuous education during hand over of the shifts, seminar and posters, ensuring the availability of adequate hand washing utilities like soap, water taps, drying tissues and reducing workload by improving nurse to patient ratio.

Whereas only (32%) of nurses performed regular oral care with an antiseptic solution (chlorhexidine). In oral care protocol for intubated patients in ICU and CICU at MNH, using a toothbrush with toothpaste, brushing with a swab, using mouthwash or oral rinse solution, suctioning the oral secretions after oral care and assessing the oral cavity were not clearly stated. The AACN guidelines recommend brushing the teeth twice a day, swabbing the mouth every 2 to 4 hours, and suctioning the oral cavity frequently as per need in order to minimize colonization of endotracheal microbes ***(Henneman, et al., 1988)***.

Although the American Dental Association has no standards for the orally

intubated patient, tooth brushing with toothpaste is recommended twice a day and swabbing the mouth every 2 to 4 hours, ***(Henneman, et al., 1988)***. In addition, this practice is now included in the AACN's oral care protocol ***(Schleder, et al., 2002).*** However, in the current study observer find using a toothbrush can be inadequate due to time-consuming and difficultness in the manipulation of the endotracheal tube which limits access to the oral cavity and causes fear of potential dislodgement of the tube.

6.4.2 Suction and cuff pressure strategies toward prevention of VAP

The results of the study showed that all of the nurses were not performed regular using the closed endotracheal suction system, and only (32%) of nurses were performed regular sterilization or disinfection to suctioning equipment. Whereas (42%) of the nurse was used sterile technique when performing tracheal suction and about (54%) disposed of suction catheter immediately after one single use. 20% of ICU nurses were performed regular subglottic suctioning before deflating cuff or repositioning the tub, and (30%) were regular control and maintenance of cuff pressure.

This finding is agreed with the study conducted by ***(A.Said, 2012)***. In Tanzania. to identify knowledge and practice of intensive care nurses toward prevention of ventilator-associated pneumonia**,** he was found that (50%) of ICU nurses discard suction tube immediately after one single use while this finding disagrees with study conducted in Addis Ababa about the assessment of knowledge and practice of nurses working in the ICU towards prevention of ventilator-associated pneumonia ***(Aferu, 2016).*** Who was reported that (76.7%) of ICU nurses were preparing sterile equipment required during suctioning.

6.4.3 Patient position, chest physiotherapy and (humidifier, circuit, filters & ETT tube) strategies toward prevention of VAP.

Most of the nurses (78%) kept the patient in a semi-sitting position at (30˚ to45˚), (88%) used the kinetic bed for a ventilated patient. Whereas about (62%) of nurses were done regular respiratory chest physiotherapy and (58%) were avoidance of elective change of ventilator circuit, filters, humidifier, and endotracheal tubes only with a new patient or when clinically indicated.

This finding is agreed with a study conducted in Mansoura, Egypt was conducted by ***(N. Kandeel and N.Tantaw, 2012).*** toward Current Nursing Practice for Prevention of Ventilator-Associated Pneumonia in ICUs. They found that there were (62%) of ICU nurses' frequent changes of ventilator circuits every new patient.

This finding disagrees with a study conducted in Egypt about the Critical Care Nurses' Knowledge and Compliance with Ventilator-Associated Pneumonia Bundle at Cairo University Hospitals ***(Shaaban, 2013).*** Who was found that there were only (33.3%) of ICU nurses were maintained continuously patient's position in (30o-45o) if not contraindicated.

6.4.4 Practice of ICU nurses about assessment, documentation, sedation and weaning protocol strategies toward prevention of VAP

This finding showed more than half of ICU nurses (54%) were checked the nasogastric tube for residual volume through the esophagus and (36%) used of protocol for weaning from mechanical ventilation. (32%) of nurses were apply sedation interruption. Whereas (66%) were applied an assessment of readiness to weaning and extubation, and about (68%) were did documented all the procedures.

This finding is agreed with study conducted in Addis Ababa, Ethiopia about Knowledge, Practice and Associated Factors of Adult Intensive Care Nurses' on Prevention of Ventilator-Associated Pneumonia in Public Hospitals was conducted by ***(Wami, Mengistu, and Gudisa, 2018).*** they reported that (58%) of ICU nurses were performed documentation to procedures during oral care.

This finding disagrees with study conducted in Amman, Jordan about evidence-based guidelines for prevention of ventilator-associated pneumonia: Evaluation of intensive care unit nurses' adherence ***(Msn, 2017).*** Who is found (90.4%) of ICU nurses were used guideline or sedation protocol (sedation vacation and assess readiness to extubate patient from mechanical ventilation.

