



St. Paul's Hospital Millennium Medical College

Graduate Study Program

**Knowledge , Practice and Associated factors towards Mechanical Ventilation
Management among Adult Intensive Care Unit Nurses at Public Hospitals in Addis
Ababa, Ethiopia, 2021 GC**

Investigator: Kemal Abdulkadir (BSc.)

Addis Ababa, Ethiopia

February, 2022



St. Paul's Hospital Millennium Medical College

Graduate Study Program

Knowledge, Practice and Associated factors towards Mechanical Ventilation Management among Adult Intensive Care Unit Nurses at Public Hospitals in Addis Ababa, Ethiopia, 2021GC

A Research thesis submitted to the School of Nursing, Graduate Studies, St. Paul's Hospital Millennium Medical College in Partial fulfillment of the Requirements for the Degree of Masters of Science in Critical Care Nursing Practitioner

By: Kemal Abdulkadir (BSc)

Advisor: Dr. Dereje Bayissa (BSc, MSc/MRH, PhD, Associate Professor)

Co-advisor: Mr. Ephrem Hassen (MSc, Lecturer)

Addis Ababa, Ethiopia

February, 2022

Name of investigator	Kemal Abdulkadir
Full title of the research project	Knowledge, Practice and associated factors towards Mechanical Ventilation Management among Adult Intensive Care Unit Nurses at Public Hospitals in Addis Ababa, Ethiopia, 2021
Duration of the project	From November 2021 to February 2022 GC
Study Area	Public Governmental Hospitals in Addis Ababa, Ethiopia,
Total Cost of the project	25,000 ETB
Source(s) of Funding	Saint Paul's Hospital Millennium Medical College
Address of the investigator	Phone No: +251924616804 E-mail: kamiabdul16@gmail.com
Name and address of Advisor(s)	Main Advisor: Dr. DerejeBayissa (BSc, MSc/MRH, PhD, Associate Professor) Phone No: +251912189560 E-mail: derebayu@gmail.com Co-advisor: Mr. EphremHassen (MSc, Lecturer) Phone No: +251911984565 E-mail: Yebatiwephrem@gmail.com

Abstract

Background: The need for mechanical ventilation is one of the most common causes of admission to the intensive care unit. There is a paucity of information on knowledge and practice towards mechanical ventilation among nurses in the current study area.

Objective: The main aim of this study was to assess knowledge, practice, and associated factors towards mechanical ventilation among adult intensive care unit Nurses at public hospitals in Addis Ababa, Ethiopia, 2021.

Methods: Facility-based cross-sectional study was done by a total survey of all 330 Adult intensive care unit nurses at public hospitals in Addis Ababa for the assessment of knowledge and 10%(33) of them included in the observational study. Data was collected using self-administered questionnaires for knowledge and observational checklist for practice on mechanical ventilation. The data was coded and entered into Epidata version 4.6 and then transferred to the statistical package for social science version 26 for further analysis. Binary and multi-variable logistic regression was done at 95% confidence interval with P-value < 0.05 to find association between variables. Results are expressed as mean $\pm$ standard deviation and percentage.

Result: Among the study participants 181(58.6%) were females and the mean age was 27.9 years ($\pm$ 3.2 SD). About 266(86.1%) were clinical nurses and first-degree holders. The overall knowledge level of the Nurses was determined that 167(54%) had poor knowledge with 95% C.I (48.5-59.5). The identified factors associated with adult intensive care unit Nurses' mechanical ventilation knowledge were: educational level, Masters of Science degree (AOR 7.316, 95% C.I 1.733, 30.895) and Bachelor Science (AOR 4.87, 95% C.I 1.63, 14.57), training (AOR 2.299, 95% C.I 1.362, 3.881) and guideline (AOR 1.67, 95% C.I, 0.979, 2.8490). About 151(49.2%) of the subjects had favorable attitude towards mechanical ventilation and 25(75.8%, n=33) of subjects demonstrated poor practice during observation with 95% C.I (60.6, 90.9).

Conclusion: The overall knowledge and practice of intensive care unit nurses was poor with identified factors that increase the likelihood of good knowledge were: educational level, training and guideline. Therefore, policy makers and health planners would better strengthen regular training and provision of guidelines and protocols to improve the knowledge and practice level of the nurses.

Keywords: Mechanical ventilation, Knowledge, Practice, Adult Intensive Care Unit Nurses, Public hospitals

Acknowledgement

First of all thanks to God for all things. Secondly, I would like to greatly acknowledge SPHMMC, School of Nursing and department of ECCN for selection of the research title and their further motivation. I would also like to express my gratitude to my advisors Dr. Dereje Bayissa (PhD) and Mr. Ephrem Hassen (MSc CCNP) for their guidance and constructive suggestions for the accomplishment of this project. Finally I would like extend my gratitude to my parents, public hospitals in Addis Ababa, Addis Ababa Public Health Research and Emergency Management Directorate, study participants and Ambo University.

Table of contents

page

Contents

Abstract	I
1. Introduction	1
1.1. Background	1
1.2. Statement of the Problem	3
1.3. Justification/Significance of the study	4
2. Literature Review	6
2.1. Overview of Mechanical Ventilation Knowledge and Practice Components	Error! Bookmark not defined.
2.1.1. Modes of Mechanical Ventilation	Error! Bookmark not defined.
2.1.2. Ventilator settings	7
2.1.3. Ventilator Troubleshooting	8
2.2. Knowledge and Practice towards Mechanical Ventilation among AICU Nurses	8
2.2.1. Factors associated with Knowledge and Practice towards Mechanical Ventilation among AICU Nurses	9
2.3. Knowledge, Attitude, and Practice of Intensive Care Nurses towards Mechanical Ventilation among admitted patients	10
2.4. Conceptual framework	12
3. Objectives	13
3.1. General objective	13
3.2. Specific objectives:	13
4.1. Study Area	14
4.2. Study Period	15
4.3. Study Design	15
4.4. Study Population	15
4.4.1. Target population	15
4.4.2. Source population	15

4.4.3. Eligibility criteria.....	15
4.5. Sample size.....	16
4.6. Sampling Procedures:.....	16
4.7. Measurement	16
4.7.1. Study variables.....	16
4.7.2. Instruments	16
4.8. Data collection and procedures	16
4.9. Operational and Term definitions.....	17
4.10. Data Quality Control and Management.....	17
4.11. Data Analysis Procedures.....	18
4.12. Ethical Consideration	19
4.13. Dissemination of Results.....	19
5. Results.....	20
5.1. Sociodemographic characteristics of the study participants.....	20
5.2. Facility related factors	20
5.3. Level of Nurses' Knowledge towards Mechanical Ventilation	21
5.4. Attitude of study participants towards Mechanical Ventilation.....	Error! Bookmark not defined.
5.5. Observational findings on Practice of Nurses towards Mechanical ventilation.....	24
6. Discussion	28
7. Conclusions and recommendations.....	31
7.2. Recommendations	31
8. References	34
9.1. Annex 1: Information sheet.....	36
9.2. Annex 2: Consent form	37
9.3. Annexes 3: English Version Questionnaires/Observational Check List.....	38

Abbreviations and Acronyms

AA: Addis Ababa

A/C: Assist- Control

AICU: Adult Intensive Care Unit

AOR: Adjusted Odd Ratio

ARDS: Acute Respiratory Distress Syndrome

CCNPs: Critical Care Nursing Practitioners

CCPs: Critical Care Practitioners

cmH₂O: Centimeter of Water

CO₂: Carbon Dioxide

COPD: Chronic Obstructive Pulmonary Disease

COR: Crude Odd Ratio

ECCN: Emergency and Critical Care Nursing

ETTs: Endotracheal Tubes

FIO₂: Fraction of Inspired Oxygen

FRC: Functional Residual Capacity

ICU: Intensive Care Unit

IBW: Ideal Body Weight

IRB: Institutional Review Board

MV: Mechanical Ventilation

NGOs: Non-Governmental Organizations

O₂: Oxygen

PCO₂: Partial Pressure of Carbon Dioxide

PEEP: Peak End-Expiratory Pressure

PH: Potential of Hydrogen

PIP: Peak Inspiratory Pressure

PO₂: Partial Pressure of Oxygen

PVA: Patient-Ventilator Asynchrony

RR: Respiratory Rate

SPHMMC: Saint Paul's Hospital Millennium Medical College

SD: Standard Deviation

VE: Minute Ventilation

TV: Tidal Volume

List of Tables

1. Table 2: Sociodemographic characteristics of AICU nurses at Public Hospitals in Addis Ababa, Ethiopia, 2021
2. Table 3: Facility related characteristics of Adult Intensive Care Unit nurses at Public Hospitals in Addis Ababa, Ethiopia, 2021
3. Table 4: Factors associated with mechanical ventilation management knowledge on binary logistic regression
4. Table 5: Factors associated with mechanical ventilation knowledge on multivariable logistic regression
5. Table 6: Findings of the observational study of practice towards Mechanical Ventilation management among AICU nurses at Public Hospitals in Addis Ababa, Ethiopia, 2021

List of figures

1. Figure 1: A Figure showing factors affecting knowledge and practice towards mechanical ventilation management among ICU nurses
2. Figure 2: Figure showing knowledge level towards mechanical ventilation management of Adult Intensive Unit nurses at Public Hospitals in Addis Ababa, Ethiopia, 2021GC
3. Figure 4: Practice level of Adult Intensive Unit Nurses on Mechanical Ventilation management at Public Hospitals in Addis Ababa, Ethiopia, 2021GC

1. Introduction

1.1. Background

Mechanical ventilation (MV) is a method used to artificially support respiratory function by means of a ventilator machine. It can be used to either assist or replace normal spontaneous breathing and can be undertaken invasively or non-invasively. This study was focused on the invasive mechanical ventilation. It is one of the most common interventions in intensive care-it is often lifesaving, but can have life-threatening physiological and psychological side-effects. Among these are ventilator-associated pneumonia (VAP), sepsis, acute respiratory distress syndrome (ARDS), atelectasis, pulmonary edema, and delirium(1, 2). Mechanical ventilation management requires good knowledge of a complex and dynamic interaction between several ventilator variables. This knowledge and skill need to be incorporated into accurate and efficient decisions about best practices while also avoiding ventilator related complications. Intensive care nurses are ideally placed to promote safe and optimal ventilation because of their role in monitoring the patient's condition and their continual bedside presence. A sound knowledge of the principles of MV is essential for its effective and safe implementation. It is highly important to know the technical specifications of the MV device and recognize and correct early the practices that cause complications for maintaining and terminating the time elapsed in MV in a healthy way. It is stated that clinicians responsible for the mechanical ventilator would need to calculate an acceptable MV number (1,3-5).

