UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences
School of Health Care Sciences
Department of Nursing Science

EXPLORING THE REPORTING PROCESS ON THE INCIDENCE OF VENTILATOR-ASSOCIATED PNEUMONIA IN LONG-TERM MECHANICALLY VENTILATED PATIENTS

by

Kimre Meintjes

Submitted in fulfilment of the requirements for the degree.

Magister Curationis (Clinical)

Supervisor: Prof T Heyns

Co-supervisor: Prof IM Coetzee

September 2021

DEDICATION

Dedicated to both my late parents, Petrus J Meintjes and Heleen C Meintjes.

ACKNOWLEDGEMENTS

After many complications slowing down the process, my supervisor Prof Tanya Heyns never gave up on me. She even organised the technical assistance of Zelda White, who has been giving regular input over the last few months.

Also, thank you to:

- Co-Supervisor: Prof Isabel Coetzee
- Biostatistician: Joyce Jordaan
- Editor: Nikki Sutherland
- Unitas Infection Prevention and Control Manager: Tania Dinwoodie (RN)

DECLARATION

Student Number: 93092840

I, **Kimre Meintjes** declare that '**Exploring the reporting process on the incidence of ventilator-associated pneumonia in long-term mechanically ventilated patients'** is my own work and that all sources that have been used or quoted have been indicated and acknowledged by means of complete references and that this work has not been submitted for any other degree at any other institution.

_____ _____

Signed **Date**

EXPLORING THE REPORTING PROCESS ON THE INCIDENCE OF VENTILATOR-ASSOCIATED PNEUMONIA IN LONG-TERM MECHANICALLY VENTILATED PATIENTS

STUDENT NUMBER:	93092840
STUDENT:	Kimre Meintjes
DEGREE:	Magister Curationis (Clinical)
DEPARTMENT:	Department of Health Studies
SUPERVISOR:	Prof T Heyns
CO-SUPERVISOR:	Prof IM Coetzee

ABSTRACT

Background

Infection prevention and control of hospital-associated complications like Ventilator-associated Pneumonia are vital to patient safety in hospitals. Accurate Ventilator-associated Pneumonia reporting processes are necessary to understand the success or challenges in preventative nursing practices. Accurate and up to date record keeping and reporting is a well-defined legal requirement of quality nursing care and regulated by the documented Scope of Practice defined by the South African Nursing Council (SANC) (South African Nursing Council, 2005. Nursing Act No 33. [Online]

Objectives

The objectives of this study are to explore and describe the reporting processes of Ventilator-associated Pneumonia incidents as per Centers for Disease Control and Prevention guidelines by combining the electronic information available using hospital information technology software systems used in the hospital, namely SAP (Hospital controlling with SAP system solution, 2019) and Bluebird (Bluebird: Home, 2019).

Methods

A quantitative observational retrospective research design was followed. The reports on Ventilator-associated Pneumonia incidents during a specific period of adult mechanically ventilated patients were collected from the Bluebird System and compared with a manual process and samples collected from the SAP system, using the same inclusion and exclusion criteria. The comparison was made using the guidelines provided by the Centers for Disease Control and Prevention to determine the incidence of Ventilator-associated Pneumonia.

Results

The difference in the sample size was twenty-six from Bluebird and sixty-one from the SAP system, although both the samples were collected using the same inclusion and exclusion criteria, as well as Ventilator-associated Pneumonia rate guideline provided by the Centers for Disease Control and Prevention. The Bluebird System reported a Ventilator-associated Pneumonia rate of 0.0 per 1000 mechanically ventilated days and the calculated Ventilator-associated Pneumonia rate from the second sample was 3.2 per 1000 mechanically ventilated days.

Conclusion

Although Information Technology solutions are recommended by the Centers for Disease Control and Prevention to understand and manage hospital-associated incidents like Ventilator-associated Pneumonia, incomplete clinical data suggest that the resulting reports of Ventilator-associated Pneumonia rates should be investigated, focusing on the processes responsible for populating these data fields.