6.5 Association between the level of knowledge and demographic characteristics of nurses toward prevention VAP

The current study has found that critical care provider's knowledge on prevention of VAP is statistically associated with the educational qualification (P-value=0.001). This is not similar to the results of the study was conducted in Tanzania on knowledge and practice of intensive care nurses on prevention of ventilator-associated pneumonia by ***(T. Ally, 2012).*** This has indicated that there is no association between the educational qualification and knowledge on prevention of VAP.

Findings of the current study showed that no significant association between level of knowledge score on prevention of VAP and years of experience in ICU (P-value= 0.37) and ICU courses training (P-value= 0.38). This is similar to the findings of the Global European Study done by ***(Dodek, et al., 2004).*** In addition, a study done in South Africa by ***(Labeau, et al., 2007).*** This indicated that there is no association

between the level of knowledge, ICU training, years of experience and knowledge on prevention of VAP.

This is findings similar with the findings reported by (***Ally. Tatu , 2014).*** Who found that ICU nurses knowledge on prevention of VAP is statistically not associated with ICU training, level of education and years of experience (p-value > 0.05). This is also similar to the findings of the ***(global European study, 2004).*** Similarly to this study was done in ***(South Africa, 2010***). This indicated that there was no association between the level of knowledge, ICU training, years of experience and knowledge on prevention of VAP.

6.6 Limitations of the study

The current study was conducted in ICUs of 4 public hospitals in Sana, a city, had few numbers of participants and short duration of observations, therefore findings may not be representative of the general population of ICU nurses in Yemen. This may threaten the external validity of the findings hence another research on this area with a large sample size is required.

Observation, like other methods, has its own limitations and ethical implications. One of the main problems is the effect of the 'observer' on the 'observed'. This is referred to as the Hawthorne effect and is an important threat to the validity of observational research, whereby participants' awareness of being in a study may cause them to change their practice ***(Kelleher & Andrews, 2008).***

However, the literature suggests that the change of behavior is usually temporary, where there is a tendency for the observed to become used to the presence of the observer and continue to perform their activities according to their normal day-to-day practice ***(Dahlgren et al., 2004).*** Therefore, the Hawthorne effect may not have affected the study findings.

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

From the results of the study, we conclude that:

- The current study revealed inadequate ICU nurses' knowledge on general information, intubation and cuff pressure strategies, oral and hands care and (humidifiers, filters and ventilator circuit) strategies and prophylaxis, sedation and weaning protocol toward prevention of VAP.
- The current study revealed adequate ICU nurses' knowledge on bed position and chest physiotherapy and suction strategies toward the prevention of VAP.
- Regarding the level of overall knowledge of ICU nurses toward prevention of VAP, this study revealed that more than half (57.5%) of ICU nurses had poor knowledge on VAP preventive strategies and knowledge did not reflect in their practice.
- Knowledge of ICU nurses was found to be a significant association with an attended training program on prevention of VAP and level of education (P-value> 0.05) but no significant association was found between sex, ICU training, years of working experience and level of knowledge (P-value< 0.05).
- Practice of hand washing, oral care and insecure environmental and suction, cuff pressure strategies and assessment and documentation, sedation and weaning protocol strategies toward prevention of VAP were observed to be inadequate therefore knowledge of the ICU nurses on VAP preventive strategies does not necessarily reflect adequate practical skills, but knowledge remains the first step toward the implementation of the VAP preventive strategies.

- The current study revealed adequate ICU nurses' practices on position, chest physiotherapy and (humidifier, circuit, filters & ETT tube) strategies toward prevention of VAP.
- More than half (52%). of ICU nurses had a poor overall level of practice toward prevention of VAP.
- The practice of ICU nurses on prevention of VAP was found to be statistically associated with ICU training and years of working experience (P-value> 0.05) but not statistically associated with sex, marital status, education level, and training program (P-value< 0.05).

7.2 Recommendations

With increasing advances in the health sciences, including nursing science and there is a rising need for constant updating of new information to develop new skills in order to provide the best care to patients. To fulfill this need ICU nurses need ongoing development in their careers in order to remain updated with current knowledge and skills. ***We recommended that:***

- **Recommendations for Clinical Nursing Practice**

1. ICU nurses need to be encouraged to translate their knowledge into practice.
2. ICU environment should enable a nurse to translate knowledge into practice by ensuring availability of facilities like hand washing sinks, soap, and disinfectants for cleaning and disinfecting equipments.
3. Adoption of acceptable guidelines based on evidence-based medicine practice to prevention of VAP is also recommended.
4. Introduction of ongoing in-service education into hospitals and ICUs to improve knowledge and practiec on prevention of VAP which is a common nosocomial infection in the intensive care units.

