INTENSIVE CARE NURSES' KNOWLEDGE ABOUT ENDOTRACHEAL SUCTIONING GUIDELINES IN ONE MAJOR ACADEMIC HOSPITALS IN JOHANNESBURG

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DECLARATION

I, Clive Tebogo Ntelele, declare that this research report is my own work. It is being submitted for the degree of Master of Science (in Nursing) at the University of the Witwatersrand, Johannesburg. It has not previously been submitted for any degree or examination at this or any other university.

Signature

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DEDICATION

This is a special dedication particularly to God who gave me the strength to continue pursuing completing this research study. A special dedication to my partner, research supervisors, intensive care nurses who willingly participated in the study and to the University of Witwatersrand for the opportunity to further my studies.

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ABSTRACT

Background: Critically ill patients in Intensive care units are often placed on mechanical ventilation which requires endotracheal suctioning to promote adequate gaseous exchange and manage any underlying progressive condition. However, endotracheal suctioning has been associated with life-threatening complications and increasing hospital stays. Evidence have suggests that poor practice has detrimental effects without appropriate evidence-based knowledge and adherence to recent evidence-based guidelines. Therefore, this South African study investigated intensive care unit (ICU) nurses' knowledge and practice of evidence-based guidelines for endotracheal suctioning.

Purpose: This study aimed to determine intensive care unit nurses' knowledge of the American Association of Respiratory Care (AARC, 2010) evidence-based guidelines on the endotracheal suctioning technique in one major hospital in Johannesburg.

Setting: The study was conducted in five ICUs which include Trauma ICU, Cardiothoracic ICU, Coronary Care ICU, Neurosurgery ICU and General ICU of one major public sector hospital in Johannesburg.

Methods: A non-experimental, descriptive and quantitative design was utilised in this study. The sample size comprised 130 (n = 130) nurse respondents. A non-probability convenience sampling method was utilised and the data was collected using a validated questionnaire (Negro *et al.,* 2014). The Questionnaire lists ten (10) strategical questions with each containing 4 options to select, and the respondents had to select the correct one from the listed options. Descriptive statistics were used to analyse the data. Statistical tests included the Chi-square test of association, and the strength of association was estimated using Cramer V tests. Testing was done on the 5% ($p < 0.05$) significance level.

Results: Out of a total sample of 130 (n = 130) respondents, the knowledge of intensive care nurses was found to be less than adequate in seven out of ten domains of endotracheal suctioning guidelines. In three of the domains which includes preparation for device for use, frequency of suctioning and manual lung recruitment was found to be satisfactory. These findings also revealed that nurses with more than five years of experience in the intensive care scored higher than average nurses with less than five years of experience (315 vs 215, respectively), and a strong association ($p<0.05$) was found in three of the ten domains. In addition, It was also revealed that respondents with diploma-level training performed better on average in terms of endotracheal suctioning knowledge than those with degrees (381 vs 178, respectively). Although, the diploma nurses outperformed their counterparts in eight of ten domains, the association in this domain was rather weak.

Conclusions: This study concluded that endotracheal suctioning remains a difficult procedure to perform according to guidelines for nurses in these ICUs. Hence it can be concluded that some nursing practices may be outdated and potentially threaten patient safety and the quality of care in these ICUs. This highlighted the need for change in practice to ensure adherence to recommendations of the current clinical guidelines and ensure practice-informed education of ICU nurses.

***Keywords*:** Endotracheal suctioning, knowledge, evidence-based practice, intensive care

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LIST OF ABBREVIATIONS

AARC	American Association of Respiratory Care
A/C or ACMV	Assist Control Ventilation
APRV/BiVent	Airway Pressure Release Ventilation
BiPAP	Bilevel Positive Airway Pressure
CDC	Centre for Disease Control and Prevention
CPAP	Continuous Positive Airway Pressure
EBP	Evidence Based Practice
EPAP	Expiratory Positive Airway Pressure
ETT	Endotracheal Tube
FiO_2	Fraction of Inspired Oxygen
HFOV	High frequency Oscillatory Ventilation
ICU	Intensive Care Unit
I:E Ratio	Inspiratory Expiratory Ratio
IPAP	Inspiratory Positive Airway Pressure
NIPPV/NPPV	Non Invasive Positive Pressure Ventilation
PC	Pressure Control
PEEP	Positive end expiratory pressure
PiP	Peak Inspiratory Pressure
Pmean/Paw	Mean Airway Pressure
Pplateau + Pplat	Peak and Plateau inspiratory pressure
PSV	Pressure Support Ventilation
RR / f	Frequency of breathing
SANC	South African Nursing Council
SIMV	Synchronized Intermitted Mechanical Ventilation
TT	Tracheal Tube
VAP	Ventilator Associated Pneumonia
VC	Volume Control
Ve/MV	Minute ventilation
V_T	Tidal Volumes

CHAPTER ONE

OVERVIEW OF THE STUDY

1.0 INTRODUCTION

This chapter presents an overview of the study. The background of the study, problem statement and purpose of the study, objectives and significance of the study is described. The operational definitions, a brief overview of the research methods, ethical considerations and the study's validity and reliability are also briefly described.

1.1 BACKGROUND OF THE STUDY

Critically ill patients in intensive care units (ICUs) are at risk of developing life-threatening complications resulting in severe psychological, physiological, and respiratory effects requiring ICU support for their respiratory failure and hemodynamic function (Asfour, 2016; Robertson *et al.,* 2013; Rodriquez *et al.,* 2001). The patients often undergo a physiological crisis, leading to undetermined impairment, an increased mortality risk, significant severe morbidity, and susceptibility to developing hospital-acquired infections resulting in increased hospitalisation (Lestari *et al.,* 2019; Ludin *et al.,* 2013; Nelson *et al.,* 2010). In order to manage critically ill patients with a compromised respiratory system, an endotracheal tube is placed in the trachea to achieve a patent airway, followed by the administration of mechanical ventilation (Caparros & Forbes, 2014; Sole *et al.,* 2019; Wang *et al.,* 2017).

Most critically ill patients admitted to ICUs are frequently put on mechanical ventilation via an endotracheal tube to promote effective lung gaseous exchange (Caparros & Forbes, 2014; Parissopoulos *et al.,* 2015; Hussein *et al.,* 2017). Patients on mechanical ventilation via an endotracheal tube experience decreased mucociliary activity and a increase in thickness and quantity of sputum production (Hussein *et al.,* 2017, Negro *et al.,2014).* In addition, they also develop a decrease in coughing reflex sensitivity which may potentially result in an increased risk of developing infections (Hussein *et al.,* 2017, Negro *et al.,* 2014; Sole *et al.,* 2015; Zahran *et al.,* 2017). Endotracheal suctioning is thus performed predominantly via the endotracheal tube to remove pulmonary secretions,

prevent lung collapse and keep the airway patent leading to increased gaseous exchange (Hussein *et al.,* 2017; Negro *et al.,* 2014).

The procedure of endotracheal suctioning is performed by the insertion of a suction catheter into the endotracheal tube. The endotracheal suction tube is connected to a negative suction vacuum when the procedure is indicated. The endotracheal tube is inserted into the trachea at 1-2 cm above the carina with negative suction to expel pulmonary secretions from the endotracheal tube (Ayhan *et al.,* 2015; Camille *et al.,* 2014; Caporras & Fobes., 2014; Pedersen *et al.,* 2009; Schmollgruber *et al.,* 2014)

There are two methods of endotracheal suctioning: open and closed endotracheal suctioning. Open endotracheal suctioning requires the nurse to disconnect the patient from the mechanical ventilator to insert a disposable suction catheter into the endotracheal tube, to perform the skill. Close endotracheal suctioning is whereby the suctioning catheter is connected to the endotracheal tube and the ventilator line forming part of the ventilator circuit connection, resulting in no need for disconnection from mechanical ventilation (Ozden *et al.,* 2014; Ozden *et al.,* 2012; Overend *et al.,* 2009; Pedersen *et al.,* 2009).

Endotracheal suctioning is one of the most fundamental practices performed routinely by nurses in an acute care setting to prevent the tube of occlusion and as well to achieve adequate alveolar gaseous exchange (Ayhan *et al.,* 2015; Hussein *et al*., 2017; Negro *et al*., 2014; Pedersen *et al*., 2009). Pedersen *et al.* (2009), Wang *et al.* (2017), and Maggiore *et al.* (2013) have reported that the endotracheal suctioning procedure is associated with life-threatening events such as lung collapse, haemorrhaging, injury to tracheal membrane mucosa, infection, and increased intracranial pressure, decrease arterial oxygenation and compromised hemodynamic status. However, the concern is if the associated life-threatening events may lead to difficulty weaning off mechanical ventilation, which may significantly increase hospitalisation, hospital cost and ICU mortality rate (Caparros & Forbes, 2014; Kelleher & Andrews, 2008; Maras *et al.,* 2017).

While the endotracheal suctioning procedure is crucial for mechanically ventilated patients, research has demonstrated poor knowledge of evidence-based practice

guidelines and various practices amongst nurses based on tradition, personal experience, and routine rather than what evidence suggests (Kelleher & Andrews, 2008; Maras *et al.*, 2017; Ozden *et al.*, 2012; Sole *et al.*, 2003). One study conducted by Maras *et al.* (2017) showed that endotracheal suctioning evidenced based knowledge level among ICU nurses was very good in 59.7%, 34.7% of nurses had good knowledge, 79.2% had fair practice, and 18.1% of the nurses' practice was good. Negro *et al.* (2014), in their study, reported that nurses working in ICU for more than five years demonstrated a higher score on questions related to the diameter of the endotracheal suction catheter, normal saline installation and the amount of negative pressure application. Contrary to Kelleher & Andrews (2008), their study found that a higher number of nurses do not auscultate the lungs before suctioning and use high suctioning pressure. Furthermore, a high number of nurses failed to perform post endotracheal suctioning assessment and selecting the appropriate diameter of suctioning catheter (Kelleher *et al.*, 2008). In addition, a quantitative cross-sectional observational study done by Mwakanyanga *et al.* (2018) found that 85.7% did not pre-oxygenate the patient. Seventy-seven-point one percentage of nurses did not perform post-hyper-oxygenation and obtained low score in hand disinfection prior to and post endotracheal suctioning (Mwakanyanga *et al.*,2018).

Similarly, Maras *et al.* (2017) found that 12.5% washed their hands during observation, and all nurses were observed to apply suctioning pressure greater than 150 mmHg than recommended by evidence-based guidelines. However, according to Ozden *et al.* (2012), the observational study reported that 77.1% washed their hands during the first observation, 85.5% performed post hyper-oxygenation, and 100% of nurses set suctioning pressure at 80-100mmhg. In a question related to knowledge, Negro *et al.* (2015) reported in their findings that 83% of people who worked more than five years in the ICU answered the duration of suctioning event correctly. Maras *et al.* (2017) found that 97.2 % of nurses knew that suctioning procedure should not be longer than 10-15 Seconds. Furthermore, in a systematic review conducted by Ayhan *et al.* (2015), it was found that 77.1% of nurses use normal saline due to the consistency of secretions, and 12.5% of nurses do not use normal saline with the belief that it might have detrimental effects, despite what evidenced-based guidelines suggest.

Perhaps the discrepancies and variations in the knowledge of the practice of endotracheal suctioning are based on tradition, experience and belief without the knowledge of evidenced-based recommendations resulting in a poor outcome for critically ill patients (Makic *et al.,* 2011; Pedersen *et al.,* 2009; Wang *et al.,* 2017). Janson *et al. (*2018) demonstrated that respondents with less than five years' experience in ICU have a higher adherence score than those with more than five years' experience in EBP guidelines. According to Janson *et al*. (2018) the least known and adhered to guidelines are the frequency of suctioning system changes, practices of endotracheal suctioning before and during suctioning of the endotracheal tube, the setting of recommended suctioning pressure and the regular assessment of patients after suctioning Another study by Maggiore *et al.* (2013) showed a significant adherence score of 95.9% after implementing an endotracheal suctioning guideline.

Despite many inconsistencies in adherence to endotracheal suctioning practice guidelines, South Africa's nurses continue to practice on experience, routine, belief, and tradition (Schmollgruber *et al*., 2014). However, the study is a comparative experimental study investing the effects of the traditional use of normal saline instillation on cardiorespiratory parameters during endotracheal suctioning. Makic *et al.* (2011) highlighted the emergence of Evidenced-Based Practice (EBP) into clinical practice supported by the most recent unequivocal research, but the practice based on instinct, traditions and experience has not changed. With the implementation of evidenced based practice into clinical settings rather than traditional or experience, nurses can deliver and improve the health care delivery system (Burns & Grove, 2011; De Vos *et al.,* 2014). Given that endotracheal suctioning is performed routinely, according to tradition, experience, and lack of adherence to suctioning practice guidelines. This study intends to investigate evidenced-based practice knowledge of endotracheal suctioning practices and the relationship between knowledge and practice. Only one published study in South Africa was found investigating the effect of endotracheal suctioning with normal saline and without normal saline on well-intubated post-cardiothoracic surgery patients, thus highlighting the necessity and significance of conducting the study locally to evaluate the state of evidence-based practice knowledge of endotracheal suctioning amongst ICU nurses.

1.2 PROBLEM STATEMENT

Many studies conducted overseas have indicated that ICU nurses do not adhere to evidence-based practices for suctioning intubated patients (Ciampoli *et al.*, 2020, Kellerher & Andrews (2008), Jansson *et al*, 2018, Negro *et al*., 2014, Mwakantange, Masika & Tarimo, 2018), but no studies have yet been done in South Africa. This non-adherence to these practices could lead to patients' health being compromised. It is unclear whether the non-compliance could be related to the lack of ICU nurses' knowledge of the latest guidelines or the absence of suctioning guidelines. No evidence-based guidelines have been developed in South Africa to date. However, the American Association of Respiratory Care (AARC, 2010) evidenced-based guidelines are considered the current and acceptable gold standard for endotracheal suctioning procedures in South Africa and globally. Therefore, it is crucial to evaluate ICU nurses' knowledge and identify barriers to EBP regarding endotracheal suctioning of the adult intubated patient, which this study aims to achieve.

This study will attempt to answer the following questions:

- What is the knowledge of ICU nurses about best practices regarding endotracheal suctioning?
- Does knowledge vary among experienced vs inexperienced ICU nurses?

1.3 PURPOSE OF THE STUDY

The purpose of this study was to determine ICU nurses' knowledge of the American Association of Respiratory Care (AARC, 2010) evidence-based guidelines on the endotracheal suctioning technique in one major academic hospital in Johannesburg.

1.4 RESEARCH OBJECTIVES

The objectives of the study were:

- To evaluate and describe the knowledge of ICU nurses about best practices regarding endotracheal suctioning in the ICU units from one major academic hospital in Johannesburg.

- To establish whether there is a relationship between training and years of experience, and nurses' knowledge of best practices regarding endotracheal suctioning.

1.5 SIGNIFICANCE OF THE STUDY

Preventing ventilator-associated pneumonia is a national priority for improving patient care as it is significantly associated with pneumonia-related morbidity and mortality. Hence, the Centre for Disease Control and Prevention (CDC) has established guidelines for preventing nosocomial-associated pneumonia (Kjonegaard, Fields & King, 2010). The ICU nurses' adherence to the latest evidence-based endotracheal suctioning guidelines is vital to the care of critically ill patients. The performance of endotracheal suctioning according to evidenced based practice recommendation has been shown to decrease the effects and complications associated with endotracheal suctioning. This is significant to our economy as complications that occur can increase patients' hospital stays, which could cost the government and medical aid unnecessary expenditures, which could be more effectively used to improve other aspects of the health sector.

1.6 OPERATIONAL DEFINITIONS

Definitions for the study are as follows:

- Intensive Care Unit

An adult intensive care unit is a specialised specifically staffed and equipped hospital unit. The management is dedicated to rescuing patients with life-threatening illness, injuries or complications requiring intensive or critical medical care (Bersten & Soni, 2003). In this study, it is abbreviated as ICU.

- Intensive care unit nurse

An intensive care unit (ICU) nurse is a specialised nurse who is formally trained and functions at an advanced level of patient care in a multi-disciplinary environment.

According to the South African Nursing Council (SANC), an ICU nurse is a registered nurse who obtains an additional qualification in advanced medical and surgical nursing: critical care at an approved learning facility (SANC, R212 of 1993 and amended). This study includes intensive care nurses working in an intensive care unit

- Endotracheal suctioning

Endotracheal suctioning is described as a component of bronchial hygiene therapy and mechanical ventilation. It involves the mechanical aspiration of pulmonary secretions from a patient with an artificial airway in position using an endotracheal suction catheter connected to a negative pressure vacuum (AARC, 2010).

- Evidence-based practice (EBP)

Evidence-based practice (EBP) is knowledge derived from research, experience, and patient situation; this informs my clinical practice decision-making. In clinical practice, critical thinking, clinical judgment, resulting in decision-making, translated into action (Sackett *et al.,* 2000). In this study, it is abbreviated as EBP.

- Guidelines and protocols

A guideline is a principle or criterion guiding or directing the action. Clinical guidelines and care protocols are used interchangeably. Protocols are a set of directions, principles or decision support tools to assist the health care practitioner about diagnostic or clinical procedures. Protocols are viewed as ‘dynamic tools in evolution’ which can be changed to accommodate new data or clinical practice (Hewitt-Taylor, 2004).

- Knowledge

Knowledge is described as what the person knows and the information acquired through learning (O’Neill, 2003). In this study, knowledge is explored in respect of a questionnaire developed by Negro *et al.* (2014), which includes the following 10

strategies, which are relevant to practice of nursing and proven in literature to prevent endotracheal suctioning complications (refer **Appendix A**).

1.8 OVERVIEW OF THE RESEARCH METHODOLOGY

The research methodology according to Burns and Grove (2011) is the blueprint that guides the study to have control over factors that could interfere with the desired outcomes. A brief overview of the research methodology of the study is provided in this section and will be discussed further in great detail in chapter 3.

A non-experimental, descriptive, quantitative survey design was utilised in this study to achieve the study objectives using a 10-item self-administered structured questionnaire by Negro *et al.* (2014). The respondents participating in the study included all ICU nurses from one major university affiliated academic public sector in Johannesburg. The target sample size included 130 nurses meeting the stipulated inclusion criteria. A non-probability convenience sample was used for selected sample size of study participants after consultation with a biomedical statistician to obtain the relevant data. Inferential and descriptive statistics were utilized for the analysis and synthesis of the data with the aid of the biostatistician from the faculty of health sciences.

Ethical clearance and permission to conduct the study was obtained from the relevant University Research Committees, the Department of Health and the relevant officials (Hospital Management) in the institutions. The study participants in the study had the right to withdraw freely and refuse to participate in the study without a penalty being granted at any point in time.

After obtaining permission from the hospital and ICU unit managers. a written consent was obtained from the respondents. Data collection proceeded using a self-administered questionnaire developed by Negro *et al*. (2014) describing ICU nurses' knowledge about endotracheal suctioning guidelines. Statistical software STATA version 13 was used for data analysis. The Reliability of the study was maintained by ensuring the researcher was the sole data collector. The sample size was achieved by non-probability convenience sampling method and the data was verified by a biomedical statistician to ensure accuracy

of the findings. The validity of the questionnaire was ensured by verification of five local domain experts in the field of intensive care which includes; two medical intensive care specialists, one ICU trained registered nurses working in intensive care unit, and two nursing education experts (with master's degree in the field of nursing education) for suitability in South African context.

1.9 OUTLINE OF THE STUDY

The research report will be presented as follows:

Chapter One:	Overview of the study
Chapter Two:	Literature review
Chapter Three:	Research design and methods
Chapter Four:	Data analysis and results
Chapter Five:	Summary of the study, main findings, recommendations and conclusions

1.10 SUMMARY

This chapter provided an outline of the study. The background of the study, problem statement and purpose of the study, objectives and significance of the study was discussed. The operational definitions of the study were defined. An overview of the research methods provided validity and ethical considerations about the study was also discussed.

In the next chapter, the literature reviewed will be discussed in greater detail.

CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

Critically ill patients frequently admitted in intensive care units often experience life threatening illness that requires them to be intubated with an endotracheal tube (ETT) to maintain their airway patent and facilitate ventilation. With an endotracheal tube in place, it is mandatory to place them on mechanical ventilator machine with a supportive mode that will allow adequate ventilation, oxygenation and decrease the workload of breathing. However, with an endotracheal tube in place, it also results in patients to ineffectively cough out secretions which may potentially occlude the airway. Which necessitates that critical care nurses to perform endotracheal suctioning to remove endotracheal secretions.

The following chapter will discuss an overview of mechanical ventilation, modes used in mechanical ventilation and highlight on the pathophysiology of endotracheal suctioning technique. Furthermore, it will also discuss current research recommendations for safe endotracheal suctioning practice, including also a brief review regarding nurses knowledge adherence and barriers towards implementing evidence based practice (EBP) guidelines.