Nurses must have the relevant skills and understanding required for their role as they are the key of information to patients, relatives, and other members of an interdisciplinary team .Ventilation management incorporates, an overall plan of care that considers fundamental decisions, such as when to administer, when to reduce and when to stop providing ventilator support and titrations made in ventilator settings in response to the patient's immediate condition. It is important that both fundamental decisions and titrations are made with expertise, as ventilation management that is inappropriate for individual patient need leads to increased risk of significant complications, such as ventilator-associated pneumonia, lung injury and the morbidities associated with prolonged sedation such as prolonged ventilation and delirium(6- 8).Studies

revealed that inconsistent adoption limited the of impact recommendations made through the past decades for optimizing the ventilation of intensive care unit (ICU) patients and in particular in acute respiratory distress syndrome (ARDS) patients, including low TV, positive end-expiratory pressure (PEEP), and early extubation. When invasive MV is needed, avoiding atelectrauma and volutrauma, and limiting asynchronies are one of the main objectives of well conducted MV (9-11).

Mechanical ventilation requires the simultaneous skills of many in the inter-professional healthcare team. Nurses are usually the first in identifying set issues, and understanding the physiology and management of MV is crucial for clinicians managing patients in the ICU. Proper MV management requires an understanding of indications for MV, physiology of MV, modes of ventilation, basic ventilator settings, ventilator troubleshooting, lung pressures and lung compliance. Studies demonstrated that ICU nurses have poor MV management. Inadequate MV management is associated with complications such as ventilator-associated pneumonia (VAP), ventilator-induced lung injury (VILI), cardiovascular compromise, gastrointestinal disturbances and long-term MV dependence. Nurses often use tools to record ventilator settings chronologically and use checklists to confirm invasive mechanical ventilation (IMV) care items, such as checking the cuff pressure. ICU staff training improved compliance to a predefined ventilator bundle and this led to a reduction in the days spent on MV, despite incomplete bundle implementation(5, 12-14).

Studies revealed that knowledge and practice towards MV management among nurses working in ICU is limited. This inadequate knowledge and practice of Nurses towards MV management related to mode selection, settings, and troubleshooting alarms lead patients to MV complications. The Ethiopian federal ministry of health (FMOH) provides short-term trainings regarding MV to ICU staff in collaboration with hospitals to enhance the knowledge and practice of ICU nurses. In addition to this nowadays universities are giving critical care and respiratory programs, but still there is lack of trained man power with the increasing ICU demands. The knowledge and practice status towards MV of ICU nurses in Ethiopia particularly in AddisAbaba was unknown.

1.2. Statement of the Problem

Mechanical ventilation presents specific challenges to the nurse, as each patient is unique in terms of lung pathology and the type of ventilation strategy and settings required for the specific lung pathology of the individual patient. Mechanical ventilation management has a direct effect on patient outcomes; however, researches demonstrate that there is an overall lack of best practice usages among nurses. Poor ventilator management inflicts serious pulmonary and extra-pulmonary damage that may not be immediately apparent. Inappropriate ventilator settings, failure by the nurse to recognize deteriorating lung function and complications can lead to ventilator induced lung injury (VILI), which may exacerbate the initial pathology of the lungs. This can lead to complications such as pneumothorax, tracheal necrosis, and ventilator associated pneumonia. These complications can at best prolong the hospital stay of the patient, thereby significantly increasing costs, and at worst lead to increased morbidity and mortality of the patient (15, 16).

Researches about nursing evaluation of MV mainly focus on single influential factors, while studies of comprehensive nursing interventions for MV systems are lacking(15). On the other hand inconsistent adoption of recommendations like low TV, and PEEP, and early extubation limited their impact for optimizing the ventilation of ICU patients. Nurses have very limited knowledge of MV and receive very little formal nursing education on this topic. Poor performance is directly related to a lack of knowledge and understanding (9-11).

Studies revealed that nurses demonstrate poor ventilator management leading patients on MV to preventable MV complications. Researchers articulated that poor ventilation management knowledge and practice which is associated with patient outcomes can be addressed through continuous education and trainings on the topic. Intensive care unit must be staffed with highly trained professionals. But in Ethiopia there is lack of adequate critical care program trained nurses and as result non critical care nurses work in ICUs. And as to the researcher's knowledge and current literature search revealed there is no published study done regarding the knowledge and practice towards MV among these nurses working in AICUs.

1.3. Justification/Significance of the study

Nurses caring for patients on MV require specialist knowledge and skills to monitor, identify, and prevent the potential deleterious effects associated with MV. Therefore, it is important for them to have an understanding of the essential components of MV and its associated risks and complications, to enable them to provide safe and effective patient care(1). Nurses play important role in MV management and assessing nurses' knowledge and practice towards MV management and associated factors provides an insight into how nurses manage MV.

Intensive care unit service is being expanded in Ethiopia and this must be in line with simultaneous work force development in using MV to its best. Studies show that the knowledge and practice status of ICU nurses regarding MV is poor and this is not known in our situation where most nurses working in ICUs are non-critical care trained nurses. It is necessary to determine the knowledge and practice level of ICU nurses to take appropriate action to improve or maintain their practice level.

This study provided a basis for further research, to improve the practice levels of ICU nurses in terms of MV in order to improve the quality of care and patient safety. Results of this study informed national healthcare policy makers and administrators, to recognize the knowledge and practice levels of ICU nurses on MV and the contributing factors hence being the basis to develop appropriate approaches to improve/maintain the ICU nurses knowledge and practice. This study informed future improvement strategies in the nursing practice and patient safety. The results of this study are an added source of information to the existing literature on this subject as well as and for the education of nursing.

Generally this study is an input to the critical care nursing professional development and researches, researchers, policy makers, health planners, government and non-governmental organizations (NGOs) through providing baseline information/data on the topic and related factors as it is the first of its type in Ethiopia. This study also initiated nurses to evaluate them in

regard to MV knowledge and practice and provided an insight to respective hospitals to identify the knowledge and skill level of their nurses and plan possible improvement strategies.

In addition this work also identified factors affecting nurses' knowledge regarding MV and put recommendations forward according to its findings. Therefore, this study assessed the knowledge and practice towards IMV and associated factors among Nurses working in AICUs at public hospitals in Addis Ababa, Ethiopia, 2021.

2. Literature Review

2.1. Overview of Mechanical Ventilation Knowledge and Practice Components

The key features of MV management components include; modes of ventilation, ventilator settings, alarms, ventilator initiation, checking the position of the endotracheal tube, checking the cuff pressure, and weaning(17).

2.1.1. Modes of Mechanical Ventilation

The mode of ventilation usually depends on many patient variables. The usual modes of ventilation include the assist-control (A/C) which delivers preset breaths in coordination with the patient's respiratory effort, the controlled mechanical ventilation (CMV) which delivers a set TV and RR, the synchronized intermittent mandatory ventilation (SIMV) which delivers a preset breaths in coordination with the patient's respiratory effort, but permitting spontaneous breathing, the intermittent mandatory ventilation which delivers a set TV at a fixed rate at the lowest setting to support and maintain an appropriate arterial blood gas regardless of effort by the patient but permitting the patient to do some breathing, and the pressure supported ventilation (PSV) in which the level of PS is set to assist every spontaneous effort made by the patient(17, 18).

2.1.2. Ventilator settings

Adjustable ventilator settings differ with mode but include RR, TV, trigger sensitivity, flow rate, waveform, and I: E ratio. An initial TV of 5-8 mL/kg of ideal body weight (IBW) is generally indicated. The goal is to adjust the TV so that plateau pressures are less than 35 centimeter water (cmH₂O). With assisted ventilation the sensitivity typically is set at -1 to -2 cmH₂O. The normal I/E ratio are 1:2. This is reduced to 1:4 or 1:5 in the presence of obstructive airway disease. The inspiratory flow rate is set at about 60 L/minute but can be increased up to 120 L/minute for patients with airflow limitation. Applying physiologic PEEP of 3-5 cmH₂O is common to prevent decreases in functional residual capacity (FRC) in those with normal lungs(17, 18).

2.1.3. Ventilator Troubleshooting

The differential diagnosis of the clinically deteriorating, mechanically ventilated patient is wide and includes endotracheal tube or ventilator dysfunction, improper ventilator settings, pain, anxiety, and pulmonary or extra-pulmonary disease processes. The diagnosis of intrinsic PEEP may be made by performing an end-expiratory hold or by detecting a non-zero end-expiratory flow on the ventilator. Its treatment is to allow for lung deflation and longer expiratory times by decreasing the RR and the TV, or changing the I: E ratio. High peak pressure with normal plateau pressures indicates increased resistance to flow, such as endotracheal tube obstruction or bronchospasm(15, 17-18).

Despite the use of numerous safety precautions, cases are occasionally documented of ventilators being connected to compressed air or nitrous oxide rather than oxygen. Increasing FiO₂ and adjusting ventilator settings to increase PEEP or respiratory rate are useful first steps after excluding equipment failure and mechanical causes of hypoxia. Endotracheal cuff pressures should be monitored initially after intubation and every 4 hours thereafter, with goal pressures of 20-30 cmH₂O, as increased risk of pneumonia has been associated with cuff pressures less than 20 cmH₂O. According to a study done in Saudi Arabia common PVAs detection assessed using observational analysis was low in critical care settings, with about 25% of PVAs going undetected by critical care practitioners (CCPs)(15, 17, 19).

2.2. Knowledge and Practice towards Mechanical Ventilation among AICU Nurses

Nurses are usually the first in identifying set issues, and understanding the physiology and MV is crucial for clinicians managing patients in the ICU. ICU nurses participate in hundreds of hours of didactic and laboratory instructions on the application and function of MV, and their role in the care of ventilated patients are indisputable. The role and autonomy of ICU nurses vary considerably between countries. One study reported that in North America, the clinical management of MV is generally the responsibility of respiratory therapists in collaboration with physicians, and most research on MV management focuses on physicians' decision-making rather than ICU nurses(7, 20).

Research evidence regarding the ICU nurses' role and autonomy focuses on their participation in the development or implementation of weaning protocols. Experienced ICU nurses assume that

role, exercising high levels of autonomy in the management of patients who require MV, with or without nurse-led weaning protocols. The study done in New Zealand revealed that nurses reported less autonomy and more influence in decision-making about ventilation management. According to the study fundamental decisions like choice of mode, initial settings, readiness to wean, stopping sedation, method of weaning and readiness to extubate were made in collaboration with physicians and nurses but nurses readily made independent adjustments to ventilator settings. A study conducted in Turkey determined that the nurses, intensive care units nurses, did not have enough knowledge about mechanical ventilation practices. Similar study done in Saudi Arabia also showed that MV management knowledge of critical care providers was limited(8, 21-22).