5. The orientation of new staff members in ICU's should include education on recommended strategies for the prevention of VAP.
6. Revision of unit protocols regularly as updates and new evidence for best practice are constantly emerging and staff should be educated on the updated protocols.
7. Motivate opinion leaders amongst nurses in the units to motivate their colleagues in putting guidelines for prevention of VAP into practice.
8. Staff members should be motivated to develop their careers by studying further and gaining more knowledge and skills in the ICU field.

- **Recommendations for Nursing Education**

The following recommendations made for nursing education:

1. Resources such as articles journals and electronic resources such as computers and the internet should be made accessible in the units for staff members. Articles on prevention of VAP should be discussed in unit meetings as part of staff education.
2. The ICU training program should include evidence-based guidelines for the prevention of VAP.
3. Nursing lecturers and clinical facilitators should incorporate evidence-based measures to prevent VAP daily in ICU's and use learning opportunities in the units to raise the topic
4. The continuing professional development program should be made compulsory for nurses to motivate nurses to participate in lectures, congresses, and another program in order to increase their knowledge and practice levels.

- **Recommendations for Nursing Research**

  Recommendations for further research based on the limitations of this study. The recommendations include the following:

  1. A similar study is recommended to include a large sample size in other hospitals and possibly other provinces with a larger population and sample. which provide care for critically ill patients in Yemen.
  2. Further research on factors affecting implementation of VAP prevention strategies is recommended
  3. Further research should be conducted to test knowledge and practice levels of nurses prior to and after the educational program on evidence-based guidelines for prevention of VAP.
  4. A study on protocols used nationally and their inclusion of evidence-based guidelines on the prevention of VAP should be carried out in order to evaluate Yemen hospitals adherence to the guideline.
  5. Raise nursing student's interest in research to keep themselves updated with current practice.

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الملحق (أ)
النسخة باللغة العربية

استبيان رقم ( )

اداة رقم واحد

تقييم معارف وممارسات ممرضي العناية المركزة حول الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي في المستشفيات العامة مدينة صنعاء – اليمن.

الجزاء الاول : الموافقة الرسمية

- **عزيزي/عزيزتي زملاء المهنة: انا الباحث عبد الفتاح صالح محمد الجرادي من كلية العلوم الطبية ـجامعة الرازي اقوم بأجراء رسالة الماجستير في مجال تمريض الحالات الحرجة، واجري هذه الرسالة بموافقة جامعة الرازي والهدف منها هو تقييم معارف وممارسات ممرضي العناية المركزة حول الالتهاب الرئوي المصاحب لاستخدام جهاز التنفس الاصطناعي في المستشفيات العامة مدينة صنعاء-اليمن.**
- **المشاركة في هذه الدراسة هي تطوعية والمعلومات التي سنأخذها منك ستحاط بالسرية التامة وفقا لأخلاقيات البحث العلمي، ولن تتأثر في مهنتك أو عملك بما سوف تدلي به من معلومات، وهوية المشارك لن يعلم بها أي أحد.**
- **نرجو اعطانا الاجابات التي تعبر عن معرفتك انت فقط.**
- **نشكركم على اعطائنا جزء من وقتكم في قراءة هذه المعلومات وبإمكانكم الاستفسار عن أي شيء في الرسالة من خلال التواصل بنا على التلفون (773661427) او على الإيميل (afatah711183371@gmail.com).**

الموافقة

هل توافق على المشاركة في هذه الدراسة

- نعم اوافق استكمال المشاركة. ( )
- لا اوافق انهي المشاركة. ( )

ملاحظات المشارك في الاستبيان:

.....

.....

.....

.....

.....

التأكد من تعبئة كل البيانات

- التأريخ:.....
- التوقيع:.....

الجزاء الثاني : البيانات الديموغرافية			
من فضلك ضع دائرة حول الإجابة الصحيحة:			
م	السؤال	الاجابة المتوقعة الصحيحة	الرمز
١.	اسم المستشفى الذي تعمل فيه	• مستشفى الثورة	١
		• مستشفى الجمهوري	٢
		• مستشفى الكويت	٣
		• مستشفى السبعين	٤
٢.	اسم وحدة العناية المركزة	• وحدة العناية المركزة العامة	١
		• وحدة العناية المركزة الأطفال	٢
		• وحدة العناية المركزة الطوارئ	٣
		• وحدة العناية المركزة الجراحة	٤
		• وحدة العناية المركزة الباطنة	٥
		• اخرى	٦
٣.	الجنس	• ذكر	١
		• انثى	٢
٤.	الحالة الاجتماعية	• عازب	١
		• متزوج	٢
٥.	العمر بالسنة	.....	
٦.	المستوى التعليمي	• درجة الدبلوم	١
		• درجة البكالوريوس	٢
		• درجة الماجستير	٣
		• درجة اخرى	٤
٧.	سنوات الخبرة في العناية المركزة	.....	
٨.	هل حصلت على درجة علمية او كرس تدريبي في العناية المركزة	• نعم	١
		• لا	٢
٩.	هل حصلت على برنامج تدريبي الوقاية من الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.	• نعم	١
		• لا	٢
١٠.	هل حصلت على دبلوم معالجة تنفسية بعد شهادة التمريض.	• نعم	١
		• لا	٢