2.2 OVERVIEW OF MECHANICAL VENTILATION

Critically ill patient in intensive care unit with an acute or life-threatening conditions are often intubated with endotracheal tube (ETT) or by placing a tracheostomy tube (TT) to maintain a patent airway. Patients with ETT in place often suffer from an acute respiratory failure condition or not able to maintain their own airway patent (Caparros & Forbes, 2014). Patients in intensive care unit (ICU) with respiratory failure are put often on a mechanical ventilation system via ETT or TT as a supportive mode of treatment until the underlying condition is managed and cleared (Caparros & Forbes, 2014; Huang *et al.*, 2021). Fifty percent of patients admitted in intensive care unit require mechanical ventilation as a supportive mode of treatment (Mellott *et al.*, 2018).

The main purpose of connecting patients to mechanical ventilator in intensive care units is to correct patients arterial blood gas parameters and acid base status by supplying sufficient oxygenation and optimizing the patients' alveolar ventilation status (Crossbach *et al.,* 2011; Carbery, 2008). The use of mechanical ventilation in critically ill patients in intensive care is vital because it allows long term and short-term respiratory support and it decreases the patients' workload of breathing by relieving the respiratory muscles synchronized with the ventilator (Crossbach *et al.,* 2011, Caparros & Forbes, 2014).

The mechanical ventilator also allows gaseous exchange in and out of the lungs by allowing blood alveolar carbon dioxide diffusion (Baird, 2016). The mechanical ventilator also allows settings of mandatory, synchronized or spontaneous patient-initiated breaths (Elliot & Elliot, 2018). The ventilator is able to sense apnoeic episodes and trigger to deliver a mandatory breath in attempt to support the mode of breathing (Elliot & Eliot, 2018). There are two forms of mechanical ventilation which include non-invasive mechanical ventilation and invasive mechanical ventilation (Elliot & Elliot, 2018., Huang *et al.,* 2021).

Non-invasive mechanical ventilation is performed with a Non-Invasive full-face mask attached with head straps around to the patients' head with an inflatable soft cushion to seal the face and a disposable foam spacer connected to the ventilator circuit to the ventilator machine. Invasive mechanical ventilation consists of placing an ET tube down the airway 2cm above the carina or by performance of tracheostomy by placing a TT in place through, by surgically opening of tracheal anterior wall through the neck (Caparros & Forbes, 2014). The endotracheal tube is connected to the ventilatory circuit to the mechanical ventilator to promote oxygenation and ventilation (Caparros & Forbes, 2014).

2.3 BASIC VENTILATION TERMINOLOGY

With the increase in developing complex modes of mechanical ventilation, has led to health care professionals to mastering the basic terminology to set the appropriate mode of respiratory support. The basic terminology in setting a mechanical ventilator are discussed below.

2.3.1 Frequency of breathing (RR / *f*)

It is charted as the number of breaths per min on ICU chart. This can be the frequency of breaths initiated by the patients (spontaneous breaths) or by the ventilator (mandatory breaths) or assisted breaths by the mechanical ventilator to reach a targeted pre-set pressure level. The breaths may range from 12-20 breaths per min or 20 – 35 breaths per min during lung protective mechanical ventilation and except during weaning of the mechanical ventilation off the patient (Baird, 2016; Elliot *& Elliot,* 2018). The rate of breaths is set to get rid or accumulate carbon dioxide levels to normal physiological parameters (Elliot *et al.,* 2018). The higher the rate of breath set, the greater the level of carbon dioxide gets blown off.

2.3.2 Tidal Volumes (V_T)

Refer to the pre – determined amount of gas delivered during inspiration to the patient with each set of breath. Vt is usually calculated by using the formula PBW (kg) = 50 + 2.3 (height (inch) – 60 for males and PBW (kg) =45.5 + 2.3 (height (inch)) – 60 for females. Vt in mechanical ventilated patients is set at 8 ml/kg/PBW (Baird, 2016; Keszler, 2009). The V_T is adjusted in conjunction with inspired oxygen (FIO_2) and positive end expiratory pressure (PEEP) to achieve sufficient gaseous exchange and with RR to maintain an effective minute ventilation (Baird, 2016; Keszler, 2009). Tidal volumes occur during mechanical ventilation results from the addition of the inspiratory effort (negative intrapleural pressure caused during inspiration) and the positive pressure given by the mechanical ventilator. The combination of these two creates a transpulmonary pressure which together with lung compliance determines the tidal volume (Keszler, 2009).

- Inhaled tidal volume (V_{ti}) : refers to the volume of gas delivered to the patients during inspiration.
- Exhaled tidal volume (V_{te}) : refers to the amount of air exhaled by the patients during expiration.

2.3.3 Minute ventilation (Ve/MV)

Is the volume of air exhaled or inhaled by the patient in a minute from the lungs calculated by as the byproduct of respirations and V_{TE} (End tidal volume) expressed as L/min (MV= Vt x RR). Normal MV ranges accounts roughly between 6-12 L/min (Baird, 2016; Keszler, 2009). Mv determines the amount of CO2 diffusion during mechanical ventilation and signifies alveoli MV and air (Carbery, 2008).

2.3.4 Fraction of Inspired oxygen (FiO_2)

A percentage of atmospheric pressure (760mmhg) is equivalent to oxygen content. This is also a fraction of oxygen content delivery in inhaled air. In natural state the atmospheric inhaled air includes 21% (FiO_2 0.21) oxygen levels (Elliot *& Elliot,* 2018). Oxygen enriched air delivered via mechanical ventilation accounts higher FiO_2 than 21% to up to 100% oxygen delivery. And 0.21 or 21% oxygen is calculated as 0.21 X 760mmHg= 159mmHg PatmosO2. The general rule is to wean FIO2 too its lowest levels, to avoid internally accumulating PO_2 to toxic levels (Elliot *& Elliot*, 2018).

2.3.5 Peak Inspiratory Pressure (PIP)

Peak pressures are determined when TVs are delivered into the patients' airway during positive pressure ventilation at the end of inspiration. PIP is generated by the pressure required to overcomes airway resistance and elastic properties of lung and chest wall (Carbery, 2008). The value is utilized to s*et al.* arm limits for pressure either high or low. In healthy lungs normal resistance and compliance is less than 35cmH2O. A pressure higher than 35cmH2O results in high resistance and low lung compliance signifying the presence of lung pathology or a condition (Carbery, 2008). PIP also indicates how far the alveoli is distended. Increased PIP can be reduced by decreasing PEEP and Vt levels. Keeping in mind that thus may reduce oxygenation and cause hypercapnia (Carbery, 2008).

2.3.6 Mean airway pressure (Pmean / Paw)

The average nearest pressure of the airway, that occurs throughout a complete cycle of respiration. It's an indication of alveolar oxygenation and a guide to change ventilation settings. Pmean airway pressure also indicates the amount of stress applied to the lung parenchyma during ventilation (Su *et al.,* 2021)

2.3.7 Pressures Measured during an Inspiration Hold (Pplateau + Pplat)

Pplateau pressures are measures during an inspiratory pause after a complete volume-controlled breath during positive-pressure mechanical ventilation. The pressure determines the patients' static lung compliance and normal parameters are less than 25cm H2O. Pplateau pressure occurs at the end of inspiration and allows the distention of the lung (Crossbach *et al,* 2011).

2.3.8 Flow rate ($\dot{v}$)

Refers to the delivery of the rate of speed for a set tidal volume breath by the mechanical ventilation, and it also affects the time spend during inspiration as compared to expiration. Thus, also includes the peak airway pressure. Normally adequate flow rate ranges from 40-60L/min (Crossbach *et al.*, 2011, Baird, 2016).

2.3.9 Trigger / Sensitivity

Ventilation triggering occurs in response to the patients' inspiratory efforts. The ventilator senses the patient's effort in correlation with changes in pressure, flow and time to deliver a spontaneous supportive breath. Trigger sensitivity is ideally set to attempt triggering / to initiate a ventilator breath when there is no inspiratory effort or not enough inspiratory effort from the patients. With pressure sensitivity, a negative pressure is required from the ventilator to trigger an initiation of a mandatory supported breath (Crossbach *et al,* 2011., Baird, 2016).

With flow sensitivity, the ventilator detects a decrease in flow via inspiration and expiration sensors attached to the circuit limbs, to release positive pressure, to support the patients' breath (Elliot & Elliot, 2018). Therefore, the negative pressure generated within the ventilatory circuit, allows the flow of air from the ventilator circuit into the patients' lungs. Normally it is set at its lowest from -1 to -2 cmH2O to trigger a ventilator breath (Baird, 2016).

2.3.10 Inspiratory: Expiratory Ratio (I: E Ratio)

This is the velocity which a tidal volume is delivered by the mechanical ventilator. This also refers to the length of time in comparison with inspiration and expiration. During normal spontaneous breathing, the I:E ratio is equivalent to 1:2. The inspiratory time is set proactively by setting tidal volumes and inspiratory flow rate, whereas expiratory time gets passively adjusted during settings (Carbery, 2008). By setting a lesser inspiratory time, it allows the ventilator delivering a 0.7 – 1.05, the I:E ratio on a mechanical ventilation is set at 1:2 or 1:3 (Baird, 2016., Crossbach *et al.*, 2011).

2.4 TYPES OF MECHANICAL VENTILATION

Mechanical ventilation as a supportive mode of respiratory system is classified into two types. The main two types of mechanical ventilation are negative pressure ventilation and positive pressure ventilation.

2.4.1 Negative Pressure Ventilation

In a normal healthy being, intra-pleural pressure ranges from -2 at rest and -10 cmH2O during the process of inspiration. Negative pressure ventilation creates a sub atmospheric pressure less than 760mmHg between the atmosphere and the alveoli. This negative pressure is generated within the thoracic cavity and in the abdominal segment which triggers the lungs to expand and diaphragmatic contraction to occur (Elliot & Elliot, 2018; Baird, 2016). This results in inspiration to deliver air flow into the lungs (Elliot & Elliot, 2018; Baird, 2016). Negative pressure ventilation is generally non-invasive, examples include Iron Lung, Chest Cuirass Shell and Poncho Chest (Baird, 2016).

2.4.2 Positive Pressure Ventilation

Positive pressure ventilators create an atmospheric pressure of greater than 760mmHg at the upper airway. This allows a difference in pressure gradient between the upper airway and lung alveoli which results in air volume and oxygen being forcefully delivered into the lung (Elliot & Elliot, 2018; Baird, 2016). This mechanism of ventilation can be applied non-invasively via a tight-fitting face mask system or invasively by insertion of ETT / TT (Elliot & Elliot, 2018).

2.4.3 Non-Invasive Positive Pressure Ventilation (NIPPV / NPPV)

This form of ventilation is performed mainly with a facemask, nasal mask, helmet or mouth delivering positive pressure support. In some ventilators its names as CPAP or BIPAP. Indication for this type of ventilation, include obstructed airway conditions, thoracic wall disease, neuromuscular fatigue and sleep apnoea. This type of mechanical ventilation is solely contraindicated in patients who are unable to maintain an open airway or having difficulty in clearing secretions and severely agitated or in shock (Baird, 2016).

2.4.4 Continues Positive Airway Pressure (CPAP)

This mode of ventilation provides a continues constant positive pressure to the airways during an entire breathing cycle. The ventilator doesn't initiate any mandatory breaths, rather it promotes the maintenance of the of the airway, prevents alveoli from collapsing during expiration by deliverance of a pre-set peep and also maintains the pulmonary lung pressures (Nigel, 1999). In this mode patients have to be able to initiate a spontaneous breath (Baird, 2016; Nigel, 1999). The PEEP given during mechanical ventilation allows the air delivered into the lungs to be maintained at the end of expiration. The advantage of using this mode during mechanical ventilation it can be administered no-invasively using a tight-fitting face mask connected to the ventilator circuit and can be used also outside of the hospital setting (Nigel, 1999).

2.4.5 Bilevel Positive Airway Pressure (BiPAP)

Also referred to as Bilevel, is a mode of mechanical ventilation that utilizes IPAP (inspiratory positive pressure) and EPAP (expiratory positive airway pressure) to augment the various changes in spontaneous tidal volumes. The airway resistance and lung compliance dictate the amount of IPAP needed to generate adequate tidal volumes. The desired tidal volumes required normally ranges from 8-12ml/kg and oxygenation status targeted is determined by the physician by titrating settings of IPAP, EPAP and FiO2 ratio (Baird, 2016).

2.4.6 Invasive mechanical Ventilation

Invasive Mechanical Ventilation is performed by placing insertion of endotracheal tube known as intubation (Huang *et al.,* 2021; Elliot *&* Elliot*.,* 2018). The placement of endotracheal tube is preferred normally by orally than nasally due to the risk of developing sinusitis. After the procedure is performed, the health care professional should make sure that the ETT tube is placed in the correct position by using a CO2 detection and by auscultation of lung sounds. The health care professional therefore should monitor for life threatening complications such as tension pneumothorax, hypoxia, bradycardia, and hypotension.

2.5 THE BASIC MODES OF MECHANICAL VENTILATION

2.5.1 Assist Control Ventilation (A/C or ACMV)

Assist Control Ventilation is a time-cycled pressure limited mode of mechanical ventilation that utilizes either volume control to deliver assisted preset tidal volume breaths or pressure control with a preset rate as back up if no spontaneous breathing is triggered (Baird, 2016; Keszler, 2009). The ventilator set breaths are delivered within a minute and any spontaneous breaths initiated by the patient, the ventilator senses the negative pressure and triggers to augment a ventilator mandatory breath of equal duration and magnitude.

The advantage of using this mode allows assisted spontaneous breaths triggered by the patient with uniform tidal volumes to reduce the workload of breathing regardless of required minute ventilation (Baird, 2016; Keszler, 2009). Every set breath delivered by mechanical ventilation is based on a time interval normally within a minute to meet the patients demands. The time it takes to complete an inspiration cycle is determined by volume (Vt) and flow rate. This is represented by the equation Ti=Vt / Flow Rate. Every triggered breath cycle upon completion whether mandatory / spontaneous it's a ventilatory breath limited to preset volume (VC mode) or pressure level (PC mode). Inspiration ends when preset tidal volume is reached (Crossbach *et al.*, 2011).

2.5.1.1 Differences between volume control and pressure control mode

Table 2.1: Differences between volume control and pressure control modes

Volume Control Modes	**Pressure Control Mode**
CMV, VCV, A/C, VC SIMV	***PSV, PCV, PC SIMV***
1. Constant volume delivery	1. The amount of volume delivered varies
2. Inspiratory pressure varies and inspiration ends when adequate Vt is delivered	2. Inspiration ends when targeted pressure is reached and inspiration pressure remains fixed.
3. Inspiratory flow rate is constant • If patient becomes tachypneac and workload of breathing increases, the physician needs to readjust settings to meet the inspiration demands.	3. Inspiration flow rate changes • If patient become tachypneac, workload of breathing increases, the physician needs to readjust settings to meet inspiratory demands by changing PS, Ti/Te settings
4. Inspiratory time is measured according to preset flow and Vt	4. Inspiratory time is set by the physician
5. Peak airway pressures vary, according to lung compliance, airway resistance or other extraordinary factors.	5. Peak airway pressures remain constant, dependent on the preset pressure level
6. Peak airway pressure increases until preset Vt is developed.	6. An increase in airway resistance or decline in lung compliance may decrease Vt delivery.

Key: CMV: controlled mechanical ventilation, VCV: volume-controlled ventilation, A/C: assist controlled ventilation, VC: volume control, PCV: pressure control ventilation, PSV: pressure support ventilation, SIMV: synchronized intermittent mechanical ventilation, PS: pressure support, Ti: inspiratory time, Te: expiratory time.

2.5.2 SIMV (Synchronized Intermitted Mechanical Ventilation)

This mode allows the mechanical ventilator to sense the patients spontaneous breathing by allowing spontaneous breathing without interruptions between the ventilators preset mandatory breaths either on volume control (volume cycled breath) or on pressure control mode (time cycled/ pressure cycled breath) (Baird, 2016; Caparros & Forbes., 2014). This mode can also provide assistance on patients' spontaneous variable pressure and volume breaths during breathing (Caparros & Forbes, 2014). However, it does differ from ACMV, because the breaths between mandatory breaths are non-ventilated breaths (Keszler, 2009).

Synchronized in this mode allows the ventilator to also deliver mandatory breaths when the patient triggers inspiration (Keszler, 2009; Baird, 2016). After completion of a breathing cycle when mandatory breaths are required, the ventilator will deliver a volume or pressure-controlled breath despite the fact that whether the patient triggers his/her own negative inspiratory effort. The pressure support in this mode is generally applied on the patients' spontaneous flow breaths. In addition, patients can also be weaned from or in this mode (Caparros & Forbes, 2014)

2.5.3 Pressure Support Ventilation (PSV)

In pressure support ventilation mode, it's the delivery of flow rather than time-cycled pressure-limited that requires the patient to breath spontaneously. On this mode the ventilator gets triggered during inspiration to deliver a pressure support with each breath with a preset PS (Pressure Support) setting (Caparros & Forbes, 2014; Baird, 2016). The pressure support delivery to the patient is administered via flow or gas during inspiration and it ends when the minimum inspiratory flow rate is; obtained. The patients keep full control over inspiratory and expiratory time, frequency, TVs, and spontaneous minute ventilation.

Using the mode on mechanical ventilation improves patients' comfort, reduces diaphragmatic stress encountered on A/C or SIMV alone. The Workload of breathing precipitated by resistance of valve or ET tube size is reduced by compensatory pressure

support provided by the mechanical ventilator. In other hand, PSV must be used in conjunction with SIMV to improve patient tolerance, reduces resistance and to decrease breathing workload. This mode it is mostly used during weaning of mechanical ventilator (Baird, 2016; Elliot *et al.*, 2018).

2.5.4 Pressure Control (PC)

The peak inspiratory pressure (PIP) its preset variable delivered with each breath and that is determined based on the patients estimated TVs required. A constant preset pressure limit gets delivered to the lung with varying TVs dependent on the patients' lung compliance (Elliot *et al.*, 2018) If the pre-set pressure is reached to soon, in encase of low lung compliance or increased airway resistance, this will result in in lower TVs being delivered. Therefore, TV delivery to the lungs is dependent on the time it takes to reach desired pre-set pressure limit (Nigel, 1999).

2.5.5 Volume Control (VC)

The volume (TV) is a preset value delivered by mechanical ventilator with each set rate of breath and the pressures vary to give the preset TV (Elliot *et al.*, 2018). A High PIP may be seen after inspiration due to decrease compliance (Baird, 2016).

2.5.6 Positive End Expiratory Pressure (PEEP)

This is not a mode on mechanical ventilation. The functions of PEEP are to keep airway patent with a certain amount of pressure above atmospheric pressure when expiration end, to improve functional residual capacity, to increase lung compliance, to reduce dead space and shunt fraction, to recruit collapse alveoli or reduce the occurrence of alveoli collapsing, to improve gaseous exchange and to equalize opening pressure in alveoli when filled with fluid (Elliot *et al.*, 2018; Nigel, 1999). When alveoli pressures rise, this results in increase in pressure applied to the vessels, resulting in decrease pulmonary blood flow which results in a decreases lung capillary perfusion.

Due to increase in pressures in the alveoli, this may result in lesser filling of the right Atrium, leading to decrease in overall perfusion. Normally, the use of PEEP during mechanical ventilation ranges from 2.5-20 cmH2O. However, caution needs to be taken when using high PEEP, which increases intrathoracic pressures, compressing the heart and great vessels resulting in decrease venous return, decrease in RV filling pressure and cardiac output, which causes hypotension or shock.

2.6 ADDITIONAL MODES OF MECHANICAL VENTILATION

2.6.1 Airway Pressure Release Ventilation (APRV/BiVent)

This mode of Mechanical Ventilation uses to basic methods which include PC/IRV and SIMV. This mode functions similarly as a CPAP that utilizes a time – controlled release valve. During closer of the release valve, a higher CPAP level and lung volumes are restored. By using IRV, it releases pressures in a short period of time. This mode uses a high-pressure time system that is remarkably long and a low-pressure time that is greatly low. The preset inverse ratio times allows a constant delivery of airway pressure and Auto-PEEP to facilitate adequate oxygenation. Settings on this mode include T – High (Inspiratory Time), T – low (Expiratory Ti), P High (Inspiratory pressure) and Plow (Expiratory pressure). Spontaneous and mandatory breaths occur merely during high time and are synchronized if need may be. At T Low, no breathing occurs until weaning starts.

2.6.2 BiLevel Ventilation

This mode of ventilation switches between low pressure and high-pressure levels based on the patients inspiratory and expiratory efforts. Patients may spontaneously breath during both times. However, airway pressures are not sufficiently controlled. If it occurs that the patients don’t breathe spontaneously, then the I: E ratio and ventilator frequency can be set to enhance ventilation and oxygenation. Bilevel ventilation can be utilized as pressure control ventilation, then weaned to BiPAP, and then followed by to CPAP prior removal of ET (Baird, 2016).