Keywords

Ventilator-associated Pneumonia; Bundle of Care; VAP-rate; Surveillance; Hospital Information Systems; Reporting on Hospital Acquired Infections

LIST OF FIGURES

LIST OF TABLES

LIST OF ANNEXURES

LIST OF ABBREVIATIONS

ARDS	Acute respiratory distress syndrome
ATS	American Thoracic Society
BCA	Best Care Always
CDC	Centers for Disease Control and Prevention
CICU	Cardiac Intensive care unit
EBP	Evidence based practice
FiO_2	Fraction of Inspired Oxygen
HAI	Hospital-associated incidents
HIT	Hospital information technology
IPC	Infection prevention and control
ICU	Intensive care unit
IHS	Intelligent hospital system
IDSA	Infectious Diseases Society of America
IVAC	Infection-related ventilator-associated condition
MICU	Multi-disciplinary intensive care unit
MCS	Microbiological culturing and screening
NHSN	National healthcare safety network
QA	Quality assurance
PVAC	Possible ventilator-associated condition
SAP	Systems application and product in data processing
TICU	Trauma intensive care unit
PEEP	Positive end-expiratory process
VAP	Ventilator-associated pneumonia
VAE	Ventilator-associated event
VAC	Ventilator-associated condition
WHO	World Health Organization

CONTENTS

1. ORIENTATION TO THE STUDY

1.1. INTRODUCTION

Infection Prevention and Control (IPC) is part of the quality processes in hospitals (Mehtar, 2015). Preventing hospital-associated incidents (HAIs) are an important part of successful IPC processes towards a safer healthcare environment and improved patient outcomes. Clinical information management and reporting on the incidences of HAIs, like ventilator-associated pneumonia (VAP), is key to a safer healthcare environment and improved patient outcomes. Accurate VAP reporting processes are important to understand possible challenges in preventative nursing practices, before planning and implementing strategies of solutions that are based on evidence-based practice. The reporting process is also necessary to assess whether the implemented processes are successful or if quality strategies need to be reviewed. Therefore, it is accepted that the reporting processes in IPC are part of integrated quality assurance in hospitals and critical care to ensure that clinical practices work towards the prevention of the incidence of VAP (Mehtar, 2015).

In 1988, The World Health Organization (WHO) defined quality in healthcare as '*doing the right thing right, the right way'* (Mehtar, 2015)**.** Quality, evidence-based practice is achieved by using effective practices that are proven to add to the safety of patients and have a positive effect on the morbidity and outcome of patients (Mehtar, 2015:3). According to Mehtar (2015), quality assurance is a process that aims to:

1) Ensure that best practice is in place
2) Ensure that all staff understand the parameters of the plan
3) Monitor, evaluate, and redefine parameters and training materials, according to the reporting processes used.

Hospitals are institutions where people with health problems receive medical and nursing care across many healthcare disciplines (Mehtar, 2015). It is known that numerous treatments (interventions) and procedures require the introduction of foreign devices into the patient's body, which increases the patient's risk for acquiring an infection, necessitating the use of antibiotics to treat the acquired infection (Mehtar, 2015). This study focuses on long-term mechanical ventilator treatment and the process of reporting on incidents of VAP, a known HAI.

Mechanical ventilation is a specialised lifesaving and commonly used therapy for patients in intensive care who need ventilatory support. Mechanical ventilation, especially if continued for an extended period, is known to place the patient at risk of acquiring one or more of several ventilator-associated conditions, the worst and most researched being VAP (Clemons & Kearns, 2016).
Long-term mechanical ventilator treatment exposes patients to the risk of acquiring a VAP because the natural defence mechanisms of the upper respiratory tract are bridged with an invasive device, for example, an endotracheal tube or a tracheotomy. The colonisation of an organism may occur due to contamination in the airway while performing nursing care, for example, mouth care using contaminated instruments or performing bronchial suctioning using unsterilised equipment (Urden, Stacey & Lough, 2014). Patients who acquire VAP spend more time on mechanical ventilation, which results in a prolonged stay in intensive care, increased mortality, and morbidity, and this consequently increases healthcare costs and the risk of developing antibiotic resistance (NHSN - Patient Safety Component Manual, 2019; Urden *et al.*, 2014).