الجزاء الثالث: معارف ممرضي العانية المركزة حول الوقاية من الالتهاب الرئوي المصاحب لاستخدام جهاز التنفس الاصطناعي.
(من فضلك ضع دائرة حول الإجابة الصحيحة)

المقطع الاول: المعارف العامة تجاه الوقاية من الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.

١. الالتهاب الرئوي المصاحب لاستخدام جهاز التنفس الاصطناعي للمريض يحدث:
   a. عند دخول المريض الى المستشفى.
   b. خلال ٢٤ ساعة من وقت ادخال انبوب القصبة الهوائية واستخدام جهاز التنفس الاصطناعي.
   c. بعد ٤٨ ساعة من وقت ادخال انبوب القصبة الهوائية واستخدام جهاز التنفس الاصطناعي.
   d. لا اعرف.

٢. الاستراتيجيات الافضل الوقاية من الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي هي:
   a. الوقاية من مستعمرات البكتيريا في الحلق واستخدام المضادات الحيوية بقوة.
   b. الوقاية من الارتشاق (aspiration)بالسوائل الراجعة من الجهاز الهضمي الى مجرى التنفس واستخدام جهاز التنفس الاصطناعي غير المخترق.
   c. البرامج التثقيفية والوقاية من مستعمرات البكتيريا والوقاية من الارتشاق بالسوائل الراجعة من الجهاز الهضمي الى مجرى التنفس.
   d. لا اعرف.

المقطع الثاني: المعارف بالاستراتيجيات الخاصة بأنبوبة القصبة الهوائية تجاه الوقاية من الالتهاب الرئوي.

٣. الطريقة الافضل التي يوصي بها عند ادخال انبوبة القصية الهوائية هي:
   a. الادخال عن طريق الفم.
   b. الادخال عن طريق الانف.
   c. كلا الطريقتين يوصى بها.
   d. لا اعرف.

٤. استخدام انبوبة القصبة الهوائية المزودة بمجرى اضافي لتفريغ السوائل المتجمعة فوق بالون القصبة الهوائية:
   a. يقلل في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
   b. يزيد في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
   c. لا يؤثر في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
   d. لا اعرف.

٥. نزع المريض لأنبوبة القصبة الهوائية واعادة ادخال الأنبوب:
   a. يؤثر في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي بشكل بسيط.
   b. يزيد في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
   c. لا يؤثر في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
   d. لا اعرف.

٦. التوصية الصحيحة لحافظ الضغط داخل بالون انبوبة القصبة الهوائية يوصي بأن يكون:
   a. يوصي بان يكون الضغط بين ٢٠ و٣٠ cmH_2O.
   b. يوصي بان يكون الضغط بين ١٠ و٢٠ cmH_2O.
   c. يوصي بان يكون الضغط بين ٠ و١٠ cmH_2O.
   d. لا اعرف.

المقطع الثالث: المعارف بالاستراتيجيات الخاصة بوضعية المريض تجاه الوقاية من الالتهاب الرئوي.

٧. وضعية المريض على السرير الموصي بها هي:
   a. يوصي بان يرفع راس المريض بزاوية (٥ الى ١٥ درجة).
   b. يوصي بان يرفع راس المريض بزاوية (١٥ الى ٣٠ درجة).
   c. يوصي بان يرفع راس المريض بزاوية (٣٠ الى ٤٥ درجة).
   d. لا اعرف.

٨. استخدام الاسرة المتحركة للمريض اثناء التنفس الاصطناعي:
   a. يقلل في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
   b. يزيد في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
   c. لا يؤثر في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
   d. لا اعرف.

٩. العلاج الطبيعي للصدر (chest physiotherapy):
a. يقلل في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
b. يزيد في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
c. لا يؤثر في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
d. لا اعرف.

المقطع الرابع: المعارف بالاستراتيجيات الخاصة بالشفط للسوائل تجاه الوقاية من الالتهاب الرئوي.

١٠. التفريغ المنتظم للسوائل المتجمعة فوق بالون القصبة الهوائية يجب ان يكون:
a. قبل تفريغ هواء البالون وقبل تحريك وضعية انبوب القصبة الهوائية.
b. بعد تفريغ هواء البالون وبعد تحريك وضعية انبوب القصبة الهوائية.
c. لا يؤثر في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي.
d. لا اعرف.