2.2.1. Factors associated with Knowledge and Practice towards Mechanical Ventilation among AICU Nurses

Mechanical ventilation management usually takes place in a dynamic and fast-paced clinical environment. Critical care providers need to adopt the newly emerging MV-related evidence and incorporate them into daily practice. An improvement in nurses' knowledge and skills is likely to enhance and optimize MV management. Studies demonstrated that optimizing ventilator parameters reduces the overall duration of MV and organ dysfunction. Any healthcare worker who makes changes to the ventilator settings must be able to demonstrate best-suited competency and training. Nurses are constantly present at the patient's bedside, and an experienced nurse can sense problems occurring and institute steps to avert a catastrophe. Nurses must be knowledgeable about the function and limitations of ventilator modes, causes of respiratory distress and dyssynchrony with the ventilator, and appropriate management to provide high-quality patient-centered care(22-24).

Training nurses to detect patient ventilator dysynchrony have advantages in that they would help compensate for the lack of critical care physicians and could detect dyssynchrony earlier than other caregivers would. Nurses are able to detect ineffective inspiratory efforts after special training with similar accuracy to critical care experts in mechanical ventilation. Prolonged mechanical ventilation is associated with a longer ICU length of stay and higher mortality. Two

recent Cochrane systematic reviews in ICU adult and pediatric populations concluded that protocols can be effective in reducing the duration of MV. Despite benefits MV at the same time is an intervention that can be attributed to increased morbidity and mortality with improper utilization and management techniques. Mechanical ventilation management has a direct effect on patient outcomes; however, researches continue to demonstrate that there is an overall lack of best practice usages. Improper MV practices are associated with increased hospital stays, healthcare costs, morbidity, and mortality (25-29).

Studies revealed that, there is limited evidence of the effectiveness of continuing education programmes on MV involving nurses in improving patient outcomes exists. In a study conducted in Australia 63% of study participants reported not receiving education about MV prior to working in ICU. According to the study self-directed learning package and competency programme were perceived as valuable and beneficial. Hands-on-practice was perceived as the most important form of education and ventilator settings as the most important topic. Older age was independently associated with not completing the self-directed learning package (AOR 0.20, 95% CI 0.04, 0.93). 4–6 years intensive care experience was independently associated with completion of self-directed learning package (AOR 17, 95% CI 1.7, 165) and part-time employment was associated with non-completion (AOR 0.23, 95% CI 0.08, 0.68). A study conducted in South Africa showed that both the ICU qualified and non- ICU qualified nurses demonstrated poor levels of competence at P-value of 0.039. A study done in Baghdad revealed that statistical associations were found between nurses educational levels, years of experience in critical unit and training sessions toward nurses' knowledge of MV. According to a study done on critical care capacity in Addis Ababa there is lack of specially trained providers in the ICUs in the city(16, 29-31).

2.3. Knowledge and Practice of Intensive Care Nurses towards Mechanical Ventilation among admitted patients

Limited knowledge on MV leads to improper MV management which in turn leads to complications to patients on MV. Complications may arise due improper MV management which includes improper settings and alarm trouble shooting. Poor performance is directly related to a lack of knowledge and understanding, with improved knowledge correlating to an

increase in performance. The intensive care unit nurses, independent of their role and job position perceive that most of the ventilated patient management is within the nurses' scope of practice(32).

In the study conducted in Brazil of the nurses interviewed, 86.36% reported not having enough information to care for a patient under MV, and 77.52% of the respondents claimed that they would not know the complications related to MV. Another study in India highlighted that though the knowledge among nurses was moderately adequate, the practice was low. An investigation in Saudi Arabia also reported that MV management knowledge of critical care providers is limited (19, 22, 33). Another study conducted in Rwanda revealed that only 1.6% of participants achieved the competence indicator of 75% other 98.4% did not achieved and the competence level was associated with qualification, job position and age with p-values, P(0.000),P(0.000),P(0.038) respectively. A study finding in Egypt also, reported that, 68.3% of nurses had unsatisfactory knowledge and all nurses in the study (100%) had unsatisfactory practice regarding the management of patients on the MV(34, 35).

2.4. Conceptual framework

Factors like lack of guideline books, interest, job description, in-service training course and insufficient financial reward to the nurses contribute to unsatisfactory practice level of nurses towards MV management. Poor performance is directly related to a lack of knowledge and understanding, with improved knowledge correlating to an increase in performance(32, 35).

Technological evolutions in delivering and monitoring of MV have rapidly expanded, currently offering a wide array of tools. With technological advancements, the terminology has become more complex, contributing to possible confusion for the clinician. The information required can be obscured by the confusing terminology attached to the various modes of ventilation(3, 36). Despite researchers postulations that nurses, who had extended years of experience in the ICU, demonstrate a superior level of competence in MV, than those with less experience, a study done in South Africa, reported that neither age nor years of experience had influence on the competency levels of either the ICU qualified or non- ICU qualified nurses(16).

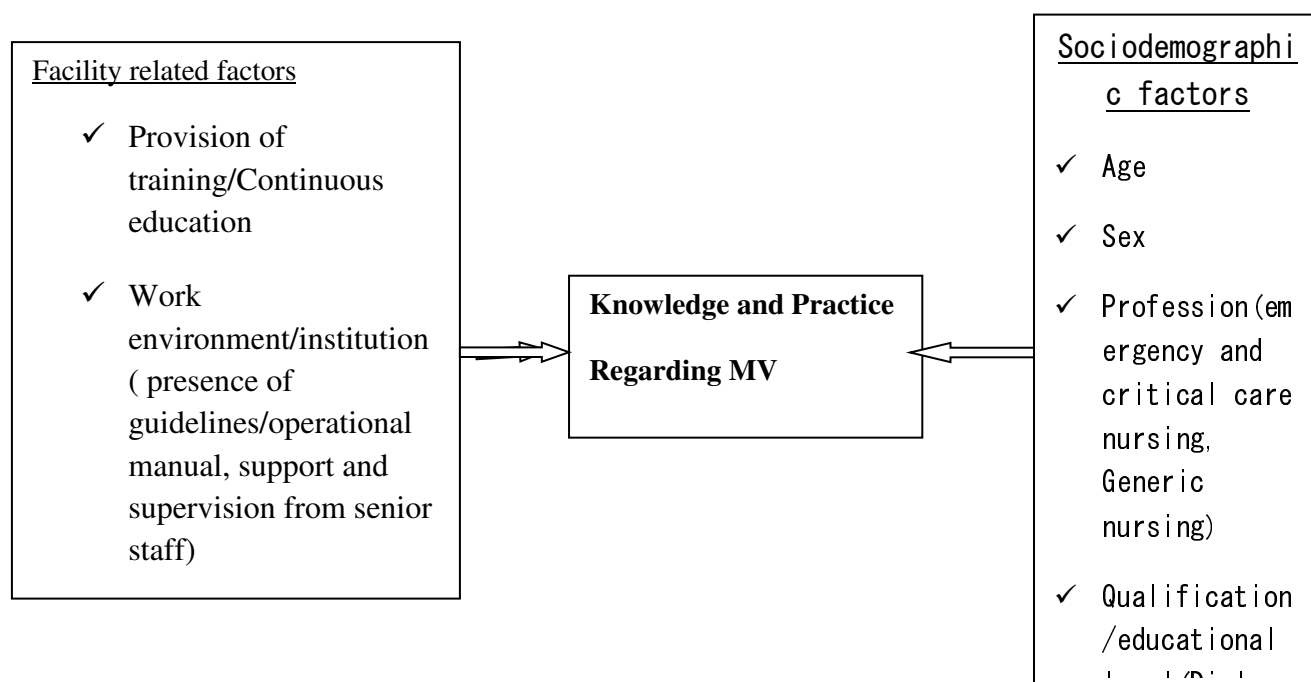


Figure 1: A Figure showing factors affecting the knowledge towards mechanical ventilation among ICU nurses (Developed using different literature works)(3, 16, 36).

3. Objectives

3.1. General objective:

- To assess knowledge, practice and associated factors towards MV management among AICU Nurses at public hospitals in AA, Ethiopia from December 1 to 29, 2021 GC.

3.2. Specific objectives:

- To assess the knowledge level towards MV management among AICU Nurses at public hospitals in AA, Ethiopia from December 1 to 29, 2021 GC.
- To assess the practice level towards MV management among AICU Nurses at public hospitals in AA, Ethiopia from December 1 to 29, 2021 GC.
- To identify factors associated with the knowledge towards MV management among AICU Nurses at public hospitals in AA, Ethiopia from December 1 to 29, 2021 GC.

4. Method

4.1. Study Area: The study area is Addis Ababa which is capital city of Ethiopia, and a seat of African Union and Economic Commission for Africa. The city has, 11 sub-cities, 5,006,000 population, 5046 peoples per square kilometer, with more slum and overcrowding. It holds 527 square kilometers of area in Ethiopia. (From Central Statistical Agency of Ethiopia, and <https://populationstat.com/ethiopia/addis-ababa>). The population pyramid is broad based, typical of a developing world. People from different regions of Ethiopia populate the city. The city has 52 hospitals (12 public hospitals, 36 private hospitals, 3 uniform military hospitals and 2 NGO hospitals). Number of health centers are 61 of which 54 are public and 7 are NGO health centers. The city has also more than 700 clinics and 500 drug venders accountable to Addis Ababa city administration. (Data obtained from medical service directorate of the federal ministry of health, Addis Ababa Regional Health Bureau, and Addis Ababa city administration). The current study area was public hospitals in Addis Ababa. All governmental hospitals in AA was selected among St. Paul's Hospital Millennium Medical Collage (SPHMMC), Tikur-Ambessa Specialized Hospital, St. Petros Hospital, AaBET Hospital, Tirunesh Beijing hospital, Zewditu Hospital, Minilik II hospital, Yekatit 12 hospital, Ras Desta Damtew Memorial hospital and Gandhi Memorial hospital except Kotobe hospital as it is COVID 19 center and Amanuel Specialized Hospital which gives special service. The study was conducted at public hospitals in Addis Ababa, Ethiopia, 2021.