2.6.3 High frequency Oscillatory Ventilation (HFOV)

This mode of ventilation uses little tidal volumes known as delta (P:P) generally equal or less than the amount of dead space of 150ml, to constantly maintain high alveolar opening pressures with high frequency rates set at 4-5 breaths per second. In ARDS, this form of ventilation protects the alveoli from shear stress caused by recurrent opening and closing of alveoli, by promoting constantly higher airway pressures which facilitates the recruiting of the alveoli and keeping alveoli open (Baird, 2016).

2.7 COMPLICATIONS OF MECHANICAL VENTILATION

Although mechanical ventilation is used in Intensive Care units as a life-saving supportive intervention to support the respiratory function while managing the underlying physiological condition, it has been associated with adverse reactions when applied or used incorrectly and when utilized for a longer a period of time.

The following associated adverse reactions may occur during mechanical Ventilation

- *Barotrauma:*

  This results from an increase in ventilatory pressures, which increases intrathoracic pressures and intrapleural pressure, resulting in damage to lungs, major vessels and referred damage to the abdomen. High ventilatory pressures may also result in compression of the heart and lung vessels, which may result in decrease venous return leading to decrease CO, decrease renal blood flow, and further fluid retention (Carbery, 2008).
- *Volutrauma:*

  This results from excessive TVs delivered to the lungs, which creates over – distension of alveoli, leading to rupturing of the alveoli or air dissection and the activation of inflammatory cascade (Baird 2016; Carbery, 2008).
- *Pneumothorax:*

  A severe form of barotrauma is known to result in pneumothorax (Nigel, 1999).
- *Tension Pneumothorax:*

This results from a continues severe increase in ventilatory pressures which causes the tearing of the lungs or lung tissue, which further results in air escaping from the lung and collecting in the thoracic cavity causing lung collapse and atelectasis (Nigel, 1999).

- *Gastrointestinal complications*

  The increase of physiological pressures and stress during mechanical ventilation may result in hemorrhaging of the gastrointestinal tract which precipitates the development of peptic ulcers. While the patients are on the mechanical ventilator with and artificial airway (ETT) in place, there may be an increase in air swallowing which causes gastric dilation or distension which causes paralytic ileus, vomiting, aspiration and restrictive diaphragmatic movement (Nigel, 1999; Carbery, 2008).

- *Increased ICP:*

  A constant increase supply in PEEP and mean airway pressure levels may result in compression of the intrathoracic blood vessels, which lead to the decrease in cerebral venous return to the heart, this resulting in an increased ICP (Baird, 2016; Carbery, 2008).

- *Fluid imbalance*

  The resulting increase in pressures from mechanical ventilator may apply pressure to the thoracic aorta baroreceptors which leads to increase in ADH secretion, resulting in fluid retention causing hypervolemia and oedema (Baird, 2016; Nigel, 1999; Carbery, 2008).

- *Ventilator Associated Events*

  Patients on mechanical Ventilator are at great risk of developing health care associated pneumonia and ventilator associated pneumonia. The presence of an ET may lead to infection, vocal cord paralysis, development of tracheoesophageal fistula or laryngotracheal stenosis (Elliot & Elliot, 2018).

- *Anxiety:*

  The loss of control over their own ventilatory process and discomfort and the perception of fear that their health status is at risk may cause patients developing stress and anxiety (Baird, 2016., Nigel, 1999; Carbery, 2008).

2.8 OVERVIEW OF ENDOTRACHEAL SUCTIONING PROCEDURE

Endotracheal suctioning is a common invasive intervention carried out by critical care nurses in intensive care units on patients who are mechanically ventilated via an artificial airway (Mwakanyanga *et al.,* 2018; Anyani *et al.,* 2018; Jansson *et al.,* 2017). Endotracheal suctioning is described as the mechanical aspiration of patients' pulmonary secretions with an artificial airway (ETT) in place and an element of bronchial hygiene therapy and mechanical ventilation (Pedersen *et al.,* 2009). The artificial airway in place results in decrease mucocialiary activity, increases the amount and thickness of mucocialiary secretions, and suppresses the coughing reflex which increases the risk of developing infections. This endotracheal suctioning is required to maintain a patent airway (Hussein *et al.,* 2017; Kellerher & Andrews., 2008; Ozden *et al.,* 2012). However, despite its benefits and as essential as the procedure may be, it has been reported to have associated adverse effects and life-threatening complications (Pedersen *et al.,* 2009; Caparros & Forbes, 2014; Wang *et al.*, 2017).

According to Wang *et al.* (2017), during the performance of the procedure serious adverse events such as hypoxemia, cardiac dysrhythmias and an elevated intracranial pressure may result. In addition, performing endotracheal suctioning for a longer period of time without initiating adequate oxygenation may lead to changes in hemodynamic status (Ozden *et al.,* 2012). Changes in hemodynamic status which may occur include; decrease oxygen saturation (Spo2), severe hypertension / hypotension, severe tachycardia or bradycardia and the development of cardiac arrhythmias (Maggiore *et al.,* 2013., Ozden *et al.,* 2014). To further add to this, bleeding, infection, lung collapse, lesions in tracheal mucosa or damage to cilia and epithelium, shortness of breath, barotraumas and bronchospasms has been also reported (Pedersen *et al.,* 2009; Jansson *et al.,* 2017).

However, the disconnecting of the patient during endotracheal suctioning from the mechanical ventilator may be a source of infection such as VAP and also precipitates hypoventilation (Aryani *et al.,* 2018). The patients may also be unable to maintain their PEEP and therefore it results in decrease arterial oxygenation (Ozden *et al.,* 2012).

VAP has been proven to develop in 8 to 28% of patients admitted in critical care units on mechanical ventilation and accounts a mortality rate of 20-71% (Ozden *et al.,* 2012). In addition, to the risk associated with contracting VAP, patients are two times more likely to die from it. If not, an increased length of stay in hospital occurs resulting in high hospital bills (Aryani *et al.,* 2018). However, hypoxia has been reported to be the most frequent occurring serious side effect associated with ETS (Hyunsoo & Whasook, 2003., Ozden *et al.,* 2014; Halm & Krisko-Hagel., 2008).

To further studying the effects that may occur of this invasive procedure. Several studies have investigated another contributing factor related to ETS complications occurring during suctioning and after suctioning. It is the traditional practice of the use of NSI into the endotracheal tube prior endotracheal suctioning. This practice has been carried conventionally over the years based on experience, beliefs and tradition without suggestive evidence (Blackwood, 1999., Caparros & Forbes., 2014; Ozden *et al.,* 2012; Schmollgruber *et al.,* 2014; Wang *et al.,* 2017).

A number of studies that have been conducted have reported that the anecdotal practice of NS instillation is associated with increased ICP, pain and anxiety, dyspnea, increased risk of developing VAP, decreased arterial oxygenation, hemodynamic instability, damage to antimicrobial properties, hemorrhaging secretions, bronchospasm, cardiac and respiratory arrest, dislodgement of ET bacteria colonies into the lower respiratory tract and eventually death (Caparros & Forbes., 2014; Halm & Krisko-Hagel, 2008; Hussein *et al.,* 2017; Maggiore *et al.,* 2013; Mwakanyanga *et al.,* 2018; Pedersen *et al.,* 2009; Riddling *et al.,* 2018).

Most of these endotracheal suctioning adverse events and complications occurring could be related to errors in practice, in appropriate suctioning technique, insufficient knowledge, non-adherence to endotracheal suctioning evidenced based guidelines, ward routine and variations in endotracheal suctioning practices (Celik & Elbas, 2000; Kelleher & Andrews, 2008; Mwakanyanga *et al.,* 2018; Negro *et al.,* 2014; Ozden *et al.,* 2012;).

To enhance the benefits associated with endotracheal suctioning technique, its believed that the instillation of a bolus of normal saline into the endotracheal tube facilitates the

removal of pulmonary secretions, loosens thick secretion, lubricates the suction catheter, irritates the tracheal mucosa, thereby stimulates the patients coughing reflex to dislodge secretions by mobilizing them into the upper airway. Thus, predominantly allows suctioning of secretions from the upper airway more effectively (Caparros & Forbes, 2014; Halm & Krisko-Hagel., 2008; Hussein *et al.,* 2017; Pedersen *et al.,* 2009; Riddling *et al.,* 2018; Wang *et al.,* 2017).

2.8.1 Types of Endotracheal Suctioning Techniques

Airway management practices are currently performed by intensive care nurses today in various ways to improve oxygenation, promote adequate ventilation and maintain effective gaseous exchange. There are two types of endotracheal suctioning technique, which includes mainly open and close system endotracheal suctioning methods Aryani *et al.,* 2018; Caparros & Forbes, 2014; Maggiore *et al.,* 2013; Overend *et al.,* 2009; Pedersen *et al.,* 2009). Open endotracheal suctioning method is performed by disconnecting the endotracheal tube from the mechanical ventilator circuit and inserting suction catheter than followed by applying suction (AARC, 2010; Aryani *et al.,* 2018; Caparros & Forbes, 2014; Overend *et al.,* 2009; Pedersen *et al.,* 2009; Schmollgruber *et al.,* 2014). In other hand, close endotracheal suctioning doesn't involve the disconnecting of the patient from the mechanical ventilator (AARC, 2010; Caparros & Forbes., 2014; Ozden *et al.,* 2012). Close endotracheal suctioning is performed with a multiple usable / reusable suction catheter enriched with a plastic cover allowing insertion and retraction of the suction catheter through the artificial airway (AARC,2010; Aryani *et al.,* 2018; Overend *et al.,* 2018; Pedersen *et al.,* 2009). The enclosed plastic cover protects the suction catheter from contamination with the surrounding environment (Pedersen *et al.,* 2009). The suction catheter is connected continuously to the mechanical ventilator with an extension allowing connection of suction tubing via a negative suction system minimizing the risk of losing TVs. Both endotracheal suctioning techniques permits two methods of suctioning based on insertion of suction catheter depth; either deep and shallow suctioning.

According to the AARC (2010), deep suctioning is described as allowing passage of the suctioning catheter into the ETT/TT to the trachea until resistance is reached, followed

by retracting the suction catheter 1cm above the carina before initiating suctioning pressure. Shallow suctioning is defined as allowing insertion of suction catheter to a preset level generally at the length of ETT with the adaptor in place (AARC, 2010). During a suctioning event in practice, health care professionals may still instill a bolus of sodium chloride directly into the trachea in advance to remove tracheal secretions (AARC, 2010; Caparros & Forbes, 2014; Overend *et al.,* 2009; Wang *et al.,* 2017) which is widely not recommended (Day *et al.,* 2015). The AARC (2010) clinical practice guidelines states that the duration of suctioning event should not last for more than 15 seconds.

2.9 EVIDENCE BASED PRACTICE FOR ENDOTRACHEAL SUCTIONING

In health care today evidenced based practice is the cornerstone that has been adopted in many clinical practice areas in health care delivery. Sackett *et al.,* 2008 defined evidence-based practice as the integration of the best available evidence with clinical proficiency and the patients values to aid in clinical decision making. Evidence based practice can be explained as incorporating the best available scientific research consisting of the data what the patient prefers and values. In addition, including the degree of clinical competency and the resources that are available to make practical clinical decisions about the health care of the patient (Leddy *et al.,* 2015). The intention to translate evidence based practice into clinical practice, with the best available scientific evidence is to improve, to examine the current clinical practices in place, and with the aim to ensure that the level of care delivered to the patient it is of safe and at its optimal level. The significance in applying in clinical setting and nursing education it is to ensure that the development of policies, protocols and clinical guidelines put in place, are in consistent with the best available scientific research evidence.

In nursing practice today, clinical guidelines, protocols and policies are put in place with the purpose to optimize delivery of health care to the patient to be effective and efficient (Leddy *et al.,* 2015). Despite with the continuation of research and development of new clinical practice guidelines, there is variances in the way health care professionals deliver the care to the patient in ICU.

One of the most practiced procedures in intensive care in patients who are under mechanically ventilation not based on research and anecdotal evidence, it's the practice of endotracheal suctioning. Endotracheal suctioning procedure is one of the procedures practiced in intensive care unit by nurses (Negro *et al.,* 2014). Since this procedure is associated with life threatening complications, it requires nurses working in intensive care units to have sufficient knowledge on how to perform the ET suctioning according to evidence based practiced guideline and constantly seeking the best available current evidence to support their practice (Pedersen *et al.,* 2009, Negro *et al.,* 2014).

Currently the latest guideline and recommendations of endotracheal suctioning procedure that stand it's the AARC 2010 Clinical practice guideline and the recommendations made Pedersen *et al.* (2009) in a systematic review. The following recommendations were made for endotracheal suction technique by the AARC (2010) and Pedersen *et al.* (2009).

- Pre-oxygenation is recommended at 100% inspired FIO2 prior to and post a suctioning event for at least 30 seconds.
- It is suggested that inserting the endotracheal suctioning catheter at the level of the whole ETT, rather than deep suctioning based on evidenced acquired from infant and paediatric studies.
- It is recommended that the use of normal saline instillation prior endotracheal suctioning to be avoided as there is no evidence to support its benefit.
- It is suggested performing close endotracheal suctioning in neonates and in adults who receive a high FIO2 or peep or who are at risk of lungs decruitment.
- It is suggested to avoid disconnecting the patient from the mechanical ventilator during suctioning and using lung recruitment manoeuvres when lung decruitment occurs. Lung decruitment may occur due to suctioning in patients who have acute lung injury
- It is recommended that to use a suction catheter that occludes less than half of the ETT lumen in paediatrics and adults and less than 70% occlusion in the infants.
- It is recommended that the suction duration event should not exceed more than 15 seconds.
- It is also recommended that to use a negative suctioning pressure between 80 and 120 mmhg during endotracheal suctioning .

- It is also suggested to use continues suctioning rather than intermittent suctioning during an individual suctioning event.
- It is also recommended to use an aseptic technique during performance of endotracheal suctioning due to the increased risk of patient acquiring infection
- Close and open endotracheal suctioning techniques are both recommended

These recommendations are further elaborated under the next heading in detail.

2.10 CURRENT RECOMMENDATIONS FOR SAFE ENDOTRACHEAL SUCTIONING

According to the AARC (2010) clinical practice guideline, it states that endotracheal suctioning is an invasive procedure, that intensive care nurses should be sensitive to the probable complications and hazardous effects that may occur during suctioning and take all necessary steps to ensure the patients safety. Day *et al.* (2001), stated that enlighten with possible complications and hazards that may occur from the procedure, nurses who have sufficient knowledge and skill in all aspects of ETS procedure may prevent the occurrence of severe complication. Ozden *et al.* (2012) found that the implementation of standard practice guidelines and training for open and close endotracheal suctioning technique, improved the level of knowledge and practice of endotracheal suctioning technique.

In other hand, Kelleher & Andrews (2008), reported that non-compliance to EBP guidelines and recommendations, resulted in participants practicing endotracheal suctioning in different ways with poor quality and discovered that the practice was based on nurse judgment and ward routine. Therefore, it is highly recommended in literature that nurses perform ETS based on standard practice guideline and adhere to ETS recent evidence-based practice recommendation when performing the procedure (Kelleher & Andrews, 2008; Maggiore *et al.,* 2013; Ozden *et al.,* 2012; Pedersen *et al.,* 2009.

The discrepancies correlated with theoretical knowledge and endotracheal suctioning practice raises a concern regarding the safe practice of the procedure in clinical setting. Endotracheal suctioning it’s an invasive procedure associated with adverse events.

Therefore, it should be practiced based on research evidence. Research recommendations for safe endotracheal suctioning technique is divided into three phases namely, prior suctioning event, during suctioning event and post suctioning event.

Recommendations for safe endotracheal suctioning are discussed below under the above subheadings

2.10.1 Prior Endotracheal Suctioning Event

Prior to endotracheal suctioning event, it is recommended that the following must be done, patient assessment, patient preparation, pre-hyper-oxygenation, infection control practices and the selection of the appropriate suction catheter size.

Patient assessment must be done to establish the indication for endotracheal suctioning due to the fact that there is a considerable risk and associated adverse events that may occur. Indication for endotracheal suctioning include auscultation of course crackles / secretions, visible sputum in ET, increased PIP, decreased TVs, oxygen desaturation, unable to generate an effective cough, presence of respiratory distress, saw-tooth pattern on flow volume loop, to obtain a specimen of pulmonary secretions and suspected gastric aspirates of the upper airway (AARC, 2010).

The patient must be notified, and an explanation given of the procedure to reduce distress, level of anxiety and alleviate the experience of pain. Also to encourage the patient to fully participate throughout the procedure and administer pain control medication if necessary. Endotracheal suctioning is being reported by patient as being unpleasant, uncomfortable, and frightening. Therefore, thus may precipitate asphyxiation resulting in vicious coughing which causes a painful sensation (Day *et al.*, 2002; Pedersen *et al.*, 2009).

Pre-oxygenation such as hyper-oxygenation or hyperinflation must be done to reduce instances of hypoxia, hypoxemia and associated adverse events of dysrhythmias, bradycardia, hypotension, and cardio-respiratory arrest (Day *et al.*, 2002). Infection prevention control measures must be undertaken such as handwashing, maintaining sterility of suction catheter and wearing of protective equipment (such as aprons, gloves,

goggles, and facemask). There is a considerable high risk of acquiring infection and cross contamination of the ETS catheter, which increases the risk of mortality, morbidity, hospital stay and hospital cost (Pedersen *et al.,* 2009).

Prior to the suctioning event, the right type and size of the endotracheal suctioning catheter must be selected (Day *et al.,* 2002; Pedersen *et al.,* 2009). It is argued that larger catheter size potentiates the risk of mucosal trauma due to a greater contact with tracheal mucosa. It is recommended that the external diameter of the suction catheter mustn't exceed one and half of the internal diameter of the ETT. The suggested formula for calculating suction catheter size is [Fr] = (ET size – 2) x 2.

2.10.2 During Suctioning Event

During suctioning event, the following elements must be taken into consideration which includes the depth of catheter insertion, negative pressure application, suctioning duration, the number of suctioning passes and normal saline instillation. It is crucial that the level at which the catheter is inserted is at the correct place in the airway. Literature recommends that inserting the catheter at the level of the carina and withdrawing 1 cm above the carina before application of negative pressure (Pedersen *et al.,* 2009).

Stimulation of the vagus nerve during suctioning may cause changes in heart rate, rhythm, a decrease in blood pressure and may also result in continuing paroxysmal coughing. Paroxysmal coughing may cause an increase in intrathoracic pressure leading to decrease venous return and hypotension (Day *et al.,* 2002). However, shallow suctioning is recommended over deep suctioning to decrease the occurrence of associated adverse events.

It is important to note that the correct negative suction pressure is set due to the associated adverse events of higher negative pressure. It has been reported that the use of higher suction pressure may increase the risk of developing lung collapse, hypoxia, tracheal tissue damage and ulceration (Day *et al.,* 2002; Pedersen *et al.,* 2009). A negative pressure ranging from 80-100mmHg in neonates and up to 150 mmHg in adults its recommended. Negative suctioning pressure must only be applied during retracting of suction catheter

to avoid invagination of the tracheal mucosa through the holes of the suction catheter (Day *et al.*, 2002). It is also recommended that negative pressure during withdrawal must be applied continuously than intermittent suctioning which may result in an increased risk of atelectasis.

It is recommended that the duration of the procedure should take between 10 – 15 seconds. The performance of the suctioning event greater than 15 seconds may increase the associated risk of hypoxia and the possibility of precipitating mucosal damage (Day *et al.*, 2002).

As much as the duration of the suctioning event is associated with resulting in complications during suctioning, so is the number of endotracheal suctioning passes. In a systematic review of current research recommendation by Day *et al.* (2002), researchers have advocated for minimal suctioning passes and should not exceed more than three passes per suctioning event. Researchers have argued that the greater the number of suctioning passes, the greater the associated risk of complications occurring.

Instillation of normal saline (also known as sodium chloride) refers to the insertion of 5-10ml bolus of sodium chloride solution into the ET tube to the trachea prior to performing the suctioning procedure (AARC, 2010; Wang *et al.*, 2017). It's believed that the insertion of sterile normal saline may aid in loosening pulmonary secretions, lubricate suction catheter and stimulate coughing to mobilize tracheal secretions (Ayhan *et al.*, 2015; Wang *et al.*, 2017). According to the AARC (2010), clinical practice guideline, the routine use of normal saline instillation during suctioning event is associated with adverse reactions such as frequently coughing, desaturation, bronchospasm, clearance of bacteria from ET bio film into the trachea, pain, anxiety, dyspnea, elevation in heart rate and ICP.

However, most of the recent reviews conducted have unsuccessfully demonstrated the beneficial effects of using sodium chloride solution (Ayhan *et al.*, 2015). Therefore, it is highly recommended in previous studies to avoid the routine use of normal saline during ETS due to the fact that there is insufficient evidence to support its usage.