١١. أفضل نوع للتشفيط من القصبة الهوائية هو (نظام الشفط المغلق او المفتوح):
a. يوصي باستخدام نظام الشفط المفتوح.
b. يوصي باستخدام نظام الشفط المغلق.
c. يوصي باستخدام كلا النظامين الشفط المفتوح والمغلق.
d. لا اعرف.

١٢. الممرض يتخلص من قسطرة الشفط من القصبة الهوائية للمريض:
a. بعد استخدامها لمره واحدة مباشرةً.
b. ممكن تنظف وتستخدم لمرتين.
c. ممكن تستخدم لعدة مرات بدون تنظيف.
d. لا اعرف.

المقطع الخامس : المعارف بالاستراتيجيات العامة للتحكم بالعدوى تجاه الوقاية من الالتهاب الرئوي.

١٣. المحلول الافضل استخدامه عند العناية الشاملة والمنتظمة بالفم هو:
a. محلول النرمل سلاين (Normal saline).
b. محلول الكلوروهيكسيدين (Cholerihyxidine).
c. محلول الماء المعقم ((sterile water.
d. لا اعرف.

١٤. نحتاج الى تعقيم اليدين ولبس القفازات من اجل التقليل في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي في الاجراءات التالية:
a. قبل الشفط للسوائل من الفم والقصية الهوائية.
b. بعد الشفط للسوائل من الفم والقصية الهوائية.
c. قبل وبعد الشفط للسوائل من الفم والقصية الهوائية.

١٥. التوصية الصحيحة لتغير مرطب الهواء ومرشحات البكتيرية التنفسية وانابيب توصيل جهاز التنفس الاصطناعي هي:
a. يوصي ان تغيير كل ٤٨ ساعة (او عند الحاجة السريرية).
b. يوصي ان تغيير كل اسبوع (او عند الحاجة السريرية).
c. يوصي ان تغيير عند كل مريض جديد (او عند الحاجة السريرية).
d. لا اعرف.

المقطع السادس : المعارف بالاستراتيجيات الاخرى تجاه الوقاية من الالتهاب الرئوي.
١٦. أفضل علاج وقائي يستخدم الوقاية من قرحة المعدة اثناء التنفس الاصطناعي من اجل التقليل في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي هو: **a.** استخدام مضاد الاحماض ومضاد الهستامين النوع الثاني (antacids and histamine type2 antagonist) **b.** استخدام ((sulcralfate only) فقط. **c.** استخدام كل الذي سبق. **d.** لا اعرف.
١٧. اعطاء المريض وقائية من حدوث الجلطات(DVT) مثل ادوية التجلط والشراب الضاغط: **a.** يقلل في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي. **b.** يزيد في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي. **c.** لا يؤثر في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي. **d.** لا اعرف.
١٨. تطبيق بروتوكول (protocol) لاستخدام المهدات واجراء الفطام من جهاز التنفس الاصطناعي: **a.** يقلل في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي. **b.** يزيد في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي. **c.** لا يؤثر في حدوث الالتهاب الرئوي المصاحب لجهاز التنفس الاصطناعي. **d.** لا اعرف.