Saint Paul's Hospital Millennium Medical College is a specialized hospital administrated by FMOH. It has a total of 580 beds and over 13 departments with over 3578 clinical and non-clinical staffs and. There are 40 nurses, 10 physicians, and 12 beds in adult Medical Intensive Care Unit. Addis Ababa Burn, Emergency, and Trauma (AaBET) an affiliate of St. Paul's hospital has a total of 250 beds and 257 nursing staff. The hospital receives trauma, non-trauma, and burn injury patients. The intensive care unit has 12 beds and staffed with 42 nurses and 10 physicians. Tikur Ambessa hospital is under Addis Ababa University's School of Medicine is located in Lideta Sub City. This hospital has 600 beds, 627 nursing staff, and 202 physicians. In the ICU, there are 16 beds with functional mechanical ventilators, 51 nurses, and 15 physicians, and all beds are functional for the management of ICU patients. There were 364 healthcare professionals working in the ICUs of the nine public hospitals at the time.

Zewditu Memorial hospital is located in Kirkos Sub City and under Addis Ababa Health Bureau. It has a total of 182 beds, 277 nursing staff, and 62 physicians. The intensive care unit is staffed with 2 anesthesiologists, 30 nurses, and six physicians, and has 12 beds. Gandhi hospital has 11 nurses and 6 beds with mechanical ventilators in the ICU. Minilik II hospital has 35 ICU nursing staff and 10 beds with ventilators. Saint Peter's specialized hospital has 32 ICU nurses and 10 beds with ventilators. Tirunesh Beijing hospital and Ras Desta memorial hospital have 32 and 23 nurses in the ICU respectively each of them having 8 beds. Yekatit 12 hospital located in Arada sub-city, has 12 different departments. It is one of the hospitals under the Addis Ababa health bureau. It has 420 beds and 1134 staff. The intensive care unit has 2 anesthesiologists, 42 nurses, and 6 physicians, and has 12 beds with functional mechanical ventilators.

4.2. Study Period: This study was conducted from December 1 to 29, 2021 GC.

4.3. Study Design: A facility-based cross-sectional study was conducted on AICU nurses at public hospitals in Addis Ababa, Ethiopia.

4.4. Study Population: AICU Nurses at public hospitals available at the time of data collection that fulfill the selection criteria.

4.4.1. Target population: All AICU nurses in AA

4.4.2. Source population: All AICU nurses at public hospitals in AA

4.4.3. Eligibility criteria

4.4.3.1. Inclusion criteria: All nurses at public hospitals' ICUs in AA who were available at the time of data collection and signed the consent form.

4.4.3. 2. Exclusion criteria: Nurses who are in leadership position not directly participating in the practice towards MV.

4.5. Sample size determination: Sample size was obtained by total census of all AICU nurses at 10 public hospitals in AA. A total survey of all 330 AICU nurses at public hospitals in AA was undertaken. For observational study 10% (33) of the total was taken by rule of thumb considering feasibility issue.

4.6. Sampling Procedures: A total survey method was used to take all AICU nurses working at public hospitals in AA. A total survey method was applied both to the hospitals and study samples. All subjects were sampled for self-administered questionnaires and 33 of them was selected using convenience sampling technique for observational checklist tool proportionally allocating to each hospital.

4.7. Measurement

4.7.1. Study variables

Dependent variable: Knowledge level, Practice level

Independent Variables:

- ✓ Socio-demographic variables (age, sex, marital status, profession, education level, work experience)
- ✓ Facility related factors (Giving training/education, providing guidelines, support and supervision from senior staff)

4.7.2. Instruments: Semi-structured questionnaires containing sociodemographic and knowledge questions adapted from studies done in Turkey, Rwanda and South Africa was used for MV knowledge assessment(4, 16, 34). Observational checklist was developed and used to collect the data on practice towards mechanical ventilation.

4.8. Data collection and procedures: Data was collected from December 1 to 29, 2021 GC during regular working time while the nurses are at work place providing care for mechanically ventilated patients and/or preparing mechanical ventilators for new incoming patients. Data was collected using self- administered semi-structured questionnaires on knowledge and

observational checklist on practice towards mechanical ventilation. The study tools were prepared in English. The observational checklist part of the data collection tool was completed by six trained MSc. CCNP by double blinded method while ICU nurses were taking care of patients on MV. Each individual was tacked until the completion of each activity incorporated in the observational checklist. The observational study data was collected during the first half of the study period and then the self administered questionnaires data was collected in the second half of the study period. All study participants were included in the self administered questionnaires planned to assess the knowledge level of mechanical ventilation management among the nurses. Ten percent (33) of the total population was observed for practice using observational checklist. One trained MSc. Critical Care Nursing Practitioner was supervised the data collection process. The principal investigator had followed the whole process and contacted any time difficulty or ambiguity encountered.

4.9. Operational and Term definitions

Mechanical ventilation: is the process of using positive pressure devices to provide O₂ and CO₂ transport between the environment and the pulmonary capillary bed(20).

Ventilation management: Refers to the decisions and actions that determine the ventilator support administered to patients(8).

Good knowledge: A score of $\geq 75\%$ of the over all knowledge questions(34).

Poor knowledge: A score of $< 75\%$ among the knowledge questions(34).

Good practice: Those who score $\geq 75\%$ of the total observational checklist was considered to have good practice(34).

Poor practice: A score below 75% of the observational checklist was considered poor practice towards MV(34).

4.10. Data Quality Control and Management

Pretest was done on 5% of the sample size outside the study population at Adama hospital prior to the study period to check for completeness. Reliability analysis was done using cronbach's alpha and it was determined to be 0.76 and 0.8 for self-administered questionnaires and the observational checklist respectively. During the data collection supervision of the data collection process was undertaken by the assigned supervisor and principal investigator throughout. Data collectors and the supervisor was trained on each items included in the study tools, the objectives of the study, rights of respondents, and the confidentiality of information obtained. The Investigator had checked for completeness and consistency of the data on daily basis. The collected data was checked for accuracy, and then sorted, categorized and summarized.

4.11. Data Analysis Procedures

Data was collected using self-administered questionnaires adapted from studies done in Rwanda, South Africa and Turkey on related topic and observational checklist. The collected data was checked for completeness and consistency before analysis and then coded and entered into Epidata version 4.6 and transferred to statistical package for social science (SPSS) version 26 for further analysis. Binary and multivariable logistic regression was done to identify factors associated with the dependent variable (knowledge) at 95% confidence interval with P-value <0.05. Variables shown significant statistical association with knowledge of MV on binary logistic regression at P-value < 0.2 was fitted into multivariable logistic regression. Multivariable logistic regression analysis was done at P-value of 0.05 to exclude possible confounding factors associated with the MV knowledge. Statistical tests were performed at the level of significance of 5%. Inferential statistics such as cross tabulations were done for knowledge towards mechanical ventilation. Descriptive analyses were done for practice towards MV on 33 study participants but association was not done because the sample size was not adequate. Results are expressed as mean $\pm$ standard deviation (SD) for continuous variables like age and work experience and as percentage (%) for categorical variables like sex, marital status and the dependent variable. Results are also presented using charts and tables.

4.12. Ethical Consideration

The research protocol was approved and ethical clearance was obtained from SPHMMC Institutional Review Board (IRB). Ethical clearance approval was obtained from the SPHMMC and Addis Ababa Public Health Research and Emergency Management Directorate and submitted to each Federal and Addis Ababa public hospitals. Consent from the public governmental hospitals will also be obtained. Prior to the launch of the study all nurses serving as data collectors and the supervisor was informed in written form about the aims of the study. Data collectors were given full information to the study subjects about the purpose of the study and asked them to give their consent before participating in the study. Participation in the study was entirely voluntary and the involvement in the study was assured only after obtaining complete verbal and written informed consent. All participants in this study were seen equally and their moral values were kept strictly. All participants' safety was secured and they were not got any harm, and the potential risk was limited to the time they lost during the filling of the questionnaires. Confidentiality was strictly adhered to and identification numbers (using codes) rather than names were used during the data collection and analysis. The progressive report was submitted to SPHMMC and to each hospitals and Addis Ababa Public Health Research and Emergency Management Directorate timely.

4.13. Dissemination of Results

The findings of this study were submitted to SPHMMC and are going to be submitted to Addis Ababa Public Health Research and Emergency Management Directorate in hard and soft copies. The copy of this study finding is going to be given ICUs of each hospitals in which the study was done. Finally efforts are to be made to publish on peer reviewed journals.

5. Results

5.1. Sociodemographic characteristics of the study participants

A total of 309 ICU Nurses participated in the current study among which 181(58.6%) participants were females. The mean age of the nurses was 27.9 years (± 3.2 SD) with a minimum age of 22 and a maximum of 39 years old. One hundred twelve (36.2%) of the nurses were in the age category of ≤ 26 . About 190(61.5%) of the participants had 3 and fewer years of work experience with mean year of experience 1.49 ± 0.67 SD. More than three-fourth (78.3%) and 266(86.1%) were comprehensive/clinical nurses and had an educational level of first degree respectively (See Table 2).

Table 2: Socio-demographic characteristics of AICU nurses at Public Hospitals in Addis Ababa, Ethiopia, 2021(n = 309).

Variable	Response categories	Frequency	Percent
Sex of participants	Male	128	41.4
	Female	181	58.6
Age of participants	≤ 26	112	36.2
	27-29	99	32
	≤ 30	98	31.7
Marital status	Single	186	60.2
	Married	123	39.8
Profession of participants	Comprehensive/Clinical nurse	242	78.3
	Emergency/critical care nurse	67	21.7
The educational level of participants	Diploma	25	8.1
	Degree	266	86.1
	Masters	18	5.8
Years of ICU ^a work experience	0-3 years	190	61.5
	4-6 years	88	28.5
	7-9 years	25	8.1
	10 years and above	6	1.9

^aICU: Intensive Care Unit

5.2. Facility related factors

Table 3 shows the facility-related characteristics of the study participants. About 216(70%) of the participants had participated on training related to MV. Only 62(20.1%) had said training is given at every rotation while 228(73.8%) had said their institution gives training occasionally.

One hundred ninety-three (62.5%) of the nurses had got support and supervision from senior nursing staff when caring for mechanically ventilated patient. Only 86(27.8%) participants reported the presence of guidelines/operational manual on MV management in their unit. An insignificant number of nurses were allowed adjust or manipulate MV in hospitals.

Table 3: Facility characteristics for Adult Intensive Care Unit nurses at Public Hospitals in Addis Ababa, Ethiopia, 2021(n = 309).