Implementing successful practices to prevent incidences of VAP is therefore important in ensuring a safe patient environment and ensuring the quality of hospital care (Connolly & Wright, 2017).
The speciality of processes mandates the identification and reporting of VAP to manage the quality of the implemented clinical practice in critical care (Prakash, Rajshekar, Cherian & Sastry, 2017). The process of reporting and comparing VAP incidence against an international gold standard at other hospitals with similar challenges or even within the same hospital over different periods enables the management of quality nursing practices and infection prevention and control. Accurate reporting on VAP incidence enables the evaluation of the quality of care when nursing a long-term mechanically ventilated patient within the hospital (Johnson *et al.*, 2016; Kunzmann, Dimitriades, Morrow, & Argent, 2016).

The successful measurement of VAP incidence requires a set of quantitative statistically analysable data, which follows researched and evidence-based guidelines (Rosenthal, 2016). The Centers for Disease Control and Prevention (CDC) has established guidelines, which are accepted by most international and national public healthcare organisations, like the South African Department of Health (Mahomed, Mahomed, Sturm, Knight, & Moodley, 2017; Timsit, Esaied, Neuville, Bouadma & Mourvllier, 2017). The details and specifications of the CDC guidelines on how to report on the incidence of ventilator-associated conditions will be discussed in this study. The international unit of measurement for VAP incidence is a VAP rate per 1000 long-term mechanical ventilator treatment days (Kaier *et al.*, 2014; Klompas, 2013; (NHSN - Patient Safety Component Manual, 2019)).

The VAP rates reported in the United States are between 1.9 to 3.8 / 1000 long-term mechanically ventilated days (Safdar *et al*., 2016). The reported VAP rate in the hospital where the study was conducted has been reported as high as between 4.2 to 6.8 / 1000 long-term mechanically ventilated days in different periods between 2015 to 2016 (van Lill, 2015; 2016) However, in 2017, the reported VAP rate was 0 / 1000 long-term mechanical ventilation treatment days (van Lill, 2017). RN van Lill was responsible for compiling the VAP incidence report in the hospital to report to management. This VAP rate, as well as the process followed to determine this rate, was the rationale for this research.

The reporting process on VAP incidence is important because an evidence-based practice has proven that VAP can be prevented through quality nursing practice, therefore it can be used as a reliable gauge of the quality of nursing practice when caring for long-term mechanically ventilated patients (Akdogan *et al*., 2017).

The Institute for Healthcare Improvement scientifically identified five interventions, that if adhered to, will improve patient outcomes and prevent or will at least decrease the incidence of VAP (Urden *et al.,* 2014). These five identified interventions were grouped into a 'care bundle' called the VAP bundle and it is a globally accepted standard to prevent the incidence of VAP (Darawad, Sa'aleek & Shawashi, 2018; Urden, Stacey & Lough, 2014).

1.2. PROBLEM STATEMENT

Mechanical ventilation is a life-supporting and necessary intervention to support critically ill patients managed in intensive care units (ICUs) (Yaffa Zisk-Rony, Weissman & Weiss, 2019). Long-term mechanically ventilated patients are at risk of acquiring VAP as a complication of the mechanical ventilation treatment process. The incidence of VAP negatively influences patient outcomes and hospital costs due to increased length of stay, as well as additional medications e.g. antibiotics to treat VAP (Robinson, Hoze, Hevener & Nichols, 2018). Incidences of VAP are preventable, therefore the Infection Prevention and Control (IPC) process, which includes VAP incident reporting processes, has to be in place to enable the management of quality nursing care and creating a safer healthcare environment with better patient outcomes (Timsit *et al*., 2017).

Challenges in the identification and reporting of VAP incidences are researched and discussed in the literature globally (Othman & Abdelazim, 2017; Curtis, Fry, Shaban & Considine, 2017; Klompas *et al.*, 2014; Rosenthal, 2016). The Centers for Disease Control and Prevention (CDC) provides clear

guidelines, which can be followed to create a framework in which the assessment, planning and implementation of VAP incidence prevention strategies can be implemented.
The recommendation supplied by the CDC (Klompas *et al*., 2014) is that the reporting or assessment process in the quality assurance strategies in a hospital should use electronic data, by implementing intelligent hospital information technology software solutions. This software would be used to populate the parameters of provided VAP algorithms, to attain comparable information, which could be used for the assessment, identification, planning and implementation of preventative and corrective strategies in clinical practice. These strategies will subsequently result in improved nursing care, prevention of incidences of VAP, and an improvement towards better patient outcomes.