شكرا لمشاركتك،،،

اداة رقم اثنين : قائمة ملاحظات ممارسات ممرضي العناية المركزة حول الوقاية من الالتهاب الرئوي المصاحب لاستخدام جهاز التنفس الاصطناعي.		
ممارسات الممرضين تجاه الوقاية من الالتهاب الرئوي	**نعم**	**لا**
الجزاء الاول: الممارسات العامة تجاه الوقاية من الالتهاب الرئوي		
١. تعقيم اليدين بانتظام قبل العناية بالفم والشفط من القصبة الهوائية وقبل وبعد العناية بكل مريض.		
٢. استخدام القفازات والجاونات العازلة بانتظام قبل العناية بالفم والشفط من القصبة الهوائية.		
٣. العناية المنتظمة للفم باستخدام محلول معقم (chlorhexidine).		
٤. عمل جل ذائب في الدهن على شفاه المرضى بعد العناية بالفم.		
٥. الحفاظ على ان تكون بيئة المريض نظيفة ومعقمة.		
الجزاء الثاني: الممارسات الخاصة بشفط السوائل تجاه الوقاية من الالتهاب الرئوي		
٦. الاستخدام المنتظم لنظام الشفط المغلق من القصبة الهوائية.		
٧. التعقيم والتطهير المنتظم لأدوات الشفط من الفم والقصبة الهوائية.		
٨. استخدام تقنية التعقيم عند التشفيط من القصبة الهوائية.		
٩. رمي قسطرة الشفط من القصبة الهوائية مباشرة بعد الاستخدام لمرة واحدة فقط.		
١٠. الشفط المنتظم للسوائل المتجمعة فوق بالون القصبة الهوائية قبل تفريغ الهواء من بالون القصبة الهوائية وقبل تحريك وضعية الانبوب.		
١١. الحفاظ والتحكم المنتظم على ضغط بالون أنبوبة القصبة الهوائية.		
الجزاء الثالث: الممارسات الخاصة بوضعية المريض وتغير الأدوات تجاه الوقاية من الالتهاب الرئوي		
١٢. عمل علاج طبيعي للجهاز التنفسي والصدر بشكل منتظم.		
١٣. الحفاظ على وضعية المريض شبة جالس على ان يكون راس السرير مرتفع بزاوية ٣٠-٤٥ درجة.		
١٤. استخدام الاسرة. الخاصة (مثل الاسرة المتحركة).		
١٥. تجنب التغير الاختياري لمرطب الهواء ومرشحات البكتيرية التنفسية وانابيب توصيل جهاز التنفس الاصطناعي الا في حالة مريض جديد او عند الحاجة السريرية.		
الجزاء الرابع: الممارسات الاخرى الخاصة بالرعاية التمريضية تجاه الوقاية من الالتهاب الرئوي		
١٦. التشيك المنتظم على انبوب المعدة لتقيم السوائل الراجعة عبر المري.		
١٧. استخدام خطة لتنظيم فطام المريض من جهاز التنفس الاصطناعي.		
١٨. الوقف اليومي للمهدات للمرضى المستخدمين لجهاز التنفس الاصطناعي.		
١٩. التقييم اليومي لجاهزية المريض للفطام من جهاز التنفس الاصطناعي وازالة أبنوبه القصبة الهوائية.		
٢٠. التوثيق لكل الاجراءات المقدمة للمريض.		

Questionnaire: English Version

Questionnaire No ( )

Tool one: the questionnaire

Questionnaire on : Assessment of knowledge and practice of ICU nurses' towards prevention of ventilator associated pneumonia at public hospitals in Sana'a City-Yemen.

Part I : Informed consent

- Dear colleague: I am a researcher (**Abdul Fattah Saleh Mohammed Al-Jaradi**) from college of Medical Sciences - Al-Razi University. I undertake a master's thesis in the field of the critical care nursing that aims to assessment of knowledge and practice of the ICU nurses' towards prevention of ventilator associated pneumonia at public hospitals in Sana'a City-Yemen.
- Participation in this study is voluntary and the information that we will take from you wassubject to strict confidentiality in accordance with the ethics of scientific research, and will not be affected in your profession or work by the information you give, and the identity of the participant will not know anyone.
- Please give us the answers that reflect your knowledge only.
- Thank you for giving us part of your time to read this information. You can inquire about anything in the message by contacting us at (773661427) or on the Email (afatah711183371@gmail.com).

The consent

Do you agree to participant in the study:

- Yes, I agree to complete participation. ( )
- I don't agree to complete this participation. ( )

Participant Observations:

.....
.....
.....

Complete mobilize of all the data Assuring

- Date:…….
- Signature:…….

Part II : Demographic characteristics of Nurses			
Please Circle on the correct answer			
QN	**Statement**	**Expected answer**	**Code**
1.	**Hospital Name**	• Al-Thowrah hospital	**1**
		• Al-Jomhury hospital	**2**
		• Al-Kuwait hospital	**3**
		• Al-Sabeen hospital	**4**
2.	**Type of ICU**	• General ICU	**1**
		• Pediatric ICU	**2**
		• Emergency ICU	**3**
		• Surgical ICU	**4**
		• Medical ICU	**5**
		• Other ICU	**6**
3.	**Sex**	• Male	**1**
		• Female	**2**
4.	**Marital status**	• Single	**1**
		• Married	**2**
5.	**Age in (Years)**	……	
6.	**Level Education status**	• Diploma degree	**1**
		• Bachelor degree	**2**
		• Master degree	**3**
		• Other specify, …….	**4**
7.	**Years of ICU Experience**	**…….**	

Part II Cont. Courses Training.			
Q	**Statement**	**Expected answer**	**Code**
9.	**Do you have a Degree or Courses training in ICU?**	• Yes	**1**
		• No	**2**
10.	**Do you have attending training programs on prevention of VAP?**	• Yes	**1**
		• No	**2**
11.	**Do you have diploma in respiratory therapy?**	• Yes	**1**

Part III- ICU nurses knowledge about Prevention of Ventilator Associated Pneumonia
(Please Circle on the correct answer)

Section I: Knowledge of ICU nurses about general information of VAP.