2.10.3 Post Suctioning Event

After a suctioning event completion, the following activities need to be taken into account; Oxygen therapy reconnection, patient assessment and monitoring, reduction of stress and anxiety, reduction of oxygen and hand washing.

To prevent the occurrence of hypoxia post endotracheal suctioning, oxygen therapy must be recommenced within 10 seconds. Hyper-oxygenation should be performed for at least 1 min especially in patients who experienced hypoxia / desaturation prior or during suctioning procedure. If decruitment is noted, it is highly suggested that the health practitioner attempts lung recruitment manoeuvres. In a study it was found that the administration of lung recruitment manoeuvres resulted in early return of oxygen status and pulmonary tidal volumes to baseline level (Pedersen *et al.,* 2009). Evidence confirms that combining hyper-oxygenation with hyperinflation decreased hypoxemia events by 55% post suctioning (Pedersen *et al.,* 2009).

However, it is also not recommended to perform hyperinflation routinely as it may potentiate barotrauma (resulting from administering frequently high TVs), increases peak airway pressures and may cause patient discomfort (Pedersen *et al.,* 2009).

To evaluate if the suctioning event was performed successfully and effective, a thorough patient assessment must be performed by auscultating of the lung fields for air entry and audible chest sounds. It is suggested that it is critical for the nurse to monitor for signs of potential adverse reactions that may occur after the entire suctioning procedure. Continues monitoring of patients' vitals (HR, SpO2, BP, RR and perfusion status) is recommended for during and after suctioning (AARC, 2010; Day *et al.,* 2002).

Assessment of tracheal secretions for colour, odour, volume and consistency are also pivotal to determine possible adverse reaction and complication that may occur, and the findings thereof must be documented including the patients' psychological response (Khimani *et al.,* 2015).

To maintain the patients' comfort and to reduce the risk of associated adverse reaction, pain and anxiety must be minimized either by administration of anxiolytics and pain control medication. Reassurance of the patients is vital after completion of the procedure, to reduce the level of anxiety and improve patients' comfort (Day *et al*., 2002). It is also of importance to note adjusting FiO2 level to initial setting prior to suctioning event to prevent the occurrence of oxygen toxicity AARC, 2010)

Nurses should willingly familiarize themselves with appropriate hand washing technique. Adherence to hand hygiene practices is recommended, therefore hands should be washed at all cost, as literature reports that the need of wearing gloves doesn't outweigh the importance of hand washing (Pedersen *et al*, 2009).

2.11 NURSES' KNOWLEDGE OF EVIDENCE-BASED GUIDELINES

The basic purpose of endotracheal suctioning in clinical practice is to open and keep the airway patent by removing pulmonary secretions which may potentially occlude the airway (Ayhan *et al.*, 2015, Day *et al.*, 2002; Wang *et al.*, 2017). Throughout the world in many regions, the practice of ETS procedure has become solely the responsibility of nurses (Ayhan *et al.*, 2015). However, this raises concerns regarding the performance of the procedure, whether nurses perform it according to evidence-based practice and whether they have sufficient knowledge regarding endotracheal suctioning (ETS) procedure. Many studies conducted internationally have reported that ETS technique is still performed by nurses based on routine, personal experience, ritualistic, culture and tradition which is not based on current research recommendations (Frota *et al.,* 2013; Kellerher & Andrews, 2008; Pedersen *et al.*, 2009; Wang *et al.,* 2017).

Furthermore, it is therefore imperative that nurses keep up to date with recent published research and current empirical evidence based practice recommendations on practice guidelines (Day *et al.,* 2002). Therefore, the lack of adherence to evidence based practice (EBP) guidelines currently have resulted in the procedure being performed in various ways, incorrectly with many errors and consequently resulting in delivery of low quality of care (Kelleher & Andrews, 2008).

In a cross-sectional study design involving 103 intensive care nurses by Mwakanyanga *et al.* (2018), it was found that 80% of the nurses did not show desirable comprehensive knowledge on endotracheal suctioning evidence-based practice recommendations. Mwakanyanga *et al.* (2018) in their study also reported that all the nurses during observation didn't auscultate the lungs, didn't perform pre-oxygenation and none of the nurses checked the cuff pressure before performing the suctioning procedure. Jansson *et al.* (2018), concluded that most of the nurses in their study knew the guidelines related to strict hand hygiene, but did not know guidelines related to practices before and after ET suctioning.

In a study conducted by Negro *et al.* (2014), it was reported that none of the nurses completed the questionnaire without an error being found and a total percentage score of 58% was reported as correct. It was also found that nurses who have more than 5 years ICU experience answered questions related to suction catheter diameter, saline instillation quantity, catheter insertion depth and negative pressure application adequately than those who were less experienced (Negro *et al.*, 2014).

In another study conducted by Ozden *et al.* (2007), it was found that all the nurses who participated in the study have set their negative suction pressure to 200mmhg or greater, did not apply hyper-oxygenation prior and post suctioning event and a significant 70.8% of the nurses performed suctioning for longer than 15seconds. Kelleher *et al.* (2018) in their study findings, it was reported that there were inconsistencies between nurses practice and nurses didn't perform ETS according to evidence-based recommendations. This was reported particularly when it comes to the performance of hyper-oxygenation, infection control measures and setting of negative pressure (Kellerher & Andrews, 2018).

For instance, in General intensive care unit (GICU), it was revealed that only one participant worn goggles and only 8 (29%) in Cardiac intensive care unit (CICU) was found unable to maintain sterility of suction catheter prior insertion (Kelleher *et al.*, 2008). Furthermore, in an experimental study design by Celik & Elbas (2000), the results confirmed that ETS technique performed by nurses wasn't based on scientific evidence-based recommendations. Celik & Elbas (2000) determined that most of the ICU nurses

omitted critical steps in endotracheal suctioning technique which include as hyper-oxygenation, hand hygiene and documenting the procedure accordingly.

Contrary to this study done by Maras *et al.* (2017), it was found that most of the nurses mean score level of knowledge and practice were good (23.29 ± 3.83) and fair (12.88 ± 2.53). This was not the case in a triangulated observational interview and questionnaire study done by Day *et al.*(2002b), which explored the nurses' theoretical knowledge and practical competence of ETS. The researchers result indicated that most nurses failed to demonstrate a satisfactorily level of theoretical knowledge and practical competence (Day *et al.* 2002b). Correspondingly, Kelleher & Andrews (2008), reported that the practical component of nurses in endotracheal suctioning wasn't based on best practice recommendations.

Ozden *et al.* (2012), in a non–participant structured observational study with a sample of 48 nurses, discovered that the implementation of a standard practice guideline based on open and closed system ETS resulted in an increase in level of knowledge and participants level of skills were brought to preferred level. In addition, in a study done by Ansari *et al.* (2012), they showed that the level of knowledge of ICU nurses was at a desired level and the average practical score was poor. They concluded that education merely it's not adequate to reinforce standards of practice in clinical setting. Ansari *et al.* (2012) and Frota *et al.* (2013) stated that because inadequate knowledge leads to insufficient practices, the lack of knowledge discovered in certain areas in their research, contributes to complications occurring such as hypoxemia, infections, hemodynamic fluctuations and thus further puts the patients' safety during the procedure at risk.

Moreover, studies have shown that it is mandatory to implement evidenced based guidelines concerning ETTs technique and nurses should be reinforced strictly to comply with such protocols.

2.7 ADHERENCE AND BARRIERS TOWARDS IMPLEMENTING EVIDENCED BASED GUIDELINES

The implementation of evidenced based guidelines such as ventilator bundles, may reduce the risk of ventilator associated adverse reactions by improving intensive care nurses' knowledge and skills related to recent clinical guidelines and by encouraging adherence (Jansson *et al.,* 2018). The implementation of clinical guidelines it's to aid nurses in providing nursing care that is based on scientific evidence (Aari *et al.,* 2008).

Currently, adherence level being reinforced, and the utilization of evidenced based guidelines has differed extensively between practices and the providers (Jansson *et al.,* 2018, Sachetti *et al.,* 2014). In an exploratory descriptive cross sectional study design by Frota *et al.* (2014), the researchers reported a mean overall adherence score of 51.33% to a standardized open ETS system guideline. The authors have discovered an undesirable adherence rate from the 16 items observed, particularly in those items with associated adverse reaction such as occupational accidents, hypoxemia, infection, and changes in hemodynamic status.

These items include hand washing prior to procedure, explanation of the procedure, hyperoxygenation, method of suction catheter withdrawal, monitoring of hemodynamic status, the return of FiO2 setting to baseline level and the use of normal saline instillation(NSI) only for copious secretions. Contradictory to these results, Jansson *et al.* (2018), in their study found 71.1% in knowledge level and in self-reported adherence of nurses. However, the nurses who were more experienced in intensive care unit (ICU) had a significant low adherence score than the less experienced who obtained a higher adherence score (Jansson *et al.,* 2018). In line with this, the most adhered guidelines were patient positioning, the recommended cuff pressure, recommended head of bed angle elevation, daily oral chlorhexidine gluconate based oral care, strict hand hygiene, donning of appropriate PPE for suctioning and in preparation to extubate the patients.

Similarly, another study conducted by De Wand *et al.* (2010), they stated in their results that nurses had good level of knowledge regarding hand hygiene measures, but they had poor adherence in hand washing. In a study conducted by Chen *et al.* (2021), the findings

presented that those nurses had minimal adherence level to recommended negative suction pressure and avoidance of routine NSI prior suctioning. In a survey response rate, by Ciampoli *et al.* (2020), the study outcomes showed a desirable level of knowledge but the implementation into clinical practice was poor. Kelleher & Andrews (2008), concluded that intensive care nurses do not adhere to EBP recommendations in regard with ETS procedure.

The study results determined by Ciampoli *et al.* (2020) where in line with previous studies that education and knowledge is not sufficient enough to cause change (Bagheri_Nesami *et al.,* 2015). Chen *et al.* (2021) highlighted to bridge the gap between evidenced based practice knowledge in clinical, theoretical education and training of nurses alone it's not sufficient to form and regulate change in practice. In other hand, Ozden *et al.* (2012) and Day *et al.* (2009), their study findings in general doesn't equivalently support this studies outcome. The evidenced achieved through conducting their studies (Day *et al.,* 2009; Ozden *et al.,* 2012) proved that nurses after training and implementation of a standard practice guidelines resulted their adherence to knowledge and practice level increased significantly. Similarly, to the study finding by Sachetti *et al.* (2014) which showed an education intervention of ventilator care bundle increased adherence significantly to the bundle in clinical setting.

In a study titled "*Nurses implementation of guidelines for ventilator associated pneumonia from the centres for disease control and prevention*" by Cason *et al.,* (2007), it was discovered that nurses in hospitals who had oral care protocols in place in the setting reported greater adherence to hand hygiene and keeping head of bed elevated. These nurses were found to be more compliant to practices of oral care than nurses who do not have protocols or guidelines put in place. The findings in this study represents a similar outcome as in a study conducted by Madhuvu *et al.,* (2020), who reported that nurses adhered to performing oral care and positioning patients in semi-fowlers position who are mechanically ventilated. A self-reported adherence score was determined to be 8/10 for hand hygiene practices, but it didn't necessarily mean that hand washing is clinically performed according to EBP recommendations.

Enlighten with considering all the above factors from previous studies conducted. What could be the possible barriers in preventing the implementation or adherence to evidence-based guidelines?

Previous studies done until to date, most of the studies have shown that intensive care nurses have a low level of adherence and poor knowledge regarding evidence-based guidelines. According to Labeau *et al.* (2016), the insufficient level of knowledge amongst health care professional may be related to lack of awareness to evidence based guidelines. Perhaps, the lack in knowledge, compliance, and awareness of evidenced based practice (EBP) guidelines is associated with the level education or working experience. A study by Jansson *et al.* (2018) have identified 3 types of barriers, which are nurse related barriers, environmental related barriers and situation related barriers.

Nurse related barriers included factors such as lack of education, skills and forgetfulness. Environmental related barriers referred to the role ambiguities, insufficient resources, insufficient time, lack of guidelines, discrepancies with trial results, inadequate orders and cost. Situation related barriers determined were uncertainties in indications of the procedure, methods or timing, fear of heavily sedating, difficulty predicting and maintaining head of bed elevation, practices related to prior and post suctioning (such as difficulty estimating suction catheter insertion depth) and duration of suctioning.

In previous studies done, factors that hindered the implementation and utilization of EBP guidelines in clinical setting, included the lack in knowledge and skill, inadequate training , recent personal believes, attitudes, role perception, demotivation and changes in life style (Hadgu *et al.*, 2015; Koh *et al.*, 2008; Abrahamson *et al.*, 2012) In addition the studies conducted by Koh *et al. (*2008) and Abrahamson *et al. (*2012), have shown that there are other environmental barriers that play a role which includes; complex working environment, mixed-shift hours, staff shortages, heavy workload / to many extra duties, no role models, group norms, leadership roles / support and the facility issues.

In addition to this, other reasons in literature were also identified preventing nurses implementing evidenced based recommendations into clinical practice. This included resistance to change, lack of support from management, insufficient intensive care

training, the inability to access literature, lack of time reading, difficulty in understanding and interpreting research, competing workload pressures, undesirable altered management processes, unable to access clinical guidelines and research that is based on endotracheal suctioning event (Leddy *et al.,* 2018; Negro *et al.,* 2014). Day *et al.* (2002a & b) discovered that most often nurses are not aware of the existence of clinical guidelines and research based on endotracheal suctioning event.

In a study conducted by Chen *et al.* (2021), it was found only 5 nurses out of 281 nurses who completed the questionnaire successfully were aware of the evidenced based practice endotracheal suctioning recommendations. According to Chen *et al.* (2021), reasons to non-compliance and awareness to endotracheal suctioning guidelines in China could be partly related to the inaccessibility of evidenced based practice guidelines, language barrier (due to the fact most ETS guidelines exist in English), inadequate training and experience of intensive care nurses.

2.13 SUMMARY

This chapter have discussed an overview of the literature based on this topic. Previous studies conducted were assessed and explored. The results and recommendations were discussed further. A brief overview of the mechanical ventilation including the subheadings; basic ventilation terminology, invasive and non-invasive mechanical ventilation, basic modes of mechanical ventilation and additional modes of mechanical ventilation was discussed. Followed by an outline of pathophysiology of endotracheal suctioning technique, how its performed, its benefits and adverse effects.

Definition of terms of mechanical ventilation was also briefly described. A detailed description of the types of endotracheal suctioning event and current research recommendation for safe endotracheal suctioning technique was given. A brief literature overview of nurses' knowledge of EBP guidelines on ETS technique, adherence, and barriers toward implementing EB guidelines has been discussed.

The following chapter will give an overview of the research methods and design used in thus study to achieve the studies objectives.

CHAPTER THREE

RESEARCH DESIGN AND METHODS

3.1 INTRODUCTION

This chapter describes the research methodology used in the study which focuses on the research design and methods. The methods of the study setting, population, sample, sampling method and data collection process. This includes the research instrument used in the data collection, methods of data analysis, pilot study, ethical considerations and validity and reliability of the study.

3.2 PURPOSE OF THE STUDY

The purpose of this study was to determine ICU nurses' knowledge of the American Association of Respiratory Care (AARC, 2010) evidence-based guidelines on the endotracheal suctioning technique in one major academic hospital in Johannesburg.

3.3 RESEARCH OBJECTIVES

The objectives of the study were:

- To evaluate and describe the knowledge of ICU nurses about best practices regarding endotracheal suctioning in the ICU units from one major academic hospital in Johannesburg.
- To establish whether there is a relationship between training and years of experience, and nurses' knowledge of best practices regarding endotracheal suctioning.

3.4 RESEARCH DESIGN

A research design originates from the nature of the research question or formulated hypothesis and from the main purpose of the study design. It is the logical steps undertaken by the researcher to answer the research question and it shapes the blueprint of study under investigation and it determines the research methodology of the study to

acquire sources of data for collection, analyses, and interpretation of results (Burns *et al*.,2011, De Vos *et al*., 2014). A non-experimental, quantitative and descriptive design was used to meet the current study objectives.

3.4.1 Non-Experimental

In non-experimental design the setting of the study is not under control and the independent variable is not manipulated, therefore no introduction of any intervention. The data is obtained in a natural setting and the variables are observed as they occur. This allows the researcher to describe, explore, and give explanation regarding the relationship between variables that occurred (Burns *et al*.,2011, De Vos *et al*., 2014). A non-experimental research design was adopted for this study because there is no intervention, no manipulation of data and the study was conducted in its natural setting which is in general ICU's.

3.4.2 Quantitative

In quantitative research design, the researcher recognizes a research problem based on the trends in the area or based on the need to define why something takes place. Data is collected with an instrument with a pre-determined questions / design question from a large population representing data in numerical form. This allows defining a research problem through describing trends, explaining relationships that may occur amongst variable, using statistical methods to analyse the data. The interpretation or analyses of results provides information to answering the research question or hypothesis (Burns *et al*.,2011, De Vos *et al*., 2014). In this study a questionnaire developed by Negro *et al* (2014) was used to obtain numerical data for statistical analyses.

3.4.3 Descriptive

A descriptive design study is used to gather more information about characteristics in a particular field with the aim of providing a picture of situation as they occur in a natural setting. The variables obtained during data collection are used to gain information to answer a research question without the intention to establish a cause – effect relationship

(Burns *et al*.,2011, De Vos *et al*., 2014). A descriptive design study was utilized to obtain knowledge, to determine issues and gain insight regarding current practices in intensive care nursing.

3.5 STUDY SETTING

The research setting for the study was five ICUs, at a 1,200 bed capacity university-affiliated, public sector hospital and tertiary level institution in Johannesburg. The ICUs include trauma ICU, cardiothoracic ICU, coronary care (CCU), neurosurgery ICU and general ICU.

These five ICUs represent highly specialised public sector ICUs which admit critically ill patients from medical and surgical disciplines. The levels of ICUs are described according to the South African Society of Anaesthesia (SASA) guidelines for ICU (SASA, 2013). As such, the general ICU, cardiothoracic and trauma ICUs are considered level 1 ICUs as they provide highly specialised care to patients with multiple-organ dysfunction/failure, while the coronary care unit and the neurosurgical unit are considered level II ICUs as they provide care to patients with single organ dysfunction/ failure.
The number of official beds range from seven to 12 ICU beds per unit. Assigned nurses to patients generally follow a one nurse to one patient ratio in the acute period of illness. Nurses practicing in these units have access to specialist health care professionals and technical support on a 24-hour basis and have contact with a variety of critically ill patients.

3.6 RESEARCH METHODS

Research method refers to the steps, procedures and strategies for gathering and analysing data. This includes the data collection strategies, population, sample and sampling methods and data analysis (Burns *et al*.,2011, De Vos *et al*., 2014). The research method describes the plan used to conduct the study systematically, and is presented in **Figure 3.1**.

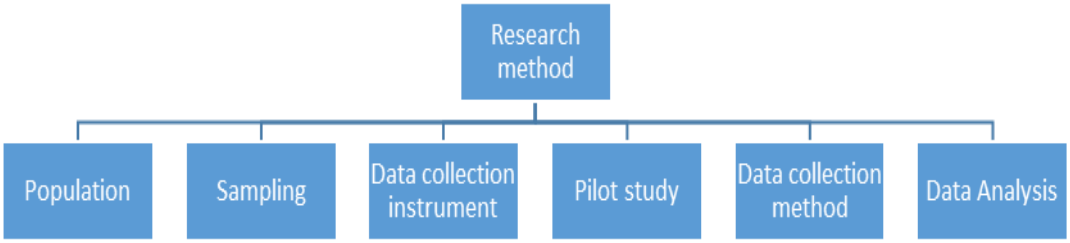

Figure 3.1 Overview of the quantitative research method used in this study

3.6.1 Target Population

A population is the entire element that is of interest to the investigator and meets the selected sampling criteria, and the target population consist of the whole on list of elements from population of interest which the researcher would like to deduce (infer) from (Burns *et al*.,2011, Burns & Grove, 2009, De Vos *et al*., 2014). From the selected Target population researchers also withdraw required sample size (Burns & Grove, 2009). The population of the study included critical care nurses who are experienced and currently working at five intensive care units in one academic affiliated public sector hospitals in Johannesburg.

A preliminary record review undertaken before commencement of the study in May 2021 indicated that there are approximately 193 (N=193) intensive care nurses working in these units.

3.6.2 Sample and Sampling Methods

Following discussion with a statistician a sample size of 130 nurses (n=130) was decided upon to ensure good representation of the population from which the sample was drawn. A large sample is needed to ensure a lower margin of error (5%) and confidence interval of 95% (Polit & Beck, 2012, Burns & Grove, 2009, Burns *et al*.,2011). A non-probability convenience sampling method was used to select the nurses who are suitable and fit the study's inclusion criteria.

Inclusion criteria for prospective respondents included:

- Registered by the South African Nursing Council (SANC) with an additional qualification in ICU nursing (Intensive care nurse/critical care nurse).
- More than six months of clinical experience in the selected ICU; and

The exclusion criterion included enrolled nurses and auxiliary nurses as their sub-professional category of nursing staff are not expected to have the skills and in-depth knowledge about endotracheal suctioning for intubated patients.