Internationally, literature shows that hospitals face numerous challenges when it comes to the assessing and reporting process of VAP incidences in adult critical care, even with the assistance of electronic information technology and designed software solutions (Mahomed *et al*., 2017). The importance of an accurate understanding of the incidence of VAP is crucial to improve safer quality nursing care and better patient outcomes when it comes to caring for a patient on long-term mechanical ventilation in adult critical care (Peet, Theobald & Douglas, 2019).

In the hospital where the study was conducted the VAP rate was reported as zero during the period between 1 November 2018 to 28 February 2019, which was questionable and required further investigation. The researcher, therefore, described and explored the reporting process of VAP incidents in long-term mechanically ventilated patients in adult critical care units of this specific hospital, using the supplied CDC guidelines (NHSN - Patient Safety Component Manual, 2019).

1.3. RESEARCH QUESTION

What are the reporting processes on the incidence of ventilator-associated pneumonia (VAP) in adult patients receiving long-term mechanical ventilation?

1.4. OBJECTIVES

The study aims to explore the reporting processes on the incidence of VAP in long-term mechanically ventilated adult patients.

Objective 1

Explore and describe the reported VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019) using the existing hospital information technology software, Bluebird (Bluebird: Home, 2019).

Objective 2

Explore and describe the VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019), by combining the electronic information available using hospital information technology software systems used in the hospital, namely SAP (Hospital controlling with SAP system solution, 2019) and Bluebird (Bluebird: Home, 2019).

1.5. DEFINITION OF KEY TERMS

To avoid misunderstandings and to ensure clarity the following terms are operationalised.

Table 1-1: Key Terms

Key	Conceptual Definition	Operational Definition
CDC Guidelines (NHSN - Patient Safety Component Manual, 2019)	The Centers for Disease Control and Prevention (CDC) is an operational division within the United States (US) Department of Health and Human Services (CDC Organization | About | CDC, 2020). The World Health Organization (WHO) describes guidelines as recommendations that can have an impact on healthcare policies and/or clinical interventions (Jakimowicz & Perry, 2015).	The Department of Health in South Africa and many other countries have an agreement with the CDC to work collaboratively towards safer healthcare, through the assessment, reporting of risks and the implementation of preventative measures, when it comes to preventable conditions like VAP (CDC Global Health - South Africa, 2020)
Hospital-associated incidents (HAIs)	Hospital Associate Incidents (HAIs) are caused by pathogens patients are exposed to while being hospitalised. Pathogens can be viral, bacterial, and fungal. Infections are the most common complication of hospitalisation, resulting in adverse patient outcomes and increased healthcare costs. They are also called Nosocomial infections (Klompas, 2013).	Patients receiving care in hospitals are at risk of being exposed to pathogens, which might cause complications during their period of hospitalisation. Incidents of complications caused by hospital care pose not only deleterious effects on the patient mortality and morbidity but also has cost implications to the hospital. Incidences of infections caused by hospital-associated care can and are used as an indicator of the quality of care received in the hospital.
Hospital Information Technology (HIT)	Hospital information technology is a designed computer application, with the purpose of tracking, tracing, and storing clinical patient records. Hospital information technology is used to manage the capturing and organisation of records within evidence-based calculations, like algorithms. Access to the records have to be controlled, with strict security protocols and there are usually audit processes to verify the authenticity of the datasets (Singh & Sittig, 2016).	Electronic information management enables relative quick and easy reporting on clinical trends. There are various software solutions available to hospitals to aid in the management of clinical trends. The hospital information technology software solutions applicable to this study are: **Bluebird** (Bluebird: Home, 2019) Used to manage the clinical practice influencing infection prevention and control (IPC) processes in the hospital, specifically related to the VAP incidence as guided by the CDC Guidelines (NHSN - Patient Safety Component Manual, 2019) **SAP** (Hospital controlling with SAP system solution, 2019) used to manage invoicing, diagnostic coding and inventory information related to the admission event per patient.