Variable	Response categories	Frequency	Percent
Ever participated in training	Yes	216	69.9
	No	93	30.1
Frequencies of training	Every year	19	6.1
	At every rotation	62	20.1
	Occasionally	228	73.8
Support and supervision	Yes	193	62.5
	No	116	35.5
Hospitals have guidelines on MV ^b management	Yes	86	27.8
	No	223	72.2
Nurses are allowed to adjust/manipulate MV ^b in hospitals	Yes	4	1.3
	No	305	98.7

^a ICU stands for Intensive care unit

^b MV: Mechanical ventilation

5.3. Level of Nurses' Knowledge towards Mechanical Ventilation Management

Of the total study participants about 167(54%) had poor knowledge towards MV with 95% CI (48.5-59.5) (see in figure 2).

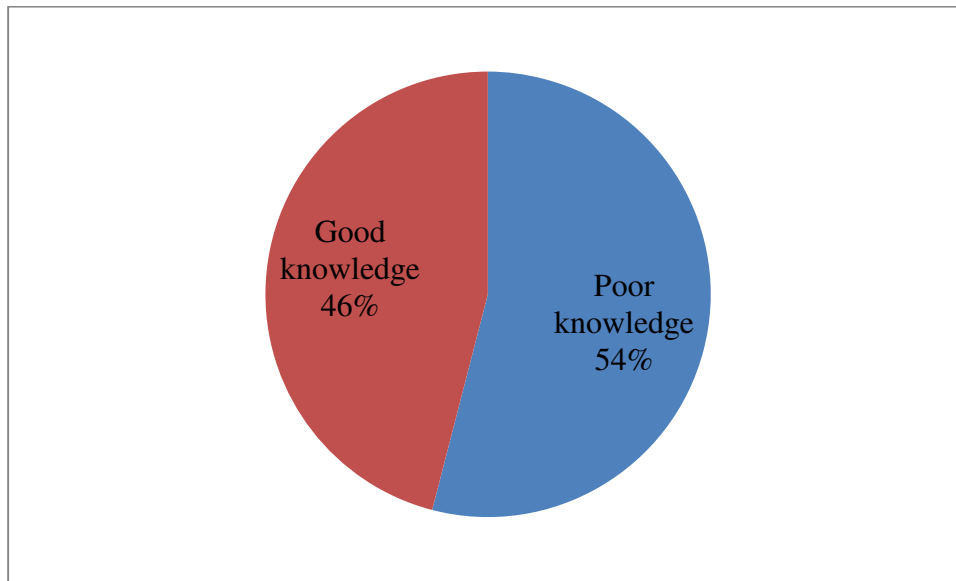


Figure 2: Figure showing level of knowledge towards mechanical ventilation among adult intensive care unit nurses at public hospitals in AA, 2021 GC(n=309)

5.3.1. Factors associated with knowledge towards mechanical ventilation

Factors like marital status, professional qualification, support and supervision from senior staffs, training and availability of guideline/operational manual in the ICU were found to be associated with knowledge of nurses towards MV management on binary logistic regression. Accordingly MSc. Degree holding nurses were 6.5 times more likely had good knowledge than diploma holders (P-value, 0.009, AOR 6.562, 95% CI 1.591, 27.066). Nurses who participated on training were found to be 2 times more likely to have good knowledge than untrained ones (P-value 0.004, COR 2.114, 95% CI, 1.273, 3.510) and those who work in hospitals reported to have guideline/operational manual were also found be more likely to have knowledge than their counter parts (P-value 0.0980, COR 1.651, 95% CI, 0.392, 1.682). Nurses who had support and supervision were 1.4 times more likely had good knowledge as compared to those who didn't had (P-value 0.138, COR 1.423, 95% C.I 0.893,2.268) (See Table 4).

Table 4: Factors associated with mechanical ventilation management knowledge among Adult ICU Nurses at Public Hospitals in Addis Ababa 2021 GC on binary logistic regression

Variable	Response	Knowledge level		P-value	COR	95% CI for COR	
		Good knowledge	Poor knowledge			Lower	Upper
Marital status	Single	79(25.5%)	108(35.9%)	0.106	0.685	0.433	1.084
	Married	63(20.38%)	59(19.09%)		1:00	1:00	1:00
Professional qualification	Diploma	4(1.29%)	21(6.79%)	0.014	1:00	1:00	1:00
	Degree	128(41.42%)	138(44.6%)	0.005	4.870	1.627	14.570
	Masters	10(3.23%)	8(2.58%)	0.009	6.562	1.591	27.066
	Degree	128(41.42%)	138(44.6%)	0.007	0.203	0.063	0.650
	Masters	10(3.23%)	8(2.58%)		2:00	2:00	2:00
Participated on training	Yes	62(20.06%)	31(10.03%)	0.004	2.114	1.273	3.510
	No	105(33.9%)	31(10.03%)		1:00	1:00	1:00
Support and supervision	Yes	47(15.2%)	69(22.3)	0.138	1.423	0.893	2.268
	No	95(30.7%)	98(31.7%)		1:00	1:00	1:00
Availability of Guideline/operational manual in the ^a ICU	Yes	33(10.6%)	53(17.15%)	0.098	1.651	0.392	1.682
	No	1093(35.27%)	114(36.8%)		1:00	1:00	1:00

^aICU: Intensive care unit

Those variables associated with the knowledge level of the nurses on binary logistic regression at P-value <0.20 were interred into multivariable logistic regression and variables like professional qualification, training, support and availability of guideline/Operational manual in the ICUs were identified to be associated with knowledge level of MV of the nurses. From these, study participants who had MSc. degree were 7.3 times (P-value 0.007, AOR 7.316, 95% C.I 1.733, 30.895) and Bachelor Science 4.87 times (AOR 4.87, 95% C.I 1.63, 14.57), more likely had good knowledge as compared to diploma educational level study participants. Nurses who hold Bachelor Science degree were found to be 0.2 times less likely to have good knowledge(P-value 0.005, AOR 0.205 95% CI. 0.069, 0.614). Those nurses participated on training were 2.3 times more likely had good knowledge as compared to those who had not trained on MV (P-value

0.002, AOR 2.299, 95% C.I 1.362, 3.881). Nurses working in hospitals having guideline/operational manual in the ICU were around 2 times more likely had good knowledge than their counter parts (P-value 0.015, AOR 2.054, 95% C.I 1.149,3.671) (See Table 5).

Table 5: Factors associated with mechanical ventilation management knowledge among Adult ICU Nurses at Public Hospitals in Addis Ababa 2021 GC on multivariable logistic regression.

Variable	Response	Knowledge level		P-value	AOR (95% C.I)
		Good knowledge	Poor knowledge		
Professional qualification	Diploma	4(1.29%)	21(6.79%)		1:00
	Degree	128(41.42%)	138(44.66%)	0.006	4.714(1.553, 14.309)
	Masters	10(3.23%)	8(2.58%)	0.007	7.316(1.733, 30.895)
	Degree	128(41.42%)	138(44.6%)	0.005	0.205 (0.069, 0.614)
	Masters	10(3.23%)	8(2.58%)		2:00
Participated on training related to mechanical ventilation	Yes	62(20.06%)	31(10.03%)	0.002	2.299(1.362, 3.881)
	No	105(33.98%)	31(10.03%)		1:00
Availability of guideline/Operational manual in ICU	Yes	33(10.67%)	53(17.15%)	0.015	2.054(1.149-3.671)
	No	109(35.27%)	114(36.89%)		1:00

5.4. Observational findings on Practice of Nurses towards Mechanical ventilation Management (n=33)

In addition to self-administered questionnaires observational study was done on 33 study subjects to assess the practice level, and of which observed 25(75.8%) had demonstrated poor practice towards MV with 95% CI (60.6, 90.9), and the proportion of good practice was observed to be 24% which ranges with 95% CI (9.1 to 39.4%). Only 7(21.2%) of the study participants performed ventilator settings correctly. Thirty one (93.9%) of the study subjects failed to check/adjust inspiratory time during high pressure alarm and rate and trigger sensitivity

settings during high respiratory alarms respectively. Insignificant numbers of nurses were able to troubleshoot auto-triggering, check ventilator graphics and identify wave forms showing air trapping and secretion while all the nurses were unable to identify wave forms showing patient ventilator asynchronies (PVAs) and air hunger.

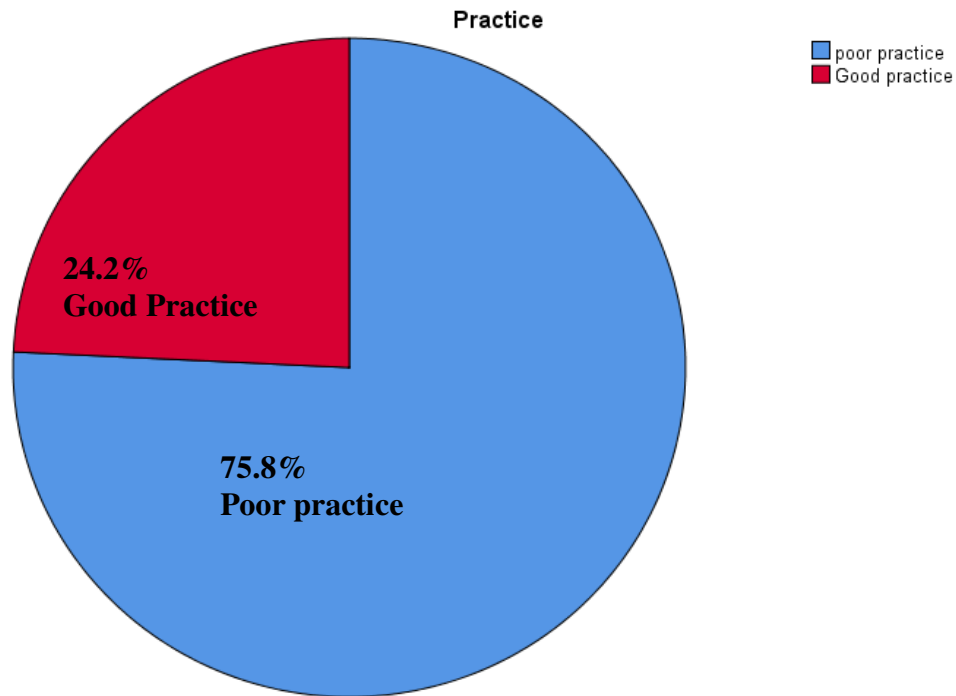


Figure 3: Practice level of Adult Intensive Care Unit Nurses on mechanical ventilation at Public hospitals in Addis Ababa, Ethiopia, 2021 (n=33)

Table 5: Findings of the observational study regarding practice towards mechanical ventilation among Adult ICU Nurses at Public Hospitals in Addis Ababa, 2021GC (n = 33)

Variable	Performed correctly	Not performed correctly
Sets MV settings properly	7(21.2%)	26(78.8%)
Adjust Ti if set too short during high peak pressure alarm	2(6.1%)	31(93.9%)
Check and adjust rate and trigger sensitivity settings	2(6.1%)	31(93.9%)
Troubleshoot auto-triggering	1(3%)	32(97%)

Checks ventilator graphics	3(9.1%)	30(90.9%)
Identifies wave forms showing air-trapping and take action to correct it	2(6.1%)	31(93.9%)
Identifies wave forms showing secretions and take action to correct it	2(6.1%)	31(93.9%)
Identifies wave forms showing PVAs and take action to correct it	33(100%)	
Identifies ventilator wave form showing air hunger and take action	33(100%)	

6. Discussion

It is highly important that nurses caring for mechanically ventilated patients must possess good knowledge and practice levels to prevent complications associated with mechanical ventilation and improve patient care quality. In the present study the knowledge and practice level of the ICU nurses were found to be low in the current study area. The proportion of knowledge and practice was determined to be 46% and 24% respectively.