3.6.3 Data Collection

3.6.3.1 Instrument

A structured questionnaire by Negro *et al.* (2014) identified in the literature was used to achieve the study objectives. The questionnaire was validated and is a reliable questionnaire designed to assess nurses' knowledge of endotracheal suctioning guidelines (Negro *et al.,* 2014).

The self-administered structured questionnaire contains two sections (refer to **Appendix A**). The first section of the instrument collected demographic data of the participants such as years of experience as a registered nurse / duration working in ICU and whether they had a degree or diploma in nursing. Section two employs ten (10) strategies which are relevant to the practice of nursing and proven in literature, to prevent endotracheal suctioning complications were recorded and where respondents were asked to choose from four responses: there was one correct response and three other incorrect alternatives, which included the choice "I don't know" to prevent participants taking a chance and with other two choices having been proven to have a preventive value in endotracheal suctioning complications. The questions are based on the American Association of Respiratory Care evidence-based guidelines (AARC, 2010) and the systematic review by Pedersen *et al* (2009). After consultation with the statistician and supervisor, a third section was added as one optional open-ended questions to allow ICU nurse respondents to write any issue related to the study aim should they wish to.

3.6.3.2 Validity and reliability of the instrument

The developer assessed face and content validity in the original study sample (Negro *et al.,* 2014). Furthermore, it was developed by a panel of experts in the field of intensive care nursing techniques in Milan Italy, tested, and refined in a pilot study (n=14) and followed by independent testing on a sample of 379 (n=379) professional nurses in the original study (Negro *et al.,* 2014). The reliability of its results wasn't mentioned in the original study.

The questionnaire was verified by five local domain experts, i.e., medical specialists in the field of intensive care (n=2) and ICU registered nurse (n=1) working in intensive care unit and nurse education experts (with Doctorate and master's degree in the field of nursing education) (n=2), and the questionnaire was found to be applicable in South African context. Only one modification was made to the questionnaire in Section A based on feedback received from the Human Research Ethics Committee of the university. In the first question: "*How long you worked as a Nurse*?" It was suggested it be changed to ICU nurse since the study focuses is on ICU nurses. The question was changed to "*How long have you worked as an ICU nurse?"*

3.6.4 Pilot Study

A pilot study was conducted before the commencement of the main study using the information sheet and the adapted version of the endotracheal suctioning questionnaire to test the understanding of the wording used. Participants (n=5) who met the inclusion criteria were included in the study. Ethical considerations were followed. The results of the pilot study were not included in the main study.

A pilot study is defined as a smaller version of a proposed study, which is conducted to refine the research methodology or strength of a study design (Polit & Beck, 2010). It serves to test feasibility, it determines whether the chosen methodology is appropriate, assesses the length of time it takes to complete the questionnaire and checks clarity of understanding of the language used (Burns & Grove, 2009).

The results of the pilot study demonstrated the instrument was understandable and took approximately 10 to 15 minutes for the participants to complete. No major changes were made to the existing questionnaire.

3.6.5 Data Collection Process

Permission was sought from the Chief Executive Officer (CEO) of the hospital being requested to participate in the study. Once obtained, permission from the Nursing Services Director was sought and thereafter the ICU unit managers were approached, informed about the study, purpose and its significance to practice and their permission sought. The researcher visited the ICUs (n=5) and observed the respective allocation list for selection of nurse participants. The ICU nurses who agreed to participate received an information letter outlining the study and its procedures and a consent form to complete (**Appendix C and D**). Each participant placed the completed questionnaire into an envelope and placed it into a sealed box in the respective ICU unit. At the end of the data collection period, which was approximately two months, the researcher opened the boxes.

3.6.6 Data Analysis

The purpose of analysing data collected in a study is to describe the data in systematic meaningful terms. The role of the researcher is to reduce, organise and give meaning to collected data (Polit and Beck, 2010). In this study, data were analysed using the Statistical Package for the Social Science (SPSS) version 29. Descriptive and inferential statistics were used to analyse the data. According to Polit and Beck (2010), descriptive statistics are used to describe and integrate data, whereas inferential statistics provide a means of drawing conclusions about the population data. The following statistical tests were used in this study:

- Percentage, mean and standard deviation were used to analyse and compare the demographic data, along with knowledge of endotracheal suctioning guidelines.
- The non-parametric Chi-square test of independence was used to explore if there is a relationship between the responses of nurse participants in the ICUs of the selected study sites.

- The Cramer's V test was used with respect on categorical data of interest between groups to calculate for statistically significant results to determine whether the results were practically significant.

Statistical assistance was obtained from a statistician from the university postgraduate office. Testing was done on the 0.05 ($p<0.05$) level of significance.

3.7 VALIDITY AND RELIABILITY OF THE STUDY

Validity refers to the issues of whether data collected in a true reflection of what is being studied (Burns & Grove, 2009), whereas reliability refers to the consistency of measure obtained by means of an instrument.

Face and content validity was assessed by the developers in the sample of the original study. A pilot test was carried out before the actual main study to ensure feasibility of the study and detect possible flaws in the instrument used.

The instrument was reviewed by local domain medical and nursing experts in this field of study to see if the content of the instrument was applicable to the South African context. Prospective studies allow the investigation of usual or unexpected results during the data collection and investigate causes that yield such results.

Reliability was maintained by ensuing consistency and accurate recording of data. Data collection was only done by the researcher. An appropriate sample size was discussed with a statistician so as to be representative of the population of the study taking into consideration possible refusal rates. Sample inclusion and exclusions were followed.

3.8 ETHICAL CONSIDERATIONS

Ethical consideration is important when conducting a research study because the rights of research participants and others must be protected. (Burns, Grove & Gray, 2013). Furthermore, ethical research generates sound knowledge for evidence-based practice. In this regard, ethical review and clearance adherence is essential to ensure a balance

between benefits and risks of the study and prevent research misconduct (Polit and Beck, 2010). The ethical considerations as applied in this study will be discussed in the next section under the headings of permission to conduct research, informed consent, confidentiality and anonymity.

3.8.1 Permission to Conduct Research

The research proposal and instruments were submitted to the Human Research Ethics Committee of the University of the Witwatersrand to ensure compliance with the ethical standards. The committee issued a clearance certificate (refer **Appendix C**). In addition, written permission to conduct the study at the selected institution was obtained from the hospital management (**Appendix D**) before commencing the study. Written permission for use of the data collection instrument was obtained from the authors (Negro *et al.,* 2014) (refer **Appendix F**).

3.8.2 Informed Consent

The informed consent process was discussed with study participants regarding what the study entails, prior to commencing the information sheet (**Appendix B**) to sign. The willingness to participate by completing the self-administered questionnaire and placing it in a sealed envelope into a sealed box provided in the respective units was also regarded as them giving consent to take part in the study.

3.8.3 Confidentiality

An envelope was provided to participants to place completed questionnaires. No identifiable information or names were requested from participants after completion of questionnaires. Participants were instructed to seal the envelopes after completion and post the within the sealed box. To ensure confidentiality is maintained, the sealed box was placed in the staff duty room for participants to place without the in their presence or collecting the questionnaires individually from them. The questionnaires were collected by the researcher and only the researcher removed them from the sealed envelopes.

3.8.4 Anonymity

To ensure anonymity is maintained throughout the study, the questionnaires issued to participants did not require any form of identifiable information or personal names. All questionnaires were coded by the researcher and were not linked with informed consent sheet as they were placed separately.

3.9 SUMMARY

This chapter has described the researcher design employed in detail to meet the study objectives and purpose conducting the study. The study setting site was also described in detail. An in-depth discussion of the study sample and sampling methods including the data collection tool used to obtain the research results was given. A brief description of data analysis strategy, data collection procedure, pilot study and ethical consideration undertaken into account conducting the study was also discussed.

The next chapter will discuss data analysis and results of the study.

CHAPTER FOUR

RESULTS AND FINDINGS

4.1 INTRODUCTION

This chapter described the results of the study describing ICU nurses' knowledge of the American Association Respiratory Care (AARC, 2010) evidence-based guidelines on the endotracheal suctioning technique. This was achieved through an explorative, descriptive and cross-sectional design. The population included all professional nurses working in the Intensive Care Units at a public sector and tertiary level hospital in Johannesburg. The population included a target sample of 130 (n = 130), and non-probability convenience sampling was used to achieve the study sample. Data was collected by means of a data collection instrument (refer to **Appendix A**) and analysed by means of descriptive and inferential statistics. The descriptive tests were used to synthesise the respondent's demographic data and questionnaire schedule. Statistical tests included Chi-square and Cramer's V tests. Testing was done on the 5% level of significance ($p<0.05$).

In this chapter the results of the data analysis are presented. Firstly, the demographic aspects of the respondents are described, the responses to the data collection questionnaire are presented on item level in tables and graphical formats, and lastly, significance of relationships between level of knowledge and demographic data are examined.

4.2 RESULTS

4.2.1 Demographic Data

The questionnaire was distributed overall to a number of 130 intensive care nurses, which 130 (n = 130) questionnaires were returned successfully during a two-month period of data collection. The target sampling size was reached, which equal a response rate of 100%. This section related to respondent demographic data, which comprises three (3) items. Items included were years of experience as a nurse, years of ICU experience and qualification. Results of this process are summarised in table 4.1.

Table 4.1: Frequencies obtained for demographic data

Categorical variables	Frequency	Percentage
Years of nursing experience		
<1 year	4	3.10%
1 to 5 years	35	26.90%
6 to 10 years	**47**	**36.20%**
>10 years	**44**	**33.9%**
Years of ICU experience		
<1 year	6	4.60%
1 to 5 years	**58**	**44.60%**
6 to 10 years	33	25.40%
>10 years	33	25.40%
Qualifications		
Degree	36	27.70%
Diploma	91	**70.00%**
No response	3	2.30%

In this study the largest group of the respondents (36.20%; n = 47) had between six to 10 years of nursing experience, followed closely by 33.90% (n = 44) in the years of nursing experience categories more than 10 years (>10 years). **Figure 4.1** displays these results.

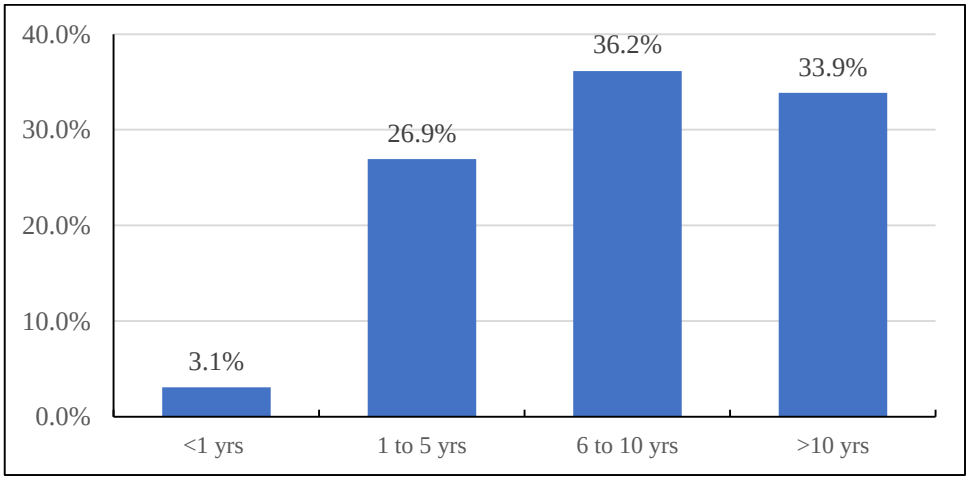

Figure 4.1: Years of experience as a nurse

The largest group (44.62%; n = 58) of the respondents had between 1 to 5 years of ICU experience. **Figure 4.2** displays the results obtained.

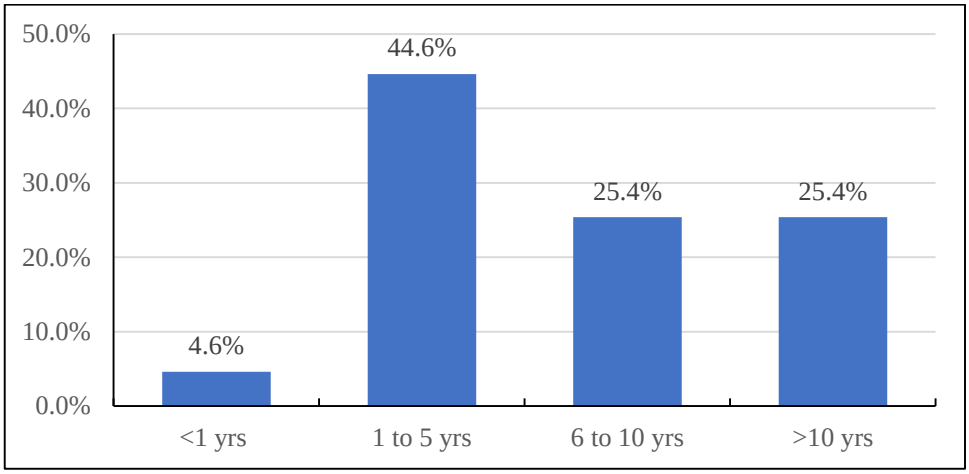

Figure 4.2: Years of ICU experience

The majority (70.00%; n = 91) of the respondents held a diploma in critical care nursing. Figure 4.3 displays these results.

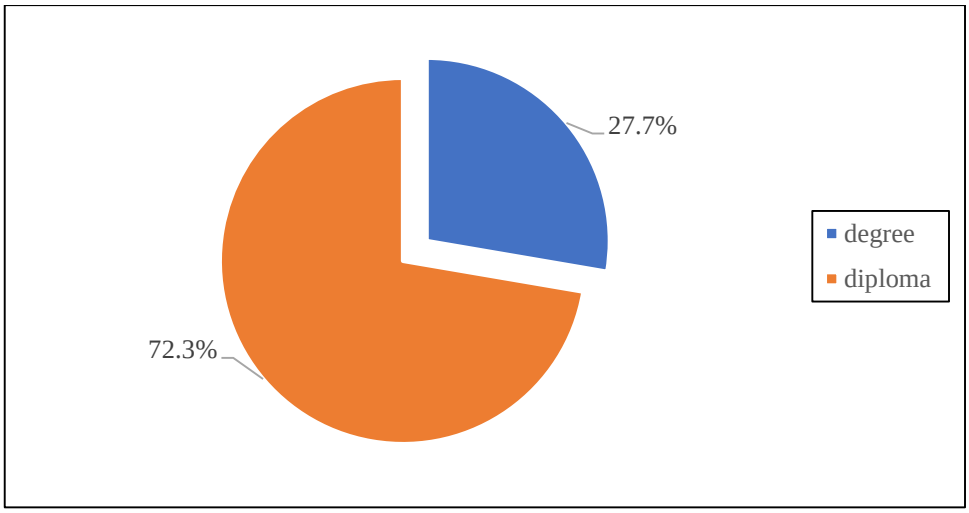

Figure 4.3: Qualifications in nursing

4.2.2. Section B: Items related to endotracheal suctioning

This section related to the nurses' responses on the questionnaire, which included 10 items (refer **Appendix A**). Each of the items is discussed separately.

4.2.2.1 Preparation of devices for use

Question 1 focused on the preparation of devices for use. The respondents were presented with a statement, which stated: *"A patient from ER is coming to ICU with acute respiratory failure; he has already been intubated and is connected to mechanical ventilation. The ICU nurse prepares the devices to use, including a closed circuit suction",* where they had to select their responses from a list of four possible responses. **Figure 4.4** displays the results obtained.

- 6.90% (n = 9) of the respondents indicated correct because the patient probably needs high FiO2 and PEEP, which is the correct response

The remaining respondents indicated the following incorrect responses:

- 92.30% (n = 120) correct because it should be used for all intubated patients or with a tracheostomy, as recommended by the guideline
- 0.80% (n=1) I do not know
- 0% (n=0) for not correct because the closed-circuit should only be used for newborns.

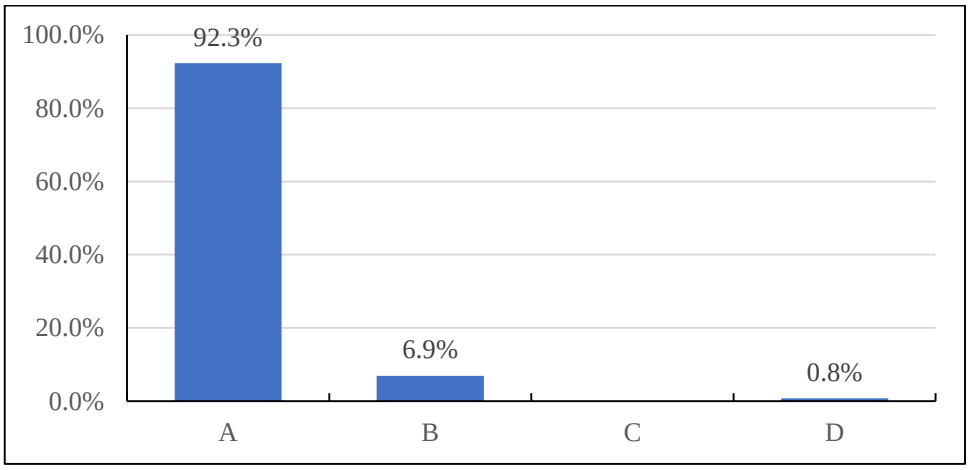

Figure 4.4: Preparation of devices for use

4.2.2.2 Closed circuit suction catheter caliber

Question 2 focused on closed circuit suction catheter caliber. The respondents were presented with a statement, which stated: *"The closed circuit prepared by the nurse has*

a suction catheter with a caliber of 14ch, and the patient is intubated with a number 8 endotracheal tube", where they had to select their responses from a list of four possible responses. **Figure 4.5** displays the results obtained.

- 32.30% (n = 42) of the respondents indicated correct because the suction catheter should occlude less than one half of the tube lumen, which is the correct response.

The remaining respondents indicated the following incorrect responses:

- 33.10% (n = 43) not correct because it is necessary to choose the largest suction catheter (33.08%; n = 43)
- 10.80% (n = 14) not correct because the suction catheter should occlude less than 2/3 of the tube lumen (10.77%; n = 14)
- 23.90% (n = 31) I do not know

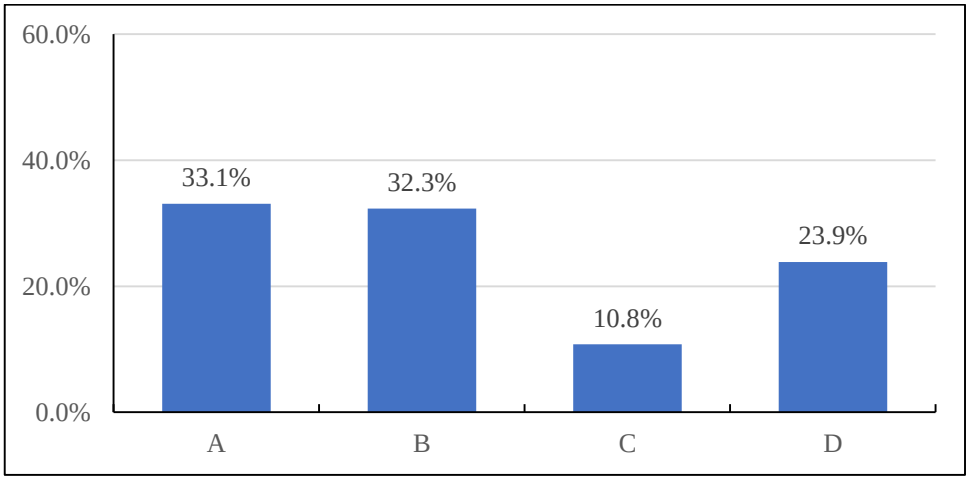

Figure 4.5: Closed circuit suction caliber

4.2.2.3 Frequency of suctioning

Question 3 focused on frequency of suctioning. The respondents were presented with a statement, which stated: *"The patient presents GCS 3, so the nurse decides to suction him one per shift",* where they had to respect their responses from a list of four possible responses. **Figure 4.6** displays the results obtained.

- 76.90% (n = 100) of the respondents indicated not correct because the manoeuver should be performed if necessary, which is the correct response.