1.5 DEFINITION OF KEY TERMS (cont'd)

Key	Conceptual Definition	Operational Definition
Infection Prevention and Control (IPC)	Infection Prevention and Control (IPC) is a process of planning, developing, and implementing safe, evidence-based practice towards improving quality healthcare. It is a process where activities, policies and procedures are designed to control and prevent the transmission of infectious disease within the healthcare environment and the community. The process is achieved by monitoring infection and implementing measures through education of patients, employees and visitors in the principles and practices of safer healthcare (Mehtar, 2015).	Infection prevention and control follow the nursing process of assessing, diagnosing, planning, implementing, and re-assessing, which aims to identify risks to patient and environment safety. Best practice in clinical nursing practice is scientifically researched and reported on. Governing bodies like the CDC then use evidence-based best practices to provide guidelines, which can be used to aid in the prevention of complications related to hospital care. The focus of this study is on exploring the assessing and reporting processes used in the hospital to identify VAP incidences, which would be used to diagnose risks to the patient outcome of long-term mechanically ventilated patients in adult critical care.
Long-term mechanical ventilation	Mechanical Ventilation is a treatment used in intensive care, where patients receive mechanical support, utilising a medical device, supplying positive pressure, using various settings to improve the efficacy of breathing and gaseous exchange (Cinel & Dellinger, 2019) Long-term mechanical ventilation is when patients are receiving mechanical ventilation treatment and care for four or more consecutive calendar days. This parameter was set by the CDC (NHSN - Patient Safety Component Manual, 2019)	Only adult long-term mechanically ventilated patients will be included in this study because the CDC guidelines clearly state that the clinical practices in the identification and prevention of VAP incidences in children and neonates differ too much. The CDC guidelines therefore only focus on the identification and management of VAP incidences of adult long-term mechanically ventilated patients (Klompas, 2013; (NHSN - Patient Safety Component Manual, 2019) Ventilation days where mechanical ventilation using non-invasive techniques were used were also excluded, as the CDC guidelines state that VAP incidence does not apply to patients, without an invasive device like an endotracheal tube or tracheotomy (Klompas, 2013; NHSN - Patient Safety Component Manual, 2019).

1.5 DEFINITION OF KEY TERMS (cont'd)

Key	Conceptual Definition	Operational Definition
Quality Assurance (QA)	Quality means that clinical nursing practices and processes follow evidence-based practice (EBP) standards, supported by scientific research. Quality assurance is a process necessary to monitor and manage the success of healthcare delivery in hospitals. Implementing evidence-based clinical practice would mean a safer patient environment and better patient outcomes, which includes avoiding unnecessary costs (NHSN - Patient Safety Component Manual, 2019). Mehtar (2019), describe the process in Figure 1.	Understanding the quality of the implemented clinical nursing practice is important because improvement and preventative strategies have to be built upon the reliable assessment of the quality of the nursing care. The identification and reporting process of VAP incidence is the focus of this study, which is an important part of the quality assurance process. Quality Assurances of clinical practices in the hospital should be measurable. Reporting on adverse events and incidents of hospital-related complications is a way of measuring the success of implemented clinical practices. Regular reporting on VAP incidence will be an indication of the quality of the related nursing care. Globally hospitals are required to report on incidences of VAP, which provides benchmarks to measure the quality of clinical practice. Although internal reporting on VAP incidences over different periods in a hospital could also be useful in determining the quality of implemented clinical practices over different periods.
Ventilator-associated pneumonia (VAP)	VAP has been defined as a hospital-associated Complication or Incident (HAI) in the lower respiratory tract, which occurs while caring for patients receiving invasive mechanical ventilation for 48 hours or more. VAP is described by the CDC as the presence of a new progressive infiltrate or signs of systemic infection (fever, altered white blood cell count), changes in sputum characteristics, and detection of a causative effect (Lowman *et al.,* 2016; Shime, 2014; NHSN - Patient Safety Component Manual, 2019)	VAP is a preventable HAI, negatively impacts patient outcomes and increases the length of stay and cost of care. It is therefore important to have clear guidelines when it comes to the identification of VAP incidence. The South African Healthcare Organisation (Department of Health) as well as the hospital in the study, uses the CDC guidelines for the identification and reporting of VAP incidence (Mahomed *et al*., 2017).