Mechanical ventilation requires the simultaneous skills of many in the inter-professional health care team. Nurses are usually the first in identifying set issues, and understanding the physiology and management of mechanical ventilation is crucial for clinicians managing patients in the ICU. These caregivers must alert the clinician managing the case immediately if there are any issues with ventilator use. Inappropriate setting changes, failure to change alarms, changing settings without appropriate orders, and failure to communicate changes to the medical team can result in poor patient outcomes(17).

In this study 167(54%) of 309 subjects had poor knowledge and 25(75.8%) of the 33 study participants observed using observational checklist had poor practice. These findings are consistent with a study conducted in India on MV knowledge which had reported that 33(66%) of the subjects as having poor knowledge regarding mechanical ventilation. Similarly the current findings are in line with another study done in Rwanda which stated that all nurses in the study had unsatisfactory practice. The current finding is also consistent with study findings in Egypt that reported 68.3% of nurses had unsatisfactory knowledge while all nurses in the study (100%) had unsatisfactory practice MV. In support of the present study an investigation in Saudi Arabia also reported that MV management knowledge of critical care providers is limited (19, 22, 34). The low knowledge and practice level of ICU nurses may be related to less education/training they receive on this topic. This indicates that knowledge and practice towards MV is an issue that must be investigated deeply in order to map strategies to improve it as quality care of mechanically ventilated patient is a major concern. The MV management is a complex and dynamic situation that requires advanced knowledge and skills. Making the right decision in time provides the patient the best service and reduces the risks.

In the current study significant association was found between variables like professional qualification/educational level, training, and availability of operational manual/guideline in ICU and MV knowledge of ICU nurses with P-values 0.007, 0.002, 0.015 respectively. This finding is similar with a study done in Baghdad that revealed statistical associations were found between nurses educational levels, years of experience in critical unit and training sessions toward nurses' knowledge of MV. From scientific point of view educational level, training and guide lines improve mechanical ventilation knowledge. The difference regarding association of ICU work experience with knowledge of mechanical ventilation from the previous study may be justified by less ICU work experience of the nurses in the current study area. In support of the current finding, a study done in Pakistan stated that nursing knowledge regarding ventilator mechanics improved after the implementation of teaching module. The present study finding is in-congruent with the findings of a study done in India which reported no significant association between demographic variables and MV knowledge of the nurses. About 93(30.1%) of the current study participants had not participated on training related to mechanical ventilation and this is less than the findings of the study done in India which stated that almost all (98%) of subjects had not attended any in service education related to mechanical ventilation(6, 7, 30). These inconsistencies with the previous study may be due to demographic differences of participants and time and setting difference of the researches.

Critical care providers need to adopt the newly emerging MV related evidence and incorporate them into daily practice. Therefore, enhancing knowledge and sharpening MV related skills will likely reduce MV related adverse events and improve outcomes. The majority of MV related adverse event are believed to arise from human errors. Therefore, engaging critical care providers in periodic educational activities and clinical training is advisable.

About 190(61.5%) of the participants had 3 and fewer years ICU work experiences and 266(86.1 %) had educational level of first degree. In these regard the current study is inconsistent with the findings done in New Zealand which reported 136(69.7%) post-graduate critical care specialty qualification. This difference may be due to recent launch of

ICUs and post-graduate critical care specialties and lack of capacity to teach many nurses in our setting(8).

Only 86(27.8%) of the current study participants reported to have guidelines in their unit which is similar with a study done in Turkey that stated 71% of the nurses work in ICUs that MV operating manual was not available. But in another study done in New Zealand two thirds (66.5%, n=204) of the nurses work in ICUs in which there are guidelines, policies or protocols to guide staff in ventilation management(3, 4). This in-consistence may be due to setting difference and less organization of ICUs in our country.

With respect to facility related factors it was found that insignificant number of nurses [5(1.6%)] were allowed to adjust or manipulate MV in hospitals. This finding is similar with a study done in America on role responsibilities of nurses on MV and weaning which reported similar finding. Another study done in New Zealand also reported nurses had less autonomy and more influence in decision-making about ventilation management in support of the current study (6, 7). This may due to limited scope of activity and lack of adequate training of nurses.

Regarding wave form identification and analysis, among the 33 study subjects observed only 2(6.1%) identified wave forms that indicate air trapping and secretion while all of them failed to troubleshoot auto triggering and identify wave forms showing patient ventilator asynchronies. This finding is consistent with a study done in Saudi Arabia which reported that common PVAs detection assessed using observational analysis as low in critical care settings, with about 25% of PVAs going undetected by critical care practitioners(19). This may be due to lack of training and awareness of the nurses working in the ICUs especially in our country. Another study conducted in Jordan stated that nurses were able to detect ineffective inspiratory efforts among patients on ventilator after special training (36). Ventilator wave form analysis helps early identification of ventilator complications that may not be visible with other assessments and take appropriate action early. Training/education and using guidelines/protocols on wave form analysis help very well nurses identify wave form abnormalities. Therefore nurses must be trained and be aware of ventilator graphics to pick the problem in the making.

7. Conclusions and recommendations

7.1. Conclusion

According to the present study the overall good knowledge and practice of adult intensive care unit nurses at public hospitals in Addis Ababa was poor. This is likely to affect negatively the patient who is mechanically ventilated. There were significant association between knowledge of mechanical ventilation and educational level, training and availability of operational manual/guideline all associated with increased level of knowledge with P values 0.007, 0.002 and 0.015 respectively.

The present study findings identified that there is a need of advanced technical education to make the staff nurses highly aware of the care of patients on ventilator and to further widen their cognitive map so as to get fruitful results in mechanically ventilated patient outcomes. Even though most of the current study participants were trained there is still knowledge and skill gap. Therefore the quality of the training provided on the intensive care and mechanical ventilation practices should be improved and it should be provided for all the intensive care nurses to bring about the desired effect: that is improved mechanically ventilated patient care.

Although recommendations are suggested in this study, it is important to state that none of the strategies alone can sort the problem of low knowledge and practice levels on mechanical ventilation among nurses working in ICUs unless implemented collaboratively.

7.2. Recommendations

Nursing Practice, Education and management

- ✓ Nurses shall use available manuals properly and read different materials related to mechanical ventilation to in order to be up to date and improve their knowledge and practice towards mechanical ventilator/ventilation
- ✓ Nurses working in intensive care units shall undergo a Post Graduate or Masters training in Critical Care Nursing to enable them to provide highly specialized care as the finding of the study and other literatures verified significant association between educational level and knowledge of MV management.

- ✓ Critical care teachers shall be up to date with current clinical practice on mechanical ventilation and ventilator technology. For example must teach ventilator graphics in the ICU curriculum and new modes of ventilation.
- ✓ ICU nurses shall be ICU qualified and their competency should be evaluated

Ministry of Health, NGOs, Health Bureaus and Hospitals

- ✓ The ministry of health shall develop guidelines and organize trainings in collaboration with hospitals on how to manage mechanical ventilation and ventilators in order to improve ICU nurses' knowledge and practice
- ✓ NGOs and health bureau shall better strive by providing training and supporting hospitals
- ✓ Hospitals shall organize trainings on regular basis and provide manuals to ICUs to improve knowledge, practice and awareness of nurses towards MV
- ✓ Activating the role of continuing educational units in each hospital.

Researchers

- ✓ Researchers shall better re-investigate this issue with different methods like pre and post training assessment by including all professionals working in ICUs and in areas outside AA

Implications

- ✓ The poor practices on mechanical ventilation in the intensive care units cause mechanical ventilation associated complications. Nurses working in the intensive care units must perform evidence-based nursing care during the mechanical ventilation and these practices will decrease MV complications.
- ✓ This study implied that training, educational level, and guideline availability increased the knowledge level of the nurses. Therefore it is recommended that the critical care nursing specialty shall be strengthened as the findings of the study showed to produce competent nurses who have good knowledge, practice and attitude towards MV

7.3. Strength and limitations of the study

7.3.1. Strength of the study

This study is the first of its type in our country and has employed total survey method.

Hands on practice were assessed using observational checklist.

7.3.2. Limitations of the study

- This study used cross-sectional study design which cannot identify cause and effect relationship.
- Due to time and resource constraint inadequate sample size was used for the observational study. Therefore factors associated with practice towards MV were not identified and the association between knowledge and practice was not done.