The remaining respondents indicated the following incorrect responses:

- 7.70% (n = 10) not correct because the manoeuver should be performed every two hours
- 12.30% (n = 16) correct in order to maintain the airways open
- 3.10% (n = 4) I do not know

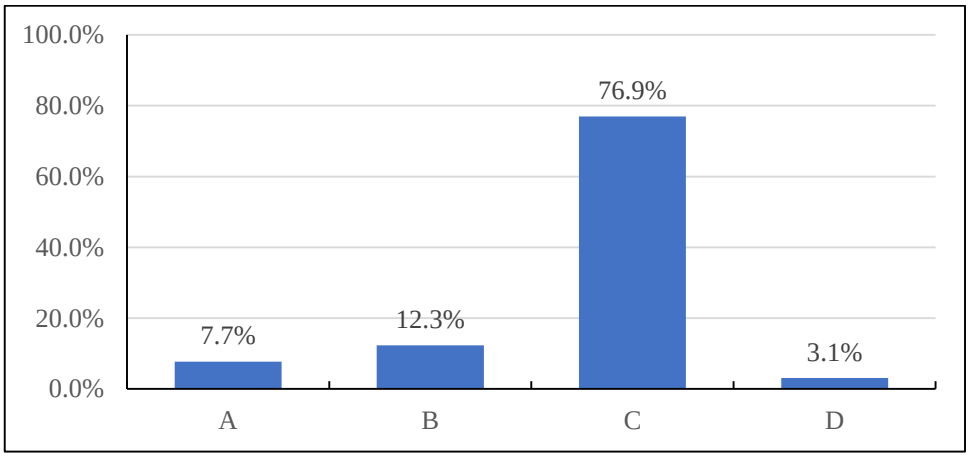

Figure 4.6: Frequency of suctioning

4.2.2.4 Manual lung recruitment

Question 4 focuses on manual lung recruitment. The respondents were presented with a statement, which stated: *"The nurse decides to perform manual lung recruitment before the suction*", which they had to select their responses from a list of four possible responses. **Figure 4.7** displays the results obtained.

- 25.40% (n = 33) of the respondents indicated not correct because it should be performed only if occurred desaturation during the previous suctioning, which is the correct response.

The remaining respondents indicated the following incorrect responses:

- 7.70% (n = 10) not correct because it should be performed only after a medical prescription

- 49.20% (n = 64) correct because it should be performed before suctioning, as recommended by guidelines
- 17.70% (n = 23) I do not know

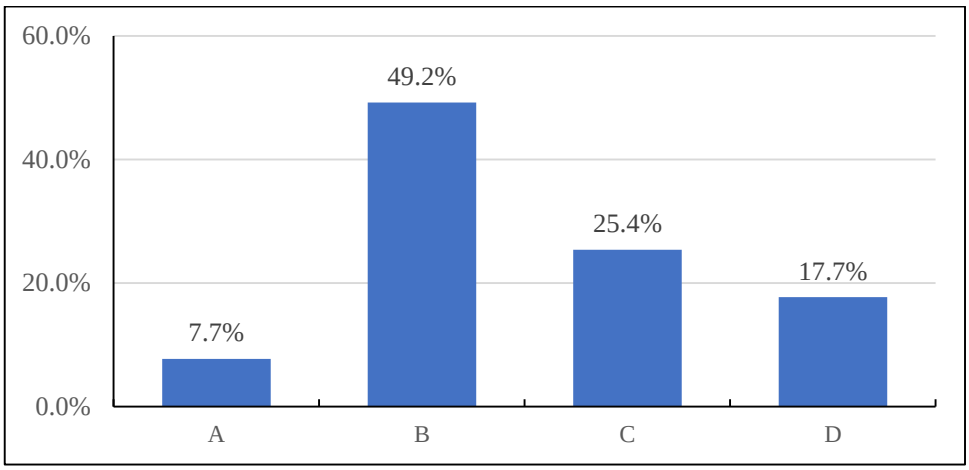

Figure 4.7: Manual lung recruitment

4.2.2.5 Peripheral oxygen saturation

Question 5 focuses on peripheral oxygen saturation. The respondents were presented with a statement which stated: *"During the first suction, the patient switched from 97% to 74% of peripheral oxygen saturation. The nurse should …*", where they had to select their responses from a list of four possible responses. **Figure 4.8** displays the results obtained.

- 89.20% (n = 116) of the respondents indicated pre-oxygenate the patient before suctioning, as recommended by guidelines, which is the correct response.

The remaining respondents indicated the following incorrect responses:

- 0.00% (n = 0) pre-oxygenate the patient because of desaturation during the previous tracheal suctioning.
- 10.80% (n = 14) perform suctioning normally because pre-oxygenation should be performed only when a desaturation less than 60% occurs.
- 0.00% (n = 0) I do not know

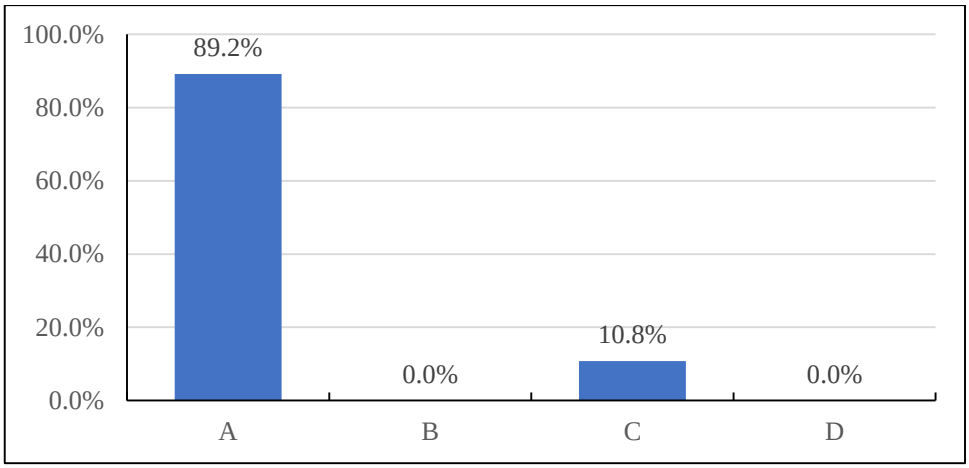

Figure 4.8: Peripheral oxygen saturation

4.2.2.6 Saline instillation

Question 6 focused on saline instillation. The respondents were presented with a statement, which stated: *"The nurse decides to perform saline instillation in order to facilitate the suction of dense secretions",* where they had to select their responses from a list of four responses. **Figure 4.9** displays the results obtained.

- 16.90% (n = 22) of this respondents indicated not correct because the manoeuver does not provide clear benefits, which is the correct response.

The remaining respondents indicated the following incorrect responses:

- 18.50% (n = 24) correct if you use a closed suction circuit
- 64.60% (n = 84) correct because it facilitates the dissolution of secretions
- 0.00% (n = 0) I do not know

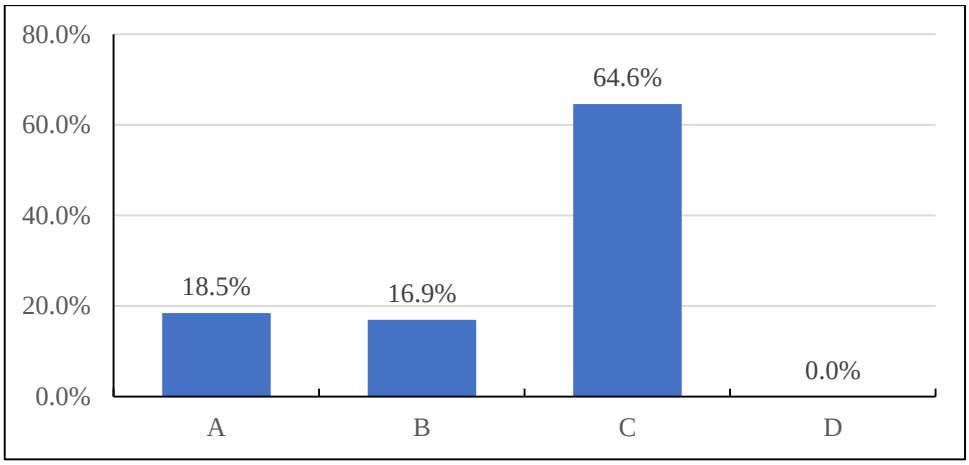

Figure 4.9: Saline instillation

4.2.2.7 Timing of suctioning

Question 7 focused on the timing of suctioning. The respondents were presented with a statement, which stated: "*The nurse decides to perform a long suction in order to remove the majority of secretion*", where they had to select their responses from a list of four possible responses. **Figure 4.10** displays the results obtained.

- 43.90% (n = 57) of the respondents indicated not correct because the suction should last less than 15 seconds, which is the correct response.

The remaining respondents indicated the following incorrect responses:

- 6.20% (n = 8) correct because the manoeuver should last one minute at least.
- 25.40% (n = 33) not correct because the manoeuver should last less than one minute.
- 24.60% (n = 32) I do not know.

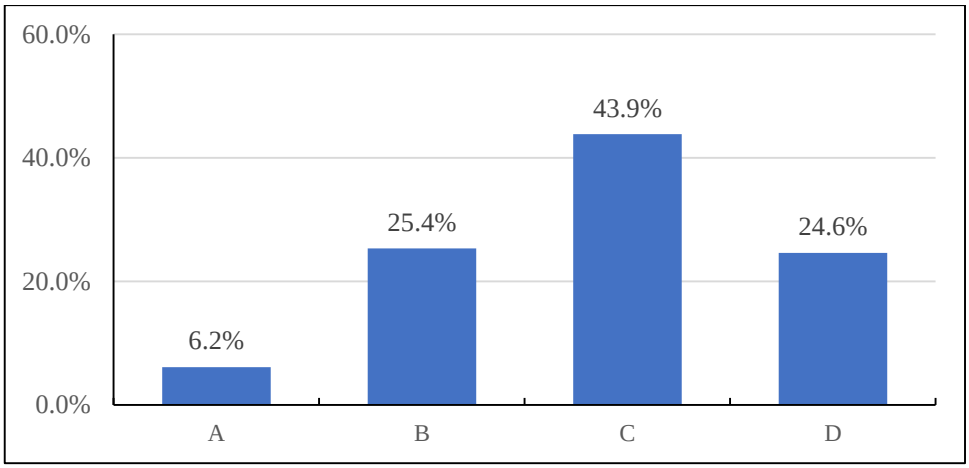

Figure 4.10: Timing of suctioning

4.2.2.8 Insertion of suctioning catheter

Question 8 focused on insertion of suctioning catheter. The respondents were presented with a statement, which stated: *"The nurse inserts the suction catheter into the endotracheal tube until it meets resistance and the retracts the catheter 1cm before applying negative pressure*", where they had to select their responses from a list of four possible responses. **Figure 4.11** displays the results.

- 18.50% (n = 24) of the respondents indicated not correct because the suction catheter should be inserted into the artificial airways for the whole length of the endotracheal tube, which is the correct response.

The remaining respondents indicated the following incorrect responses:

- 55.40% (n = 72) correct because it reduces the risk to cause suction injury on endotracheal mucosa
- 16.20% (n = 21) not correct because a suction catheter should be inserted until 2/3 of the length of the endotracheal tube
- 10.00% (n = 13) I do not know

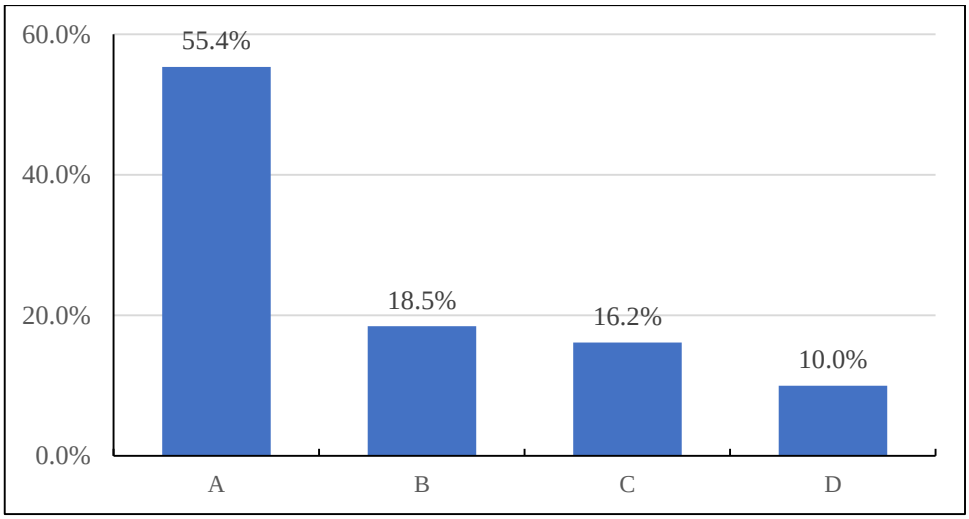

Figure 4.11: Insertion of suction catheter

4.2.2.9 Suction pressure

Question 9 focused on suction pressure. The respondents were presented with a statement, which stated: *"The nurse decides that endotracheal suctioning is needed with a negative pressure of 170mmHg to remove the most secretions",* where they had to select their responses from a list of four possible responses. **Figure 4.12** displays the results obtained.

- 39.20% (n = 51) of the respondents indicated not correct because the negative pressure should be below 150mmHg in adult, which is the correct response.

The remaining respondents indicated the following incorrect responses:

- 10.00% (n = 13) correct because the manoeuver provides complete removal of secretions
- 0.00% (n = 0) Not correct because the negative pressure should be over 170mmHg in adult
- 50.80% (n = 66) I do not know

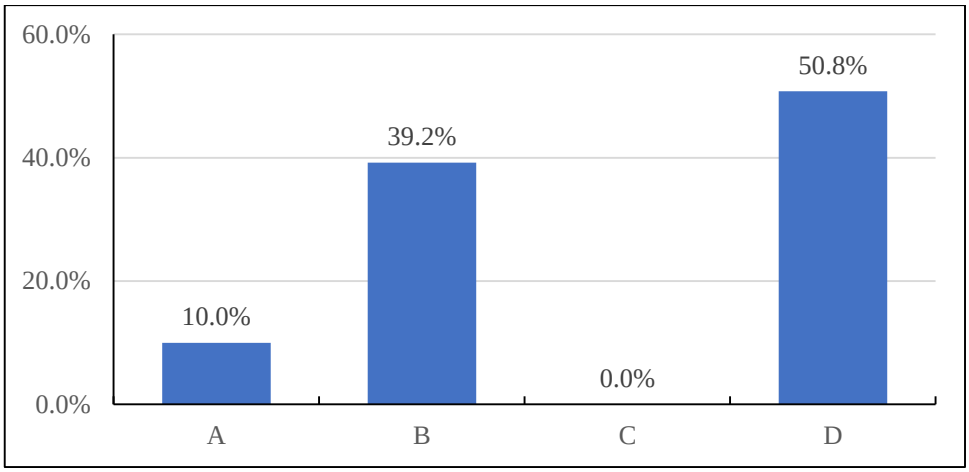

Figure 4.12: Suction pressure

4.2.2.10 Ventilator disconnection

Question 10 focused on ventilator disconnection. The respondents were presented with a statement, which stated: "*The nurse takes care not to disconnect the patient from the ventilator during the tracheal suction",* where they had to select their responses from a list of four possible responses. **Figure 4.13** displays the results obtained.

- 80.00% (n = 104) of the respondents indicated correct because it facilitates the continuation of mechanical ventilation, which is the correct response.

The remaining respondents indicated the following incorrect responses:

- 8.50% (n = 11) not correct because it does not permit suction of all secretions
- 8.50% (n = 11) correct because the nurse can suction all secretions
- 3.10% (n = 4) I do not know

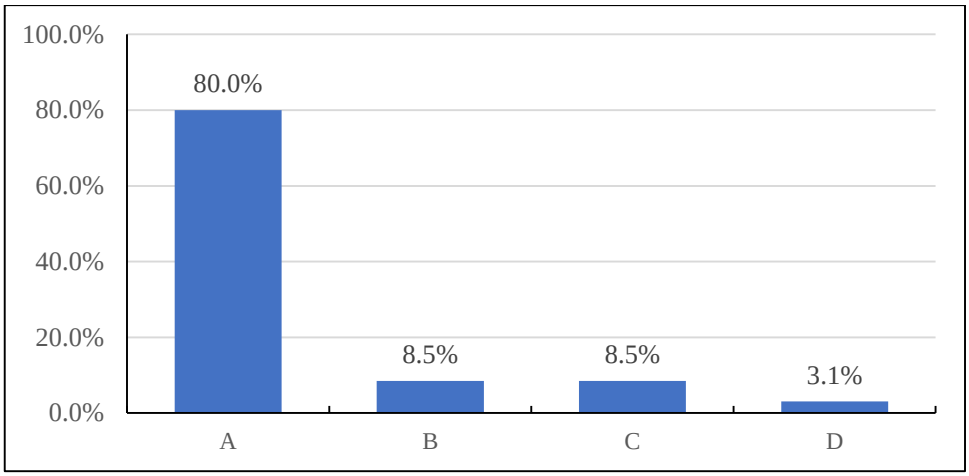

Figure 4.13: Ventilator disconnection

4.2.3 Summary of Results obtained for ETT Suctioning

Table 4.3: Summary of proportion of incorrect and correct responses

Item	Statements	Incorrect response		Correct response	
		n	%	n	%
1	Preparation of equipment	121	93.10%	9	6.90%
2	Closed circuit suction catheter caliber	88	67.70%	42	32.30%
3	**Frequency of suctioning**	30	23.10%	100	**76.90%**
4	Use of manual lung recruitment	97	74.60	33	25.4%
5	**Pre – oxygenation before suction**	14	10.80%	116	**89.20%**
6	Saline instillation	108	83.10%	22	16.90%
7	Long suction procedure	69	53.10%	61	46.92%
8	Insertion of the suction catheter	106	81.50%	24	18.50%
9	Suction pressure	79	60.7%	51	39.2%
10	**Disconnection from ventilator**	26	20.0%	104	**80.0%**

Table 4.2 shows the proportions of correct answers by intensive care nurses on knowledge on current evidence-based guidelines on endotracheal suctioning in intensive care units. In this study, the nurses answered six of the ten endotracheal guidelines items incorrectly. A high percentage of correct responses was scored in only three out of the ten questions: frequency of suctioning 76.95 (n = 100) in Question 3, pre-oxygenation before suction 89.20% (n = 116) in Question 5, and not disconnecting the ventilator during suctioning question 80.00% (n =104) in Question 10.

4.2.4 Comparison of the Total Score of Knowledge on Demographic Data

To determine the relationship between the demographic aspects of the respondents and their knowledge of endotracheal suctioning, a Chi-square test of association was performed, and the strength of the associations was estimated using Cramer's V (Mchugh, 2013; Prematunga, 2012). Due to the study's multiple variables, the researcher conducted additional risk estimates and presented the odds ratios at a 95% confidence interval (Mchugh, 2013; Prematunga, 2012). The results of this process are presented in Tables 4.3 to 4.5.

Table 4.3: Relationship between nurses' years of work experience and their knowledge on endotracheal suctioning

Variables	**Nurses experience/endotracheal suctioning**			**Chi-Square_ X^2 stat. (P value)**	**Cramer's V**	**Outcome odds ratio (95% CI)**
	< 5 years	**> 5 years**	**Total n (%)**			
Q1: During mechanical ventilation use a closed suction circuit						
Correct	1	8	9(6.9)	1.64(0.20)	0.11	3.66 (0.44 – 30.33)
Incorrect	38	83	121(93.1)			
Q2: Closed-circuit requires 14ch and 8 endotracheal tube						
Correct	10	32	42(32.3)	1.13(0.29)	0.10	1.57 (0.68 – 3.64)
Incorrect	29	59	88(67.7)			
Q3: Patient presents GCS 3, so the nurse decides to suction him once per shift						
Correct	29	71	100(76.9)	0.21(0.65)	**0.40***	1.22 (0.51 – 2.93)
Incorrect	10	20	30(23.1)			

Q4: The nurse decides to perform manual lung recruitment before the suction						
Correct	10	23	33(25.4)	0.00(0.97)	0.00	0.98 (0.42 – 2.32)
Incorrect	29	68	97(74.6)			
Q5: Suctioning, switched from 97% to 74% of peripheral oxygen saturation						
Correct	35	81	116(89.2)	0.02(0.90)	0.01	0.93 (0.27 – 3.15)
Incorrect	4	10	14(10.8)			
Q6: Perform saline installation in order to facilitate the suction of dense secretions.						
Correct	8	14	22(16.9)	0.51(0.48)	0.06	0.71 (0.27 – 1.85)
Incorrect	31	77	108(83.1)			
Q7: Perform a long suction in order to remove the majority of secretion.						
Correct	14	44	58(44.6)	1.71(0.12)	0.19	1.67 (0.77 – 3.62)
Incorrect	25	47	72(55.4)			
Q8: Inserts the suction catheter into the endotracheal tube until it meets resistance						
Correct	10	14	24(18.5)	1.91(0.17)	0.12	0.53 (0.21 – 1.32)
Incorrect	29	77	106(81.5)			
Q9: Endotracheal suctioning requires negative pressure of 170mmHg to remove the most secretions						
Correct	14	37	51(39.2)	0.26(0.61)	0.05	1.22 (0.56 – 2.66)
Incorrect	25	54	79(60.8)			
Q10: Takes care not to disconnect the patient from the ventilator during suctioning						
Correct	25	79	104(80.0)	**8.80(0.00)**	**0.26**	3.69 (1.51 – 0.90)
Incorrect	14	12	26(20.0)			

Key: Bold = significant findings; Bold* = strong association (Giacomo & Paolo, 2021)

Table 4.3 presented these results. In this study, nurses with **less than five years of experience scored lower** on average **than those with more than five years of** experience (156 vs. 403). In the area of types of endotracheal tubes required for suctioning (Q1), decision to perform suctioning based on GCS scores (Q3), switching suctioning based on peripheral tissue oxygenation (Q5), long suctioning to remove majority of secretions (Q7), endotracheal suctioning requiring negative pressure (Q9), and not disconnecting the ventilation during suctioning (Q10), **nurses working more than five**

years provided correct responses on the endotracheal suctioning guidelines **than their counterparts** (**Table 4.3).**

In terms of the types of endotracheal tubes required for suctioning (Q1), 10/39 nurses with less than 5 years and 32/91 nurses with more than 5 years of experience correctly responded (X^2 = 0.29, Cramer's V = 0.10), yielding an odds ratio of 1.57 (0.68 - 3.64). With a GCS-based suctioning question (Q3) (correct answers: 29/39 nurses vs. 71/91 nurses, X^2 = 0.65, Cramer's V = 0.40), with an odds ratio of 1.22 (0.51 - 2.93). Also, on switching suctioning based on peripheral tissue oxygenation (Q5) (correct responses 35/39 nurses vs. 81/91 nurses, X^2=0.90, Cramer's V=0.01), with odds ratio of 0.93 (0.27 – 3.15). Furthermore, the odds ratio was 1.67 (0.77 - 3.62) for long suctioning to remove the majority of secretions (Q7) (correct responses: 14/39 nurses vs. 44/91 nurses, X2 = 0.11, Cramer's V = 0.19. The odds ratio for endotracheal suctioning requiring negative pressure (Q9) is 1.22 (0.56–2.66) (correct responses: 14/39 nurses vs. 37/91 nurses, X^2 = 0.61, Cramer's V = 0.05). Finally, during endotracheal suctioning, the patient's ventilator was not disconnected (Q10) (correct answers: 25/39 nurses vs. 79/91 nurses, X^2 = 0.00, Cramer's V = 0.26), with an odds ratio of 3.69 (1.51 - 0.90).