1.5 DEFINITION OF KEY TERMS (cont'd)

Key	Conceptual Definition	Operational Definition
VAP bundle	A 'care bundle' is more than one well-described intervention, which if collectively followed, will work towards preventing specific identified risks like VAP incidences. (*Best Care – Always!,* 2019; Eom *et al*., 2014; Prakash *et al*., 2017).	The hospital in the study implemented the VAP bundle as described and documented by the Best Care Always (BCA) organisation. The Best Care Always (BCA) (2019) VAP bundle describes the implementation of five steps: 1. Elevation of the head of the bed to 45°, if possible, alternatively attempt to maintain the head of the bed not lower than 30º. 2. Daily evaluation of readiness for discontinuing invasive mechanical ventilation (extubation). 3. The utilisation of the endotracheal tubes with the ability to use continuous subglottic secretion drainage. 4. Regular mouth care and decontamination with undiluted Chlorhexidine solutions. 5. Initiation of safe enteral nutrition within 24–48h of ICU admission and use of Proton Pump Inhibitors daily while on treatment.
VAP incidence reporting process	This process is an important step of the quality assurance process to improve clinical practice and prevent VAP incidences. The reporting process includes the regular collection, collation, and analysis of information on VAP, either continuously or at regular intervals, and the timely dissemination and feedback to those who plan and implement clinical improvement initiatives and other stakeholders (Mehtar, 2015:365).	The VAP incidence reporting process includes the Bluebird (Bluebird: Home, 2019) and CDC guidelines (ref). This process is discussed in full detail under the theoretical framework of this study.

1.6. SETTING

The study was conducted in the largest private hospital in the Gauteng province, South Africa. The hospital has a total of 469 beds. The hospital has nineteen units and a level two Trauma and Emergency unit, with a helicopter landing pad. The speciality units include no less than three adult Intensive Care Units (ICUs), a Neonatal ICU, as an extension of the Obstetric area, as well as a Paediatric ICU, with a High Care unit with twenty-seven beds to cater for patients who require higher-level care.

Many smaller hospitals refer patients requiring higher-level care to this hospital due to the availability of 'Cath lab' facilities, a radiology service provider enabling intervention radiology, to name a few. The hospital is also part of a bigger hospital group, which, due to the availability of specialist care, results in referrals of patients from within the hospital group. The diagnoses of patients admitted in the three adult Intensive Care Units (ICUs) vary over different specialities.

The study focused on the long-term mechanically ventilated patients admitted over a specific retrospective period in the adult Intensive Care Units (ICUs):

- Multi-disciplinary Intensive Care Unit (MICU) (Twenty-four beds)
- Trauma Intensive Care Unit (TICU) (Eight beds)
- Cardiac Intensive Care Unit (CICU) (Twenty-two beds)

The period used for this study was 1 November 2018 to 28 February 2019. Table 1-2 shows the number of admissions and the number of long-term mechanically ventilated patients who were in each of the units, during the chosen period.

Table 1-2: Number of admission vs long-term mechanically ventilated patients

Unit description	Number of admissions	Number of long-term mechanically ventilated patients
CICU	765	6
MICU	420	31
TICU	129	23
Total number of patients	**1314**	**60**

1.7. DELINEATION

This study was conducted in the adult ICU units of one private hospital in Gauteng. Only long-term mechanically ventilated patients were included in the study.