12. Ventilator associated pneumonia definition as Pneumonia in a patient receiving mechanical ventilation that.

A. Was present on the time of admission to hospital.
B. Occur in 24 hours after intubation and mechanical ventilation.
C. Occur after 48 hours after intubation and mechanical ventilation.
D. I don't know.

13. Which the following is the best strategies to prevention of VAP?

A. Prevent colonization and aggressive antibiotics use.
B. Prevent aspiration and use non-invasive ventilation.
C. Education program, reduce colonization and prevent aspiration.
D. I don't know.

Section II: Knowledge of ICU nurses about ETT tube strategies to prevention of VAP

14. Which way is the best recommended when is intubating a patient?

A. Oral intubation is recommended.
B. Nasal intubation is recommended.
C. Both routes of intubation are recommended.
D. I do not know.

15. Endotracheal tubes with extra lumen for drainage of subglottic secretions.

A. Reduce the risk for VAP.
B. Increase the risk for VAP.
C. Does not influence the risk for VAP.
D. I do not know.

16. Accidental extubation and re-intubation for endotracheal tube are?

A. Slightly influence the risk for VAP.
B. Increase the risk for VAP.
C. Do not influence the risk for VAP.
D. I don't know.

17. The correct recommendation to maintenance of adequate pressure inside of the tracheal balloon should be:

A. Recommend to be between 20 and 30cmH2O.
B. Recommend to be between 10 and 20cmH2O.
C. Recommend to be between 0 and 10cmH2O.
D. I don't know.

Section II1: Knowledge of ICU nurses about position strategies to prevention of VAP.

18. Positioning for patient on the bed if there is no contraindication

A. Should be elevate head of the bed from (5 - 15º) recommended.
B. Should be elevate head of the bed from (15 - 30º) recommended.
C. Should be elevate head of the bed from (30 - 45º) recommended.
D. I do not know.

19. Kinetic (automatically to rotate bed) standard beds

A. Reduce the risk for VAP.
B. Increase the risk for VAP.
C. Does not influence the risk for VAP.
D. I do not know.

20. Chest physiotherapy it is recommended due to the following reason.

A. Reduces the risk for VAP.
B. Increases the risk for VAP.
C. Does not influence the risk for VAP.
D. I do not know.

Section IV: Knowledge of ICU nurses about suction strategies to prevention of VAP.

21. The regular subglottic suction should be done.

A. Before deflating tube cuff or before reposition the tube
B. After deflating tube cuff or after reposition the tube
C. Does not influence the risk for VAP.
D. I do not know.

22. The best type of endotracheal suction is (open or closed systems.

A. Open suction systems are recommended.
B. Closed suction systems are recommended.
C. Both systems can be recommended.
D. I do not know.

23. A nurse is required to dispose a suction catheter.

A. Immediately after one single use.
B. Can be cleaned and used twice.
C. Can be used more than one without cleaned.
D. I don't know.

Section V: Knowledge of ICU nurses about common prevention strategies to prevention of VAP.

24. Which the best of solutions that used with Comprehensive and regular oral care?

A. Normal saline solution.
B. Cholerihyxidine solution.
C. Sterile water solution.
D. I do not know.

25. When caring for a ventilated patient is required to disinfect hand and wear gloves.

A. Before oral and ETT suctioning.
B. After oral and ETT suctioning.
C. Before and after oral / ETT suctioning.
D. I don't know.

26. The correct recommendation to changes of the humidifiers, filters and ventilator circuit should be changes?

A. Every 48 hours (or when clinically indicated).
B. Every week (or when clinically indicated).
C. Every new patient (or when clinically indicated).
D. I do not know.

Section VI: Knowledge about other strategies toward prevention of VAP.

27. The best type of prophylaxis drugs to peptic ulcer for decreased the risk of VAP.

A. Use the antacids and histamine type2 antagonist.
B. Use the sulecrafate only.
C. Use all the above.
D. I don't know.

28. Give the patient a prophylaxis dose from DVT such as anticoagulant and elastic stoking

A. Decrease the risk for VAP.
B. Increase the risk for VAP.
C. Do not influence the risk for VAP.
D. I don't know.

29. Implementation of ICU protocol for using sedation, weaning from mechanical ventilation?

A. Decrease the risk for VAP.
B. Increase the risk for VAP.
C. Do not influence the risk for VAP.
D. I don't know.

Thank you for your participation!!!