Overall, there was **a strong association** for only two of the questions among the nurses: GCS-based suctioning question (Q3), and not disconnecting the ventilator during suctioning question (Q10).

Table 4.4: Relationship between ICU Nurses years of work and their knowledge on endotracheal suctioning

Variables	ICU Nurses experience/endotracheal suctioning			Chi-Square_ X^2 stat. (P value)	Cramer's V	Outcome odds ratio (95% CI)
	< 5 years	> 5 years	Total n (%)			
Q1: During mechanical ventilation use a closed suction circuit						
Correct	2	7	9(6.9)	2.67(0.10)	0.14	1.67 (0.77 – 3.62)
Incorrect	61	60	121(93.1)			
Q2: Closed-circuit requires 14ch and 8 endotracheal tube						
Correct	16	26	42(32.3)	2.67(0.10)	0.14	3.56 (0.71 – 17.83)
Incorrect	47	41	88(67.7)			
Q3: Patient presents GCS 3, so the nurse decides to suction him once per shift						
Correct	45	55	100(76.9)	2.08(0.15)	0.13	1.86 (0.88 – 3.95)
Incorrect	18	12	30(23.1)			
Q4: 4. The nurse decides to perform manual lung recruitment before the suction						
Correct	16	17	33(25.4)	0.0(0.99)	0.00	1.83 (0.80 – 4.20)
Incorrect	47	50	97(74.6)			
Q5: Suctioning, switched from 97% to 74% of peripheral oxygen saturation						
Correct	55	61	116(89.2)	0.47(0.49)	**0.60**	0.99 (0.45 – 2.20)
Incorrect	8	6	14(10.8)			
Q6: Perform saline installation in order to facilitate the suction of dense secretions.						
Correct	9	13	22(16.9)	0.61(0.44)	0.07	
Incorrect	54	54	108(83.1)			1.45 (0.48 – 4.53)
Q7: Perform a long suction in order to remove the majority of secretion.						
Correct	24	34	58(44.6)	2.10(0.15)	0.13	1.44 (0.57 – 3.66)
Incorrect	39	33	72(55.4)			
Q8: Inserts the suction catheter into the endotracheal tube until it meets resistance						
Correct	14	10	24(18.5)	1.15(0.28)	0.09	0.61 (0.25 – 1.51)
Incorrect	49	57	106(81.5)			

Q9: Endotracheal suctioning requires negative pressure of 170mmHg to remove the most secretions						
Correct	18	33	51(39.2)	5.83**(0.02)**	**0.21**	2.43 (1.17 – 5.02)
Incorrect	45	34	79(60.8)			
Q10: Takes care not to disconnect the patient from the ventilator during the						
Correct	45	59	104(80.0)	5.61(**0.02**)	**0.21**	2.95 (1.18 – 7.39)
Incorrect	18	8	26(20.0)			

Key: Bold = significant findings; Bold* = strong association (Giacomo & Paolo, 2021)

Table 4.4 presented these results. Findings in this study indicated nurses in ICU with **more than five years of experience scored higher** on average than **those with less than five years of experience** (244 vs. 315). Overall, the ICU nurses with **more than 5 years working experience performed well in seven out of the ten domains** of the endotracheal suctioning guidelines than their counterparts. These include the endotracheal tube diameter required for suctioning, performing suction based on GCS scores, switching suctioning based on peripheral tissue oxygenation, installing saline to make suctioning easier, using long suctioning to remove most secretions, using negative pressure during endotracheal suctioning, and keeping the ventilation on while suctioning (**Table 4.4**).

When it came to the types of endotracheal tubes needed for suctioning (Q1), 16/64 ICU nurses with less than 5 years of experience and 26/66 ICU nurses with more than 5 years of experience correctly responded (X^2 = 0.10, Cramer's V = 0.14), yielding an odds ratio of 3.56. (0.71 – 17.83). With a GCS-based suctioning question (Q3) (correct answers: 45/64 ICU nurses vs. 55/66 ICU nurses, X^2 = 0.15, Cramer's V = 0.13), there is an odds ratio of 1.86 (0.88–3.95). Moreover, on switching suctioning based on peripheral tissue oxygenation (Q5) (correct responses 55/64 ICU nurses vs. 61/66 ICU nurses, X^2=0.49, Cramer's V= 0.60), with odds ratio of 0.99 (0.45 - 2.20), on saline installation to facilitate suction of dense secretions (Q6) (correct responses 9/64 ICU nurses vs. 13/66 ICU nurses, X^2=0.44, Cramer's V= (0.48 – 4.53). Furthermore, the odds ratio for long suctioning to remove the majority of secretions (Q7) was 1.44 (0.57-3.66) (correct responses: 24/64 ICU nurses vs. 34/66 ICU nurses, X^2 = 0.15, Cramer's V = 0.13). Endotracheal suctioning requiring negative pressure (Q9) has an odds ratio of 2.43 (1.17-5.02) (correct responses:

18/64 ICU nurses vs. 33/66 ICU nurses, $X^2 = 0.02$, Cramer's V = 0.21). Finally, the patient's ventilator was not disconnected during endotracheal suctioning (Q10) (correct answers: 45/64 ICU nurses vs. 59/66 ICU nurses, $X^2 = 0.02$, Cramer's V = 0.21), with an odds ratio of 2.95. (1.18–7.39). For more information, see Table 4.4.

Overall, among the ICU nurses in the current study, there was a **significant correlation** between endotracheal suctioning requiring negative pressure (Q9), switching suctioning based on peripheral tissue oxygenation (Q5), and not disconnecting during endotracheal suctioning questions (Q10).

Table 4.5: Association between Nurses qualification and their knowledge on endotracheal suctioning

Variables	Nurses qualification/endotracheal suctioning				Chi-Square_ X^2 stat. (P value)	Cramer's V	Outcome odds ratio (95% CI)
	Diploma	Degree	Total n (%)				
Q1: During mechanical ventilation use a closed suction circuit							
Correct	8	1	9(6.9)		1.64(0.20)	**0.11***	3.66 (0.44 – 30.33)
Incorrect	83	38	121(93.1)				
Q2: Closed-circuit requires 14ch and 8 endotracheal tube							
Correct	31	11	42(32.3)		0.43(0.51)	0.06	1.32 (0.56 – 2.99)
Incorrect	60	28	88(67.7)				
Q3: Patient presents GCS 3, so the nurse decides to suction him once per shift							
Correct	70	30	100(76.9)		0.0(1.00)	0.00	1.00 (0.41 – 2.44)
Incorrect	21	9	30(23.1)				
Q4: The nurse decides to perform manual lung recruitment before the suction							
Correct	22	11	33(25.4)		023(0.63)	0.04	0.81 (0.35 – 1.89)
Incorrect	69	28	97(74.6)				
Q5: Suctioning, switched from 97% to 74% of peripheral oxygen saturation							
Correct	81	35	116(89.2)		0.02(0.90)	0.01	0.93 (0.27 – 3.15)
Incorrect	10	4	14(10.8)				

	Q6: Perform saline installation in order to facilitate the suction of dense secretions.						
Correct	12	10	22(16.9)		3.01(0.08)	0.15	
Incorrect	79	29	108(83.1)				0.44 (0.17 – 1.13)
	Q7: Perform a long suction in order to remove the majority of secretion.						
Correct	38	20	58(44.6)		1.0(0.32)	0.09	0.68 (0.32 – 1.45)
Incorrect	53	19	72(55.4)				
	Q8: Inserts the suction catheter into the endotracheal tube until it meets resistance						
Correct	15	9	24(18.5)		0.79(0.38)	0.08	0.66 (0.26 – 1.66)
Incorrect	76	30	106(81.5)				
	Q9: Endotracheal suctioning requires negative pressure of 170mmHg to remove the most secretions						
Correct	31	20	51(39.2)		3.39(0.07)	**0.16***	0.49 (0.23 – 1.05)
Incorrect	60	19	79(60.8)				
	Q10: Takes care not to disconnect the patient from the ventilator during the						
Correct	73	31	104(80.0)		0.01(0.92)	0.01	1.05 (0.41 – 2.66)
Incorrect	18	8	26(20.0)				

Key: Bold* = weak association (Giacomo & Paolo, 2021)

Table 4.5 presented these results. In this study, respondents with **diplomas performed better on average** in terms of endotracheal suctioning knowledge **than those with degrees (381 vs. 178**). Further, respondents with **diplomas outperformed their counterparts** in **eight of the ten domains** of the endotracheal suctioning guidelines. These include the preparation of endotracheal suction equipment (Q1), selection of endotracheal tube diameter required for suctioning (Q2), suctioning based on GCS scores (Q3), performing manual lung recruitment prior to suctioning (Q4), switching suctioning based on peripheral tissue oxygenation (Q5), using long suctioning to remove most secretions (Q6), using negative pressure during endotracheal suctioning (Q9), and keeping the ventilation on while suctioning (q10) (Table 4.5).

In terms of the size of endotracheal tubes needed for suctioning (Q2), 31/91 diploma nurses and 11/39 degree nurses correctly responded (X^2 = 0.51, Cramer's V = 0.06), yielding an odds ratio of 1.32. (0.56–2.99). Regarding the GCS-based suctioning question

(Q3) (correct answers: 70/91 diploma nurses responded correctly vs. 30/39 degree nurses, $X^2 = 1.00$, Cramer's V = 0.00), and an odds ratio of 1.00 (0.41 - 2.44).

Also, with an odds ratio of 0.81 (0.35 - 1.89), on performing manual lung recruitment prior to suctioning (Q4) (correct responses: 22/91 diploma nurses vs. 11/31 degree nurses, $X^2 = 0.06$, Cramer's V = 0.04), and with an odds ratio of 0.93 (0.27 - 3.15), on switching suctioning based on peripheral tissue oxygenation (Q5) (correct responses: 81/91 diploma nurses vs. 35/39 degree nurses, $X^2 = 0.90$, Cramer's V = 0.01). Furthermore, the odds ratio for prolonged suctioning to remove the majority of secretions (Q7) was 0.68 (0.32-1.45) (correct responses: 38/91 diploma nurses vs. 20/39 degree nurses, X2 = 0.32, Cramer's V = 0.09). Endotracheal suctioning requiring negative pressure (Q9) has an odds ratio of 0.49 (0.23-1.05) (correct responses: 20/39 degree nurses vs. 31/91 diploma nurses, X2 = 0.07, Cramer's V = 0.16). Finally, yet importantly, the patient's ventilator was left on while endotracheal suctioning was being performed (Q10) (correct responses: 73/91 diploma nurses versus 31/39 degree nurses, X2 = 0.92, Cramer's V = 0.01), with an odds ratio of 1.05 (0.41 - 2.66). For more information, refer to Table 4.6. Generally, the association under this domain was rather weak.

4.3 OPEN ENDED RESPONSES

The questionnaire made provision for one open-ended question at the end of the questionnaire (refer **Appendix A**) for open comments. The study participants chose not to elaborate by providing additional information on the space provided on the questionnaire (**Appendix A)** for open comments.

4.4 DISCUSSION OF MAIN FINDINGS

The purpose of this study was to determine intensive care nurses' knowledge of the American Association Respiratory Care (AARC, 2010) evidence-based guidelines on endotracheal suctioning in one major academic hospital in Johannesburg, in order to make recommendations for clinical practice, education and training of these nurses.

In this study, the demographic profile of the respondents is presented in this part of the questionnaire. Three items supported the results and discussion in this part of the questionnaire.

The distribution of the sample revealed the majority 66.1% (n = 86) of the respondents had less than 10 years of experience as a nurse, while 33.9% (n = 44) had more than ten years of experience as a nurse.

In this study, the majority 70.0% (n = 91) of the nurse respondents had a diploma level of education. This finding is higher than 60.2% reported in a survey (Mwakantange, Masika & Tarimo, 2018) with Tanzanian nurses (n = 103). In this current study, 27.7% (n = 36) of the respondents had a Bachelor's degree in nursing. This finding is slightly higher than 22.3% reported in a survey (Mwakantange, Masika & Tarimo, 2018) with a sample of Tanzanian nurses (n = 103), but lower than 73.9% reported in one Ethiopian study by Afenigus *et al.* (2021) in their sample of 180 nurses.

Most (74.6%; n = 97) of the respondents in this study had less than 10 years of ICU work experience. This finding is lower than 91.7% reported in a survey (Mwakantange, Masika & Tarimo, 2018) with Tanzanian nurses (n = 103), but higher than 55.0% reported in a survey (Negro *et al.,* 2014) with Italian nurses (n = 247). In this current study, 25.4% (n = 33) had more than 10 years of ICU experience. This finding is lower than 45.0% reported in a survey (Negro *et al.,* 2014) with Italian nurses (n = 247).

The *first objective* of this study was to evaluate and describe intensive care nurses' knowledge of the current evidence-based guidelines for endotracheal suctioning in intensive care units. Ten items supported the results and discussion in this part of the questionnaire.

Several authors have indicated that ETT suctioning is indicated when the patient is unable to clear visible or audible secretions independently (Chaseling *et al.,* 2014; Pedersen *et al.,* 2008). Also the patient should be suctioned when the airway pressure increases on the ventilator, when desaturation occurs on pulse oximetry or when the patient coughs (Sole, Bennett & Ashworth, 2014). The current study findings revealed that the majority

76.9% (n = 100) of the nurse respondents were in agreement with the indications mentioned above.

Selection of the appropriately sized catheter for a given inner endotracheal tube lumen is an important consideration to avoid complications. According to Chaseling *et al.* (2014) and Pederson *et al.* (2008) recommendations choosing the correct size might be harmful to patients and compromise their safety. These study findings revealed that the majority 67.7% (n = 88) of the respondents selected the incorrect response, and might compromise the safety of the intubated mechanically ventilated patient. Arbon and Siew Ping (2011) stated that the suction catheter used during ETT suction should occlude half the internal diameter of the ET tube. It will prevent a large in-pulmonary pressure building up in the ET tube due to lack of sufficient return airflow down the ET tube to compensate the air removed in the lung during the suctioning procedure (Arbon & Siew Ping, 2011). However, according to the AARC (2010) evidence-based recommendation the internal diameter should be less than half of the amount of the internal diameter of the ET tube. In this current study, it should be noted that only 32.3% (n = 42) of the nurse respondents were more inclined to select the correct response. These findings are lower than 47.2% reported in a survey (Maras *et al.*, 2017) with a sample of Turkish nurses (n = 72).

The lowest possible suction pressure is 80 to 120 mmHg and it is recommended to reduce the risk of atelectasis, hypoxia and damage to the mucosa (AARC, 2010). These study findings showed that 60.7% (n = 79) nurses were more inclined to choose the incorrect response. The current pressures suggested by these nurses practicing in intensive care units have been proven to be unsafe and are not based on the evidence-based practice recommendations (Pedersen *et al.*, 2009). Kelleher and Andrews (2008) reported similar findings where 33.3% (n = 45) of their sample of British nurses (n = 45) failed to use the recommended pressure of 80 to 120 mmHg.

Chaseling *et al.* (2014) and AARC (2010) recommendations suggest the application of hyper-oxygenation by delivery 100.0% oxygen for at least 30 seconds before and after ETT suctioning. Hyper-oxygenation is recommended to prevent or minimize desaturation and effects of hypoxia (Pedersen *et al.*, 2009). The study findings showed that 89.2% (n

= 116) of the nurse respondents indicated agreement with the current evidence-based recommendation.

The evidence-based practice recommendations suggest that the application of hyperinflation should be used after an individual patient's assessment has been done because it can be harmful to some patients (AARC, 2010; Pedersen *et al.,* 2009). According to Oh and Seo (2003), Ayhan *et al.* (2015) and Wang *et al.* (2017) this procedure is presumed to enhance the patient's oxygen capacity by recruiting pulmonary volume and loosening secretions. The application of hyperinflation should be performed manually using the mechanical ventilation (Day *et al.,* 2002; Pedersen *et al.,* 2009). The study findings showed that the majority 80.0% (n = 104) of the nurse respondent indicated that they do practice hyperinflation before ETT suctioning using the best recommended practice method, namely a ventilator, and might thus enhance the safety of the mechanically ventilated patient.

Several authors have reported that normal saline instillation in airway management does not thin or loosen secretions and may have significant effects on the patient (Ayhan *et al.,* 2015; Wang *et al.,* 2017). The study findings showed that the majority 83.1% (n = 108) of nurse respondents could not state the correct indications for using normal saline. These findings are congruent with other studies overseas. In one Turkish study, Ayhan *et al.* (2015) indicated that 87.7% (n = 57) of the nurses (out of a sample of 65) instilled normal saline bolus prior to and during ETT suctioning, while another study conducted in America (Sole *et al.,* 2009) reported that most institutions include the instillation of normal saline as a treatment for thick secretions in their institutional policies. However, the current practice related to saline instillation as performed by nurses is not considered to be the best-recommended practice (AARC, 2010; Chaseling *et al.,* 2014; Pedersen *et al.,* 2009).

The evidence-based practice recommendations suggest the duration of suctioning should not exceed ten seconds (AARC, 2010). The study findings showed that the close majority 53.1% (n = 69) of the nurse respondents failed to select the best practice recommended response. These findings are higher than 48.6% (n = 17) in a survey (Mwakanyanga, Masika & Tarimo, 2018) with a sample of Tanzanian nurses (n = 103).

Regarding the depth of insertion of the suction catheter, the best practice recommendations are that the suction catheter should be advanced until it reaches the carina, which would be felt by resistance or by a cough. Advancing the catheter further beyond the recommended depth will cause the application of greater negative pressure on the lungs. According to Day *et al.* (2002), this may lead to bradycardia. However, a small percentage of the nurse respondents 18.5% (n = 24) indicated correctly that the catheter should be advanced until it reaches the carina. Also, the study findings showed that 81.5% (n = 106) of the nurse respondents in intensive care units do not insert the catheter to the recommended depth.

The *second objective* of the study was to establish whether there is a relationship between qualification, years of experience and knowledge of nurses on evidence-based guidelines for ETT suctioning.

In this study, nurses with **less than five years of nursing experience scored lower** on average **than those with more than five years of** experience (156 vs. 403). In the area of types of endotracheal tubes required for suctioning (Q1), decision to perform suctioning based on GCS scores (Q3), switching suctioning based on peripheral tissue oxygenation (Q5), long suctioning to remove majority of secretions (Q7), endotracheal suctioning requiring negative pressure (Q9), and not disconnecting the ventilation during suctioning (Q10), **nurses working more than five years provided correct responses** on the endotracheal suctioning guidelines **than their counterparts**. Overall, there was **a strong association** for only two of the questions among the nurses: GCS-based suctioning question (Q3), and not disconnecting the ventilator during suctioning question (Q10). (see Table 4.3, page 64-65).