Exploring the reporting process in place to determine incidences of VAP, the researcher used the Hospital Information Technology software solutions implemented in the hospital to collect the applicable electronic data:

- The Bluebird Intelligent Hospital System (IHS) is the system implemented to manage Infection Prevention and Control (IPC) in the hospital (Bluebird: Home, 2019).
- The SAP (Hospital controlling with SAP system solution, 2019) is the system where patient invoicing (which includes all consumables and processes in the hospital) and diagnosis coding data is being captured as part of the day to day processes in the hospital

The rationale behind using the electronic Hospital Information Technology software solutions to collect the data is to be able to explore and describe the 'real world' VAP-incident reporting process in place in the hospital. Literature states that a practical, usable reporting process has to be unbiased, using quantifiable data, in evidence-based algorithms (NHSN - Patient Safety Component Manual, 2019), preferably using information technology (Mahomed *et al*., 2017).

After discussion with the biostatistician, the selection of the population was chosen including the following criteria: long-term mechanically ventilation patients, who had been ventilation via an invasive device, namely either an endotracheal tube or a tracheostomy, for more than four consecutive days.
A retrospective period of 1 November 2018 to 28 February 2019 was selected from the three adult Intensive Care Units (ICUs) in the hospital. The retrospective time was not chosen according to a specific time of year, nor was the focus of the study about epidemiology, but rather, it focused on the management and reporting process of VAP incidence. The population minimum was described by the statistician as, at least twenty-five patients and/or at least one hundred (100) long-term mechanical ventilator treatment days.

The paediatric and neonatal Intensive Care Units (ICUs) were not included in this study since the clinical practices and guidelines differ between paediatric and adult units. This is significant to the study because different practices require different quality assurance and reporting processes on safety practices in Infection Prevention and Control (IPC) (NHSN - Patient Safety Component Manual, 2019).

1.8. LIMITATIONS

Only electronic data available on the Bluebird and SAP systems were used. The data from patient files were not made accessible for the research project by the hospital in which the study was conducted, which could have limited the identified VAP cases by incorporating patient data.

1.9. THEORETICAL FRAMEWORK

The focus of the study is on the risk assessment, relating to incidences of VAP. Preventing the HAI and VAP, form part of the quality assurance of healthcare, when it comes to the care of long-term mechanically ventilated patients. The reporting process on VAP incidence is well researched and the selected hospital is using the specific guidelines supplied by the CDC to determine incidences of VAP (NHSN - Patient Safety Component Manual, 2019).

The guidelines provided by the CDC are shown in figure 1-1 below:

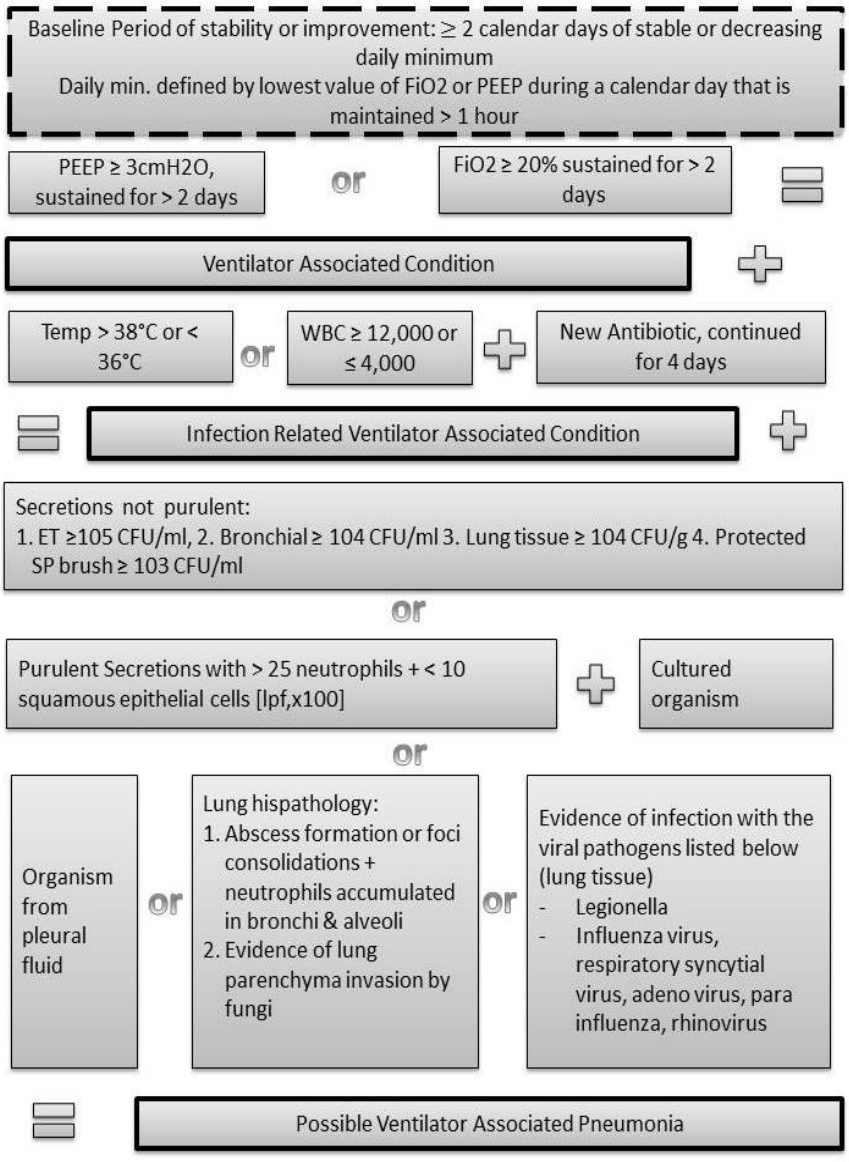


Figure 1-1: CDC Guidelines

The guidelines summarised in Figure 1-1 are well-documented and described processes, which are used internationally to determine and report on incidences of VAP, it is also discussed in more detail in Chapter 3, while the researcher followed the process as described by the CDC (NHSN - Patient Safety Component Manual, 2019)

The process of data collection and the risk assessment, through the reporting process, is, therefore, an established and documented plan, which can be observed and described, comparing the results with literature from findings by global research. This reporting process starts with the collecting of clinical information, that is then interpreted through the reporting of quality indicators, like a VAP rate per 1000 mechanical ventilated days (Kaier *et al.*, 2014; Klompas, 2013; Mahomed *et al.*, 2017; Mitchell & Gardner, 2014; NHSN - Patient Safety Component Manual, 2019).

Risk assessment is done by comparing the results of the reports (VAP incidence reports) against the international and local reported VAP incidence of other hospitals or the same hospital at different periods (Larsson, Itenov & Bestle, 2017). The success of already implemented preventative strategies is measured through the risk assessment done on the results of the VAP incidence reports. The implemented clinical practices will then be reviewed supported or changed. A process of monitoring and capturing clinical parameters will then follow to allow either improvement or support, after which the whole quality assurance process will follow (Mehtar, 2015).

1.10. RESEARCH DESIGN AND METHODS

The research design and methods are discussed in depth in Chapter 3.

1.11. ETHICAL CONSIDERATIONS

The study commenced after a written ethical approval was granted by the Faculty of Health Science Research Ethics Committee of the University of Pretoria, reference number 163/2018 (Annexure A1), as well as from the Hospital (Annexure A3) and the Hospital Group that the Hospital belongs to (Annexure A2).

To ensure that ethical and legal considerations had been adhered to, the researcher applied for ethical approval from the Research Ethics Committee of the Faculty of Health Sciences at the University of Pretoria. Once ethical approval had been received from the Research Ethics Committee of the Faculty of Health Sciences at the University of Pretoria the researcher applied to the chosen private hospital group and selected hospital for clinical research approval. This process involved submitting the research proposal and other specified documents to the deputy nursing services manager responsible for the quality of clinical practice in the hospital. It was then reviewed and submitted to the Clinical Research Approval Committee of the private hospital group for final approval.

To ensure ethical principles are adhered to, the researcher applied the basic ethical principles and guidelines for research involving human subjects as stipulated in The Belmont Report (The Belmont Report, 2020). The Belmont Report aims to protect human subjects who participate in biomedical and behavioural research through the application of basic ethical principles namely: Respect for persons, beneficence, and justice. These principles are applied through informed consent, assessment of risk and benefits, and selection of subjects (The Belmont Report, 2020). Ethical considerations applicable to