8. References

1. Elliot ZJ, Elliot SC. An overview of mechanical ventilation in the intensive care unit. *Nursing Standard*. 2018;32(28).
2. Haribhai S, Mahboobi SK. Ventilator Complications. *StatPearls* [Internet]. 2021.
3. Hill B. Principles of mechanical ventilation for non-critical care nurses. *British Journal of Nursing*. 2020;29(8):470-5.
4. Saritas S, Kaya A, Dolanbay N. Knowledge and Practices of Intensive Care Nurses on Mechanical Ventilation. *International Journal of Caring Sciences*. 2019;12(1).
5. De Jong A, Citerio G, Jaber S. Focus on ventilation and airway management in the ICU. *Intensive care medicine*. 2017;43(12):1912-5.
6. Fathimath S, Jancy G, Jancy T. Assessment of knowledge regarding mechanical ventilation among staff nurses working in selected hospital Mangalore with a view to develop an information pamphlet. *International Journal of Recent Scientific Research*. 2013;4(9):1410-3.
7. Blackwood B, Junk C, Lyons JDM, McAuley DF, Rose L. Role responsibilities in mechanical ventilation and weaning in pediatric intensive care units: a national survey. *American Journal of Critical Care*. 2013;22(3):189-97.
8. Henderwood M, Wilkinson J. ICU nurses' role in ventilation. 2015.
9. Kostov V, Mercado-Montoya M, Bonfanti N, Gundert E, Drewry A, Bedimo R, et al. 40th International Symposium on Intensive Care & Emergency Medicine 2020–Part 2. *Critical Care*. 2020;24(2):P513.
10. Jaber S, Bellani G, Blanch L, Demoule A, Esteban A, Gattinoni L, et al. The intensive care medicine research agenda for airways, invasive and noninvasive mechanical ventilation. *Intensive care medicine*. 2017;43(9):1352-65.
11. Del Sorbo L, Goligher EC, McAuley DF, Rubenfeld GD, Brochard LJ, Gattinoni L, et al. Mechanical ventilation in adults with acute respiratory distress syndrome. Summary of the experimental evidence for the clinical practice guideline. *Annals of the American Thoracic Society*. 2017;14(Supplement 4):S261-S70.
12. Tsukuda M, Fukuda A, Taru C, Miyawaki I. Development of a Questionnaire for the Reflective Practice of Nursing Involving Invasive Mechanical Ventilation: Assessment of validity and reliability. *Nursing open*. 2019;6(2):330-47.
13. Bloos F, Müller S, Harz A, Gugel M, Geil D, Egerland K, et al. Effects of staff training on the care of mechanically ventilated patients: a prospective cohort study. *British Journal of Anaesthesia*. 2009;103(2):232-7.
14. Carpio ALM, Mora JI. Ventilator management. *StatPearls* [Internet]. 2021.
15. Amitai A, Sinert R, Regan A, Jain A, Conrad A, Talavera F, et al. Ventilator management. *Medscape*, Online, accessed May. 2020;18:2021.
16. Botha L. Level of Nurses' Competence in Mechanical Ventilation in Intensive Care Units of two tertiary health care institutions in Gauteng. *Masters of Science in Nursing*, University of the Witwatersrand, Johannesburg. 2012.
17. Williams LM, Sharma S. Ventilator safety. *StatPearls* [Internet]. 2021.
18. Wood S, Winters ME. Care of the intubated emergency department patient. *The Journal of emergency medicine*. 2011;40(4):419-27.
19. Maurya S, Mishra SB, Azim A, Baronia AK, Gurjar M. Ventilator-associated complications: A study to evaluate the effectiveness of a planned teaching program for intensive

care unit staff nurses—an Indian experience. *American journal of infection control*. 2016;44(11):1422-3.

20. Tobin MJ, Laghi F, Jubran A. Ventilatory failure, ventilator support, and ventilator weaning. *Comprehensive Physiology*. 2012;2(4):2871-921.

21. Guilhermino MC, Inder KJ, Sundin D. Education on invasive mechanical ventilation involving intensive care nurses: a systematic review. *Nursing in critical care*. 2018;23(5):245-55.

22. Al-Otaibi HM. Evaluation of critical care providers' knowledge in basic mechanical ventilation management: An opportunity for improvement. *Evaluation*. 2019;8(3):162-6.

23. Grossbach I, Chlan L, Tracy MF. Overview of mechanical ventilatory support and management of patient-and ventilator-related responses. *Critical care nurse*. 2011;31(3):30-44.

24. Jubran A. Nurses and ventilators. *Critical Care*. 2012;16(1):1-2.

25. Chacón E, Estruga A, Murias G, Sales B, Montanya J, Lucangelo U, et al. Nurses' detection of ineffective inspiratory efforts during mechanical ventilation. *American Journal of Critical Care*. 2012;21(4):e89-e93.

26. Jordan J, Rose L, Dainty KN, Noyes J, Blackwood B. Factors that impact on the use of mechanical ventilation weaning protocols in critically ill adults and children: a qualitative evidence-synthesis. *Cochrane Database of Systematic Reviews*. 2016(10).

27. Catchpole K, McCulloch P. Human factors in critical care: towards standardized integrated human-centred systems of work. *Current opinion in critical care*. 2010;16(6):618-22.

28. Tallo FS, de Campos Vieira Abib S, de Andrade Negri AJ, Cesar P, Lopes RD, Lopes AC. Evaluation of self-perception of mechanical ventilation knowledge among Brazilian final-year medical students, residents and emergency physicians. *Clinics*. 2017;72:65-70.

29. Guilhermino MC, Inder KJ, Sundin D, Kuzmiuk L. Education of ICU nurses regarding invasive mechanical ventilation: Findings from a cross-sectional survey. *Australian Critical Care*. 2014;27(3):126-32.

30. HadiAtiyah H, Abdul-Wahhab MM. Nurses Knowledge toward Essential Care for Adult Patients Undergoing Mechanical Ventilation at Critical Care Unit in Baghdad City. *Higher education*. 2016;4(8.0):100-0.

31. Laytin AD, Sultan M, Debebe F, Walelign Y, Fisseha G, Gebreyesus A. Critical care capacity in Addis Ababa, Ethiopia: A citywide survey of public hospitals. *Journal of critical care*. 2021;63:1-7.

32. Guilhermino MC. Intensive Care Nurses' perceptions of the continuing education regarding mechanical ventilation at a major regional tertiary-referral hospital in Australia: The University of Newcastle, Australia; 2018.

33. Hammod HJ, Mohammed S. Effectiveness of an Educational Program on Nurses Knowledge Concerning Complications Prevention of Mechanical Ventilation at Intensive Care Unit in Al-Hussain Teaching Hospital at Nassiriyah City. *Kufa journal for nursing sciences*. 2016;6(2).

34. Mahoro JdD. Competence regarding mechanical ventilation among the nurses working in intensive care units of two university teaching hospitals in Rwanda: University of Rwanda; 2019.

35. Hesham S. Assessment of nurses' performance regarding management of patients on mechanical ventilator. *Port Said Scientific Journal of Nursing*. 2016;3(1):161-77.

36. Wrigge H, Girrbaach F, Hempel G. Detection of patient-ventilator asynchrony should be improved: and then what? *Journal of thoracic disease*. 2016;8(12):E1661.

9. Annexes

9.1. Annex 1: Information sheet

Good morning/afternoon, my name is _____. I am here on behalf of Mr. Kemal Abdulkadir to collect data for a study to assess the Management of mechanical ventilation and associated factors among nurses working in intensive care units of public hospitals in Addis Ababa, Ethiopia. I am a data collector on the above stated research title for the partial fulfillment of the requirements for the degree of Masters of Critical Care Nurse Practitioner at St. Paul's Hospital Millennium Medical College. This location has been selected randomly, and your involvement is completely based on volunteer participation. I guarantee that your identity will be kept confidential. I will not ask for your name or any other information that directly identifies you. There are no risks anticipated of this study, and no benefit or compensation will be awarded for participating in the study, but the results of your response will be essential for policy makers and health planners in regards to identifying problems. You have the right to participate or not to respond to the question partially or fully, and you also have the right to withdraw your participation at any time. This question will last at most 1:30-2hrs. If you agree to participate, you will start with a question.

Before we start, I need you to explain that I have read you this consent and you understand and freely agree to self-administered questionnaire and observational checklists.

Are you a volunteer? 1. Yes. 2. No.

If yes, please continue. If not, please stop participating in the study.

If you have any inquiries or questions, please contact Mr. Kemal Abdulkadir.

+ 251 924616804 (Email: kamalabdulkadir56@gmail.com)

Name of data collector: _____ Signature: _____

Date _____

9.2. Annex 2: Consent form

In signing this document, I am giving my consent to participate in the study entitled "Mechanical Ventilation Management and Associated factors among Nurses working at Federal Public Hospitals in Addis Ababa". I have been informed that the purpose of this study is to assess the Management of mechanical ventilation and associated factors among nurses working in intensive care units. I have understood that participation in this study is entirely voluntarily and my participation or refusal to answer the questions will have no effect on me. I have been told that my answers to the questions or reports of this study will never identify me in any way. I understood that Kemal Abdulkadir is the contact person if I have questions about the study or about my rights as a study participant. I also know that the address of the principal investigator is: Kemal Abdulkadir, mobile number + 251 924616804 (Email: kamalabdulkadir56@gmail.com)

I here approve my consent to take part in the study with my signature.

Signature.....

Date.....

9.3. Annexes 3: English Version Questionnaires/Observational Check List

Part I. Questions on Sociodemographic Characteristics

S.N	Questions	Categories	Remark
1	Sex	A. Male B. Female	
2	Age	-----years	
3	Marital status	A. Single B. Married C. Divorced D. Widowed	
4	Profession	A. Comprehensive Nursing B. Emergency/Critical care nursing	
5	Professional qualification	A. Diploma B. Degree C. Masters D. Other (specify.....)	
6	Years of ICU work experience	A. 0–3 years B. 4–6 years C. 7–9 years D. 10 or more years	
7	Ever participated on training related to mechanical ventilation	A. Yes B. No	

8	How often does your hospital give training/education regarding MV	A. Every year B. At every rotation when new nurses come to ICU C. Occasionally	
9	Are you given adequate support and supervision by your senior nursing staff when caring for the ICU patient?	A. Yes B. No	
10	Does your hospital have guide lines on MV management	A. Yes B. No	
11	Is it allowed for you to adjust/manipulate MV in your facility?	A. Yes B. No	

Part II. Vignettes

Vignette one: Normal post operative patient

A 48yrs old patient is admitted to the ICU post operatively having undergone major abdominal surgery. He has no history of lung pathology and the surgeon wants him ventilated only overnight, with a view to extubation 24hrs later. Soon after admission to the ICU, the patient becomes agitated and restless. Blood gas is done which is normal.

12. Select the **ONE** correct answer from the choices below with regard to SIMV

- A) The ventilator cycles with each respiratory effort made by the patient
- B) The ventilator supplements each breath with positive pressure
- C) The ventilator delivers a preset number of ventilator breaths per minute **ONLY**
- D) The ventilator delivers a preset number of ventilator bpm and allows the patient to breathe spontaneously between ventilator breaths.
- E) Don't Know.

13. After assessing the patient the PS increased from 10 cm/H20 to 15 cmH20. The PEEP is 5 cmH20. Select **TRUE** statement regarding PSV

- A) PSV breaths always have the same tidal volume
- B) PSV is not used when weaning patients from the ventilator
- C) PSV breaths are triggered and cycled by the ventilator
- D) PSV aids in ventilation and is adjusted in response to C02 levels.
- E) Don't know

14. You notice the pt. exhaled tidal volume is 100mls less than his inhaled tidal volume. Select **INCORRECT** statement from the choices below.

- A) There is a leak in the ventilator circuit.
- B) The ventilator was not calibrated with the humidification system in place
- C) The exhaled tidal volume **SHOULD** be larger than the **INSPIRATORY** tidal volume
- D) The ET tube cuff is leaking
- E) Don't know

15. Fill in the blank spaces in the chart below to show the differences between VCV and PCV. If you would **set** the parameter for that type of ventilation place a **tick** in the box. If the parameter is **NOT set** and is variable then write **VARIABLE** in the box.

Comparison chart

	Volume	Pressure	flow	I-time
Spontaneous				
Volume control V				
Pressure control V				
PS				

16. Whilst you are doing the ventilator observations you notice that the trigger sensitivity on the ventilator is set at -4cm/H₂O. Select the **CORRECT** statement with regard to trigger sensitivity.

A) A trigger sensitivity of -4 is a normal setting for a post-operative patient being ventilated

B) Trigger sensitivity setting has no effect on the patient breathing efforts.

C) The trigger sensitivity should be set at -2 to commence ventilation and then adjusted to the specific patient.

D) Trigger sensitivity is only related to ventilator breaths

E) Don't Know.

17. Which one of the signs and symptoms listed below is **NOT** indicative of patient who is ready to be weaned?

A) Patient still dependent on inotropic support to maintain hemodynamic stability

B) RR rate > 10 and <30 breaths per min

C) Temp 36 degrees.

D) PCO₂ 33-35mm/Hg

E) Don't Know

18. With regard to the weaning process which of the following is the correct weaning sequence?

A) O₂ is reduced to 35-40% followed by a decrease in mandatory RR, followed by decreasing the PS, followed by decreasing CPAP.

B) CPAP /PEEP is decreased first, followed by reduction in PS, followed by reduction of O₂ % followed by reduction of mandatory RR.

C) PS reduced first, followed by reduction of mandatory RR, followed by reduction in O₂% followed by reduction in PEEP/CPAP.

D) RR reduced first, followed by reduction of O₂% followed by reduction of PS, followed by reduction of PEEP/CPAP.

E) Don't Know

19. Select the **INCORRECT** answer below with regard to extubating a patient.

- A) The oropharynx must be suctioned and then down the ET tube.
- B) The cuff of the ET tube must be inflated to prevent aspiration on extubation
- C) The patient is asked to cough
- D) Post extubation the patient must be sitting up in bed and 40% O₂ administered.

E) Don't Know

Vignette two: ARDS

A 48yr old patient has been mechanically ventilated in your ICU for 3 days and she has Acute Respiratory Distress Syndrome (ARDS) as a result of fat embolus.

20. With regard to mechanically ventilating the patient with ARDS which one of the choices below is **NOT** correct?

- A) The TV should be calculated as 4-8mls/kg/ideal body weight
- B) The patient airway pressure should not exceed 45cm/H₂O
- C) High PEEP levels are often required to prevent shearing injury of the lung
- D) The patient with ARDS usually has non-compliant (stiff) lungs

E) Don't Know

21. 4hrs later the patient continues to deteriorate. Her lungs have become stiffer and she requires higher levels of O₂ to maintain her P_{O₂} at 60mm/Hg. Her high airway pressure alarm is constantly alarming. Which **ONE** of the following would be the **MOST APPROPRIATE** intervention at this stage?

- A) Increase the O₂% to 100%
- B) Increase the mandatory rate to blow off the CO₂
- C) Decrease the PEEP

D) Place the patient in the prone position and recruit the lungs

E) Don't Know

22. With regards to PEEP, what is the effect of optimal PEEP at alveolar level of the lungs?

A) Decreases the risk of barotraumas

B) Decreases the FRC of the lung

C) Opens up the alveoli and prevents alveolar collapse at the end of expiration

D) Decreases oxygenation

E) Don't Know

23. Below is a pressure/volume loop as displayed on the patient's ventilator graphics monitor of the ventilator. Which **ONE** statement listed below the graphic is **CORRECT** in relation to the graphic depicted on the screen.



A) Shows the lung has normal compliance

B) The patient has significant increased work of breathing

C) The lungs are over distended

D) The PEEP level setting on the ventilator is 15cm/H₂O

E) Don't Know

Vignette three: Chronic Obstructive Airways Disease.

24. Two hours later pt is deteriorating and the nurse places her on a 35% oxygen face mask, and she is admitted to the high care unit for monitoring. Her respiratory rate is now 40 bpm, her work of breathing is markedly increased, and she is sweating profusely, and is extremely anxious. She is however still co-operative and awake. Which **ONE** of the following interventions would be the most appropriate?

- A) Increase the supplemental O₂ to 100%
- B) Commence a continuous infusion of bronchodilator therapy **ONLY**
- C) Intubate and ventilate the pt
- D) Give the pt a trial of noninvasive ventilation using BiPAP
- E) Don't Know

25. Which **ONE** of the following ventilator setting combinations would be **the most appropriate** at this stage for Mrs. Smith?

- A) V/C SIMV, O₂ 100%, Peak Flow 40 liters, Mandatory rate 22 bpm, PS 15cm/H₂O, PEEP 5 cm H₂O, TV 400mls, trigger sensitivity -2cm/H₂O, IE 1;2
- B) P/C SIMV, Pressure limit 35cm/H₂O, Ti 0.8seconds, PS 15cm/ H₂O, PEEP 5 cm/H₂O, O₂ 100% Mandatory respiratory rate 22,
- C) Spontaneous mode, PEEP 7.5cm/H₂O and Pressure support 25cm/H₂O
- D) V/C SIMV, Peak Flow 40L Mandatory rate 10 bpm, PS 15 Cm/H₂O, PEEP 7.5 cm/H₂O, 35% O₂, IE 1:4
- E) Don't Know

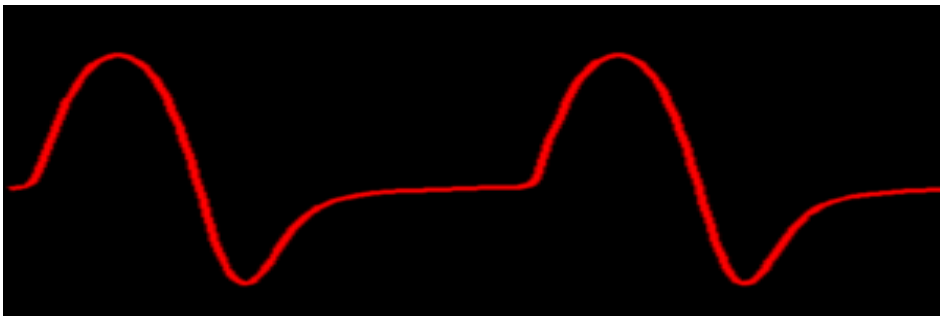
26. Which of the following would be adjustments you would make to the ventilator settings to **PREVENT** Auto- PEEP from occurring. Select **TWO** correct answers.

- A) Increase the respiratory rate

- B) Decrease the respiratory rate
- C) Increase the inspiratory time
- D) Decrease the expiratory time
- E) Don't know

27. Below is the ventilator graphic shown on the graphics screen of Mrs. Smith ventilator? What problem can you interpret from this flow volume loop?

Explain your answer in the space provided below the graph.



Answer:-----

Part III: Observational Checklist

S.N	Tasks	Yes	No	Remark
32	Performs ventilator testing before initiation			
33	Sets MV settings properly			
	A. Can choose appropriate ventilation mode (A/C, SIMV, CPAP, PS)			
	B. Sets PEEP at 5-10cmH ₂ O			
	C. Set TV 5-10ml/kg			
	D. Sets RR 10-20bpm			

	E. Sets pressure limit 10-25cmH ₂ O				
	F. Flow rate: 40-100L/min				
	G. I:E ratio	1:2 for normal lung			
		1:3-1:4 for COPD and Asthma			
34	Identifies cause and responds to MV alarms correctly				
	1. High peak pressure alarm	A. Identifies and removes the root cause of: -High airway resistance (secretions, kinked ETT, water in the patient circuit, patient biting the tube)			
		B. Adjust T _i if set too short			
		C. Reassure, sedate or give anti pain if the patient is fighting the vent.			
	2. Low peak pressure	A. Identify and remove the root cause(Gas leak, Tube disconnection)			
		B. Check and readjust mode and control settings(if Inspiratory flow set too low and /or T _i set too long in volume mode)			
		C. Check and adjust alarm settings			
	3. High TV alarm	A. Adjust the set TV high alarm limit(if high TV alarm limit set too close to the actual TV)			
		B. Check and adjust mode and control settings (eg. In pressure mode if the pt's actual demand is greater than expected)			
	4. Low TV	A. Check for circuit disconnection/loose connection and reconnects			
		B. Check the low alarm limits if set too close (less than 20% of the set parameter)			

	5. High VE alarm	A. Check minute ventilation high alarm limit and adjust it			
		B. Check and adjust RR, TV and inspiratory pressure if set too high			
		C. Correct if there is auto-triggering			
	6. Low VE alarm	A. Check the pt's circuit and airway for leaks or occlusion			
		B. Check and adjust the mode and control settings			
		C. Check and adjust alarm settings if set too close			
	7. High RR	A. Check and adjust rate and trigger sensitivity settings B. Give analgesia if there is pain C. Check upper limit alarm and adjust D. Troubleshoot auto-triggering if present			
35	Checks ventilator graphics				
36	Identifies ventilator graphics (wave form) abnormalities	A. Identifies wave forms showing air-trapping and take action to correct it			
		B. Identifies wave forms showing secretions and take action to correct it			
		C. Identifies wave forms showing PVAs and take action to correct it			
		D. Identifies ventilator wave form showing air hunger and take action to correct it			

10. Assurance of Principal Investigator

I the undersigned agree to accept all responsibilities for the scientific and ethical conduct of the research project. I will provide timely progress report to my advisor and seek the necessary advice and approval from my primary advisors in the course of the research. I will communicate timely to my advisors all stakeholders involved in the study including any source of funding for this research.

Name of the student: _____

Signature: _____

Date: _____

Approval of the Primary Advisor

Name of the primary advisor: _____

Signature: _____

Date: _____

Approval of the Co-Advisor

Name of the primary advisor: _____

Signature: _____

Date: _____

Approval of the Examiner

Name of the Examiner: _____

Signature: _____

Date: _____