Tool two - Observational check list on ICU nurses practice on Prevention of Ventilator Associated Pneumonia		
VAP Prevention Practice	**Yes**	**No**
Part I: Practice of ICU nurses about common prevention practice toward the prevention of VAP.		
1. Apply hands washing before oral care, tracheal suction, before and after every patient care.		
2. Wear sterile gloves before oral care and tracheal suction		
3. Apply oral care with an antiseptic solution (chlorhexidine).		
4. Apply water-soluble jelly to patient lips after oral care.		
5. Insuring environmental cleanness and sterilization		
Part II: Practice of ICU nurses about suction practice toward prevention of VAP.		
6. Using the closed endotracheal suction system.		
7. Sterilizing/disinfecting suctioning equipments.		
8. Using sterile technique during tracheal suction.		
9. Discard suction catheter immediately after one single use.		
10. Apply subglottic suctioning before deflating cuff or repositioning the tube.		
11. Control and maintenance of cuff pressure.		
Part III: Practice about position and ventilator equipment's change toward prevention of VAP.		
12. Keep the patient in semi sitting position at (30˚ to 45˚).		
13. Use kinetic bed for ventilated patient.		
14. Avoidance of elective change of ventilator circuit, filters, humidifier and endotracheal tubes only with new patient or when clinically indicated.		
15. Apply chest physiotherapy		
Part IV: Practice about other nursing care practice toward prevention of VAP.		
16. Checking the nasogastric tube for residual volume through the esophagus.		
17. Use of protocol for weaning from mechanical ventilation.		
18. Apply sedation interruption.		
19. Apply assessment of readiness to wean and extubation.		
20. Documentation		

Appendix-B
Litters to principles of hospitals

Republic of Yemen
Ministry of Education & High Research
Al-Razi University

الجمهورية اليمنية
وزارة التعليم العالي والبحث العلمي
جامعة الرازي

الأخ / مدير عام هيئة مستشفى الثورة

المحترم أ.د عبداللطيف ابو طالب

بعد التحية،،

تهديكم جامعة الرازي أطيب التحايا وتتمنى لكم دوام التوفيق والنجاح في جميع أعمالكم

الموضوع / السماح للطالب بعمل استبيان لإنجاز رسالة الماجستير

بالإشارة إلى الموضوع أعلاه وفي إطار التعاون والتبادل العلمي وبناءً على العقد الموقع بين الجامعة وهيئتكم الموقرة نرسل اليكم **الطالب / عبدالفتاح صالح محمد الجرادي** من الطلاب الدارسين في الجامعة (ماجستير) تمريض حالات حرجة وذلك بهدف إجراء استبيان لإنجاز رسالة الماجستير بعنوان: knowledge and practices of ICU nurses toward prevention ventilator associated pneumonia at Public Hospitals Sana'a City Yemen.

وعليه/

نأمل ان تتكرموا مشكورين بالتوجيه لمن يلزم بتسهيل مهام الطالب.

وتقبلوا خالص التحية والتقدير،،

عميد كلية العلوم الطبية
أ.د/ نبيل الربيعي

صنعاء - شارع الرباط - خلف البنك اليمني للإنشاء والتعمير
406760 774440012 216923
جامعة الرازي ... اختيارك ... نحو مستقبل أفضل
www.alraziuni.edu.ye alraziuni.edu.ye alraziuniv info@alraziuni.edu.ye

الجمهورية اليمنية
هيئة مستشفى الثورة العام – صنعاء
الشؤون الاكاديمية والتدريب
قسم البحوث والنشر

الاخ /مدير إدارة التمريض المحترم

تحية طيبة وبعد ،،،،

نرجو منكم التعاون مع الباحث / عبد الفتاح صالح محمد الجرادي طالب ماجستير تمريض حالات حرجة جامعة الرازي وذلك لجمع معلومات عن طريق الاستبيان لرسالة الماجستير المعنونة بـ:

(Knowledge and practices of ICU nurses to ward prevention ventilator associated pneumonia public hospital Sana`a city Yemen)

لمدة 3 شهر ابتداء من 2018/4/11م وحتى 2018/7/11م

وتقبلوا تحياتنا ،،،،

رئيس قسم البحوث والنشر
د/ عبد الرحمن الكرازي

نائب المدير العام للشؤون الاكاديمية والتدريب
د/ نجيب ابو اصبع

Republic of Yemen
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Al-Razi University

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جامعة الرازي

الأخ / مدير عام هيئة مستشفى الجمهوري

أ.د نصر القدسي المحترم

بعد التحية،،

تهديكم جامعة الرازي أطيب التحايا وتتمنى لكم دوام التوفيق والنجاح في جميع أعمالكم

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وعليه/

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وتقبلوا خالص التحية والتقدير،،

عميد كلية العلوم الطبية

أ.د/ جميل الربيعي

الأخ / مدير عام هيئة مستشفى السبعين

أ.د حسين الحداد **المحترم**

بعد التحية ،،

تهديكم جامعة الرازي أطيب التحايا وتتمنى لكم دوام التوفيق والنجاح في جميع أعمالكم

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وتقبلوا خالص التحية والتقدير ،،

عميد كلية العلوم الطبية

أ.د/ نبيل الريمي