Findings in this study indicated nurses in ICU with **more than five years of work experience in ICU scored higher** on average than **those with less than five years of experience** (244 vs. 315). Overall, the ICU nurses with **more than 5 years working experience performed well in seven out of the ten domains** of the endotracheal suctioning guidelines than their counterparts (Q1, Q3, Q5, Q6, Q7, Q9, Q10, respectively). Overall, among the ICU nurses in the current study, there was a **significant correlation** between endotracheal suctioning requiring negative pressure (Q9), switching

suctioning based on peripheral tissue oxygenation (Q5), and not disconnecting during endotracheal suctioning questions (Q10) (see Table 4.4, page 66-67).

In this study, respondents with a **diploma level training performed better on average** in terms of endotracheal suctioning knowledge **than those with degrees (381 vs. 178**). Further, respondents with **diplomas outperformed their counterparts** in **eight of the ten domains** (Q1, Q2, Q3, Q4, Q5, Q6, Q9 and Q10, respectively) of the endotracheal suctioning guidelines. These include the preparation of endotracheal suctioning equipment (Q1), endotracheal tube diameter required for suctioning (Q2), suctioning based on GCS scores (Q3), performing manual lung recruitment prior to suctioning (Q4), switching suctioning based on peripheral tissue oxygenation (Q5), using long suctioning to remove most secretions (Q6), using negative pressure during endotracheal suctioning (Q9), and keeping the ventilation on while suctioning (q10). Generally, the association under this domain was rather weak. (see Table 4.5; page 68-69).

4.5 SUMMARY

The chapter presented and discussed descriptive and comparative statistical tests used to describe and analyse the data collected. The data and interpretations of findings supported by literature discussion were presented. In the next chapter the findings will be discussed in relation to relevant literature including the study limitations, recommendations for nursing practice, education, management and future research and conclusion of the study.

CHAPTER FIVE

SUMMARY, MAIN FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.1. INTRODUCTION

This final chapter will present a summary of the study, the main findings and conclusions of the main findings. This will be followed by a discussion of the limitations of the study and recommendations for clinical practice, nursing education and further research in this areas.

5.2. SUMMARY OF THE STUDY

5.2.1. Purpose of the Study

The purpose of this study was to determine ICU nurses' knowledge of the American Association of Respiratory Care (AARC, 2010) evidence-based guidelines on the endotracheal suctioning technique in one major academic hospital in Johannesburg.

5.2.2. Objectives

The objectives of the study were:

- To evaluate and describe the knowledge of ICU nurses about best practices regarding endotracheal suctioning in the ICU units from one major academic hospital in Johannesburg.
- To establish whether there is a relationship between training and years of experience and knowledge of nurses on best practices regarding endotracheal suctioning.

5.3 RESEARCH METHODOLOGY

The Human Research Ethical Committee (Medical) of the University of the Witwatersrand granted ethical clearance before the commencement of the study. Permission to conduct the study was granted by the Faculty of Health Sciences,

Postgraduate Committee and the Chief Executive Officer of one major academic hospital in Johannesburg.

A panel of local domain experts did face and content validity of the self-administered questionnaire before the commencement of the study to ensure the applicability of the instrument to the South African context.

To test feasibility of the questionnaire pre-testing was conducted with five participants who completed the self-administered questionnaire before commencement of the main study. The questionnaire used in this study was developed by Negro *et al.* (2014), and permission was obtained from the developer for use the instrument. The questionnaire comprised of three sections. The first section collected demographic data, section two collected data for evaluation of nurses' knowledge related to the evidence-based guidelines of endotracheal suctioning. One open-ended question was added at the end of the questionnaire that allowed nurse respondents to comment on any issues relating to the study aim.

Data was collected over a period of four months and questionnaires where coded to ensure confidentiality of participants. The objective of the study was met by using an explorative, descriptive and cross-sectional design. Descriptive and comparative statistics were used to analyse the data which was done in consultation with a biomedical statistician from the research office of the Faculty of Health Science.

5.4. SUMMARY OF MAIN FINDINGS

The *first objective* was to determine and describe intensive care nurses' knowledge of the evidence-based guidelines on endotracheal suctioning in intensive care units.

Overall the study findings revealed nurses knowledge of evidence-based practice guidelines on ETT suctioning was **less than adequate** in seven out of ten domains. Most nurses were aware on the guidelines when it comes to the use of pre-oxygenation before ETT suctioning (89.2%; n = 116) and taking care not to disconnect the patient from the ventilator, during suctioning (80%; n = 104). In this study nurses performed poorly on

the guidelines when it comes to correct preparation for the use of closed-suction equipment (6.9%; n = 9), use of saline instillation (16.9%; n = 22), insertion of depth of suction catheter (18.5%; n = 24), use of manual lung inflation (25.4%; n = 33), closed suction circuit catheter size (32.3%; n = 42), and suction pressure (39.2%; n = 51).

The *second objective* was to establish whether there was a relationship between training, years of experience and knowledge of nurses on the evidence-based guidelines for endotracheal suctioning.

Findings in this study revealed nurses with **less than five years of experience in nursing generally scored lower** on average than nurses with more than five years of experience (156 vs. 403 points). These findings also revealed a statistically significant correlation in two out of ten domains.

Findings in this study revealed nurses in ICU with **more than five years of working experience in ICU** scored higher than on average than nurses with less than five year of experience (315 vs 215 points). In addition, the nurses with more than five years of working experience in ICU performed well in seven out of ten domains. These findings also revealed a statistically significant correlation in three out of ten domains.

In addition, findings revealed that nurses with a **diploma level training performed better** on average in terms of endotracheal suctioning knowledge than those with degrees (381 vs 178 points). Although the diploma nurses outperformed their degree counterparts in eight of the ten domains, the association under this domain was rather weak.

In light of these findings ETT suctioning remains a challenge for nurses working in these South African ICUs hence it can be concluded that some nursing practices may be outdated and potentially threaten the safety of patients in adult intensive care units.

5.5. LIMITATIONS OF THE STUDY

The researcher acknowledges the following limitations in this study.

- The study was conducted in one major academic hospital in Johannesburg, and therefore the findings cannot be generalised to other populations.
- The sampling method used in this study is based on convenience sampling and relatively small sample size.
- The perceptions and practices of nurses may not be representative of actual patient care because the study only surveyed nurses' knowledge of endotracheal suctioning.

In consideration of these limitations, the findings of this study cannot be generalised unless replication of the study is carried out on a larger scale including intensive care units in other public hospitals and provinces.

5.6 RECOMMENDATIONS ARISING FROM THE STUDY

Based on the findings of this study the following recommendations for clinical practice, nursing education and further research are made.

5.6.1 Recommendations for Clinical Practice

The study findings revealed nurse's knowledge of evidence based practice guidelines on ETT suctioning in ICU was less than adequate in seven out of ten domains, Hence ETT suctioning remains a challenge for nurses working in these South African ICUs. Recommendations for clinical practice are as follows:

- Intensive care units need to develop clinical guidelines that are aligned with current best practice. These can be used to audit current practices and promote change based on the recognition that best practice is dynamic and evolving as new empirical evidence become available.
- Also, these measures could assist those developing standardized protocols in South Africa to ensure that evidence practiced guidelines are used to develop these protocols. Protocols should be reviewed on a regular basis to maintain currency.
- Individual unit based protocols can be used to inform clinical training programmes to drive the process of change amongst nurses involved in direct care to ensure practice remains current.

5.6.2 Recommendations for Nursing Education

Recommendations for nursing education are as follows:

- The nurse educators and the clinical facilitators in the ICU setting should together attend ward rounds, both should teach in the clinical setting and participate in nursing and multi-disciplinary journal clubs in order to ensure that the gap between theory and practice is decreased.
- The study recommends that in the training of ICU nurses should include evidence based practice especially the up dated guidelines that are used worldwide in educating the nurses in undergraduate courses as well as postgraduate courses.
- Clinical skills manuals should include the up dated steps that are used in the current evidenced based practice guidelines used worldwide. In addition, clinical work books (assessment tools) should be compiled by the clinical facilitators and the educators in order to bridge the gap between theory and practice thus using up dated evidence based practice.

5.6.3 Recommendations for Further Research

The following recommendations are made for further research:

- This study can also be extended to include other hospitals and possibly other provinces in South Africa thus a larger population and sample will be obtained. The larger study's findings then can be used to enhance generalizability of the study findings.
- Further studies that utilizes a qualitative approach or an observational research method should be done to assess the skill performed in the clinical setting. This can also help in order to explore barriers that prevent ICU nurses from following the evidence based practice guidelines in the clinical setting.
- A research study using a Pre-test and a Post- test (theory and practical skill observed) can be done in either the clinical setting or in the simulation environment. This will allow the researcher to correlate the differences if any between the ICU nurses prior and post knowledge training. This type of study will also address the areas of knowledge deficits in applying knowledge to practice.

5.7 CONCLUSION

In conclusion this research report has described intensive care nurse's knowledge and practices of current evidence based recommendations for ETT suctioning in five adult intensive care units of one major public hospital. The findings from this study provide evidence that supports a theory-practice gap in the South African setting where best practice clinical guidelines on ETT suctioning is not being implemented.

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APPENDIX A

INTENSIVE CARE NURSES' KNOWLEDGE ABOUT ENDOTRACHEAL SUCTIONING GUIDELINES IN ONE MAJOR ACADEMIC HOSPITALS IN JOHANNESBURG

DATA COLLECTION INSTRUMENT

SECTION A – DEMOGRAPHIC DATA

Please read each item below and place an X at the correct answer or fill in the correct response where required.

How long have you worked as an ICU nurse?

< 1 year	
1 to 5 years	
6 to 10 years	
>10 years	

How long have you worked in your ICU?

< 1 year	
1 to 5 years	
6 to 10 years	
>10 years	

Do you have a degree or diploma in nursing?

Degree	
Diploma	

SECTION B: ENDOTRACHEAL TUBE SUCTIONING

Please read each item below and place an X at the correct answer or fill in the correct response where required.

1. A patient from ER is coming to ICU with acute respiratory failure; he has already been intubated and is connected to mechanical ventilation. The ICU nurse prepares the devices to use, including a closed suction circuit.

Correct, because it should be used for all intubated patients or with a tracheostomy, as recommended by the guideline	
Correct, because the patient probably needs high FiO2 and PEEP	
Not correct because the closed-circuit should only be used for newborns	
I do not know	

2. The closed-circuit prepared by the nurse has a suction catheter with a calibre of 14ch, and the patient is intubated with a number 8 endotracheal tube.

Not correct because it is necessary to choose the largest ..suction catheter	
Correct, because the suction catheter should occlude less than one half of the tube lumen	
Not correct because the suction catheter should occlude less than 2/3 of the tube lumen.	
I do not know	

3. The patient presents GCS 3, so the nurse decides to suction him once per shift.

Not correct because the manoeuvre should be performed every two hours	
Correct, in order to maintain the airways open	
Not correct because the manoeuvre should be performed only if necessary	
I do not know	

4. The nurse decides to perform manual lung recruitment before the suction.

Not correct because it should be performed only after a medical prescription	
Correct, because it should be performed before suctioning, as recommended by guidelines.	
Not correct because it should be performed only if occurred desaturation during the previous suctioning	
I do not know	

5. During the first suction, the patient switched from 97% to 74% of peripheral oxygen saturation. The nurse should:

Preoxygenate the patient before suctioning, as recommended by guidelines.	
Preoxygenate the patient because of desaturation during the previous tracheal suctioning.	
Perform suctioning normally because preoxygenation should be performed only when a desaturation less than 60% occurs.	
I do not know	

6. The nurse decides to perform saline installation in order to facilitate the suction of dense secretions.

Correct if you use a close suction circuit.	
Not correct because the manoeuvre does not provide clear benefits.	
Correct, because it facilitates the dissolution of secretions.	
I do not know	

7. The nurse decides to perform a long suction in order to remove the majority of secretion.

Correct because the manoeuvre should last one minute at least.	
Not correct because the manoeuvre should last less than one minute.	
Not correct because the suction should last less than 15 seconds.	
I do not know	

8. The nurse inserts the suction catheter into the endotracheal tube until it meets resistance and then retracts the catheter 1cm before applying negative pressure.

Correct, because it reduces the risk to cause suction injury on endotracheal mucosa.	
Not correct because the suction catheter should be inserted into the artificial airways for the whole length of the endotracheal tube.	
Not correct because a suction catheter should be inserted until 2/3 of the length of the endotracheal tube.	
I do not know	

9. The nurse decides that endotracheal suctioning is needed with a negative pressure of 170mmHg to remove the most secretions.

Correct because the manoeuvre provides complete removal of secretions.	
Not correct because the negative pressure should be below 150mmHg in adult	
Not correct because the negative pressure should be over 170mmHg in adult.	
I do not know	

10 The nurse takes care not to disconnect the patient from the ventilator during the tracheal suction.

Correct, because it facilitates the continuation of mechanical ventilation	
Not correct because it does not permit suction of all secretions	
Correct because the nurse can suction all secretions	
I do not know	

Section C: Open Ended Question:

If there is anything else you wish to add about the topic, please feel free to use the space below.

THANK YOU FOR YOUR TIME AND CO-OPERATION IN ANSWERING THIS QUESTIONNAIRE

APPENDIX B

WITS UNIVERSITY

INFORMATION SHEET

INTENSIVE CARE NURSES' KNOWLEDGE ABOUT ENDOTRACHEAL SUCTIONING GUIDELINES IN ONE MAJOR ACADEMIC HOSPITAL IN JOHANNESBURG

Dear Colleagues,

My name is Clive Tebogo Ntelele, I am currently registered as a student at the University of the Witwatersrand, in the Department of Nursing Education for the degree of Masters of Science in Nursing (ICU Nursing). As part of my qualification requirement, I'm bound to complete a research study. The purpose of this study is to describe ICU nurses' knowledge on the American Association of Respiratory Care (AARC, 2010) evidenced-based guideline of endotracheal suctioning technique in two major academic hospitals in Johannesburg.

The endotracheal suctioning procedure is currently performed according to tradition, routine, experience, and belief. However, the performance of this procedure incorrectly may result in complications that may increase hospital cost and ICU stay.

Secondary, the study will also establish whether there is a relationship between training and years of experience and the nurses' knowledge on best practices regarding endotracheal suctioning. I would therefore like to invite you to participate in this study and complete the questionnaire that will be provided by me to you.

There is no known associated risk or harm involved in participating in the study. If you do decide to participate in the study, a questionnaire will be given to you. I will then ask you to fill out a questionnaire consisting of 10 strategies questions that are relevant to the practice of nursing and proven in the literature to prevent endotracheal suctioning complications. The questionnaire is anonymous in that it requires no personal identifiable information from you. This should not take you more than 15 minutes to complete. By you completing the questionnaire and depositing it anonymously in the sealed box, it implies that you have consented to participate in study. I have obtained permission from your unit manager for you to complete the Questionnaire in 'on-duty time. Your participation is entirely voluntary, and you may choose not to participate or to withdraw from the study at any time without being questioned. If you choose to withdraw from the study, there is no associated penalty and may not disadvantage you in any way.

Upon completion of the questionnaire, you will be required to place it in sealed box. The sealed box will be collected by me and all completed questionnaires will be kept under lock and key in a secured location. Only my supervisors and I will have access to the completed Questionnaire. Questionnaires will be kept for two years until publication, or if not published yet for six years until publication, then the data will be destroyed accordingly. To ensure anonymity and confidentiality are maintained, no personal information will be asked from you; all information will be coded by myself. The results

of the study will be reported in general terms, without disclosing personal identifying information. The results of the study will be made available to you upon your request.

I have obtained permission to conduct the study from the University of Witwatersrand Human Research Ethics Committee (Medical), the CEOs of the Institute, the Nursing Director and the relevant Hospital Unit Managers. An ethical Clearance certificate has been granted to conduct the study by HREC of Witwatersrand University.

While you may not benefit directly from participation in this study, it is hoped that it will help clarify the educational needs of nurses regarding endotracheal suctioning of the intubated adult patient.

Should you require further information regarding this research study or your rights as a study participant, feel free to contact me on the following contact number 084 346 5937 or e-mail me on the following address ctebza@gmail.com or my research supervisors Prof Shelley Schmollgruber and Viv Herbert, Tell + 21 11488 4270, e-mail; Shelley.Schmollgruber@wits.ac.za or Vivien.Herbert@wits.ac.za.

Should you have any further concerns or queries, please feel free to contact Mrs Zanele Ndlovu, Secretary of the University of Witwatersrand, HREC, at 011717 1252 (Zanele.Ndlovu@wits.ac.za) or research Administrator Rhulani Mkansi at 011717 2700/2656 (Rhulani.Mkansi@wits.ac.za). Thank you for taking the time to read this study information sheet.

Yours Sincerely
xxx
MSc Nursing Student

ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Mr CT Ntelele

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M210736

NAME: (Principal Investigator)	Mr CT Ntelele
DEPARTMENT:	School of Therapeutic Sciences Department of Nursing Education Medical School University
PROJECT TITLE:	*Intensive care nurses' knowledge about endotracheal suctioning guidelines in two major academic hospitals in Johannesburg*
DATE CONSIDERED:	2021/07/30
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Professor S Schmollgruber and Ms V Herbert
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2022/02/25

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **July** and therefore reports and re-certification will be due in the month of **July** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator Date

PERMISSION TO CONDUCT RESEARCH

APPENDIX D

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA
MAXEKE JOHANNESBURG ACADEMIC HOSPITAL

Office of the Nursing Director
Enquiries: Mr. Moses Tshabuse
Tel: (011) 488-4558
Email: Moses.Tshabuse@gauteng.gov.za
22 September 2021

GP_202109_038

Dear Mr, Ntelele Clive

TITLE: INTENSIVE CARE NURSES' KNOWLEDGE ABOUT ENDOTRACHEAL SUCTIONING GUIDELINES IN TWO MAJOR ACADEMIC HOSPITALS IN JOHANNESBURG

Permission is granted for you to conduct the above-mentioned study as described in your request provided:

1. Charlotte Maxeke Johannesburg Academic Hospital will not anyway incur or inherit costs as result of the said study.
2. Your study shall not disrupt services at the study sites.
3. Strict confidentiality shall be observed at all times.
4. Informed consent shall be solicited from patients participating in your study.

Please liaise with the HOD and Unit Manager or sister in charge to agree on the dates and time that would suit all parties.

Kindly forward this office with the results of your study on completion of the research.

Supported / ~~not supported~~

Signed by:Motlagomang Martha Pule
Signed at:2021-09-22 15:51:19 +02:00
Reason:Witnessing Motlagomang Martha

Ms. M Pule
Nursing Director

Approved/~~not approved~~

Signed by:Gladys Magugudi Bogoshi
Signed at:2021-09-22 22:47:48 +02:00
Reason:Witnessing Gladys Magugudi Bo

Ms. G.M Bogoshi
Chief Executive Officer

Approval of Title

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

26 August 2021
Person No: 451967
PAG

Mr CT Ntelele

Dear Mr Clive Ntelele

Master of Science in Nursing: Approval of Title

We have pleasure in advising that your proposal entitled *Intensive care nurses' knowledge about endotracheal suctioning guidelines in two major academic hospitals in Johannesburg* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Permission to use Questionnaire

From: Shelley Schmollgruber <Shelley.Schmollgruber@wits.ac.za>
Sent: 26 May 2021 07:41
To: alessandra negro <negro.alessandra1@gmail.com>
Subject: Re: interest in research

On 25 May 2021, at 15:07, alessandra negro <negro.alessandra1@gmail.com> wrote:

Dear prof. Shelley Schmollgruber,
Thank you for your attention to the topic, I absolutely agree to the proposal of study of your student.
Keep me updated.
Best regards
Alessandra Negro

Il giorno mar 25 mag 2021 alle ore 07:31 Shelley Schmollgruber <Shelley.Schmollgruber@wits.ac.za> ha scritto:

Dear Alessandra,
My name is Shelley Schmollgruber, I am currently supervising a Master of Science nursing student in intensive care nursing, at the University of the Witwatersrand in Johannesburg, South Africa. My student has expressed a particular interest in your study, *"Survey of Italian Intensive Care Unit Nurses' knowledge about endotracheal suctioning guidelines"*, Published in 2014 in Intensive and Critical Care Nursing, 30: 339-345. This student is doing a similar study and we would like to request your permission to use your Questionnaire in our South African study.

Our University does require students to adhere to all Ethical Procedures, hence this is the reason we are contacting you to ask for your permission. Our students are expected to publish their research studies and also acknowledge sources of data collection tools. I anticipate this student would be completed with his research study by December, 2014. The student will be conducted in a tertiary hospital in Johannesburg, on a group of specialist nurses in intensive care nursing.
Your email response will be sufficient.

Kind regards

Professor Shelley Schmollgruber

Prof Shelley Schmollgruber (PhD)
Associate Professor.
Specialisation: Intensive and Critical Care Nursing, Trauma and Emergency Nursing.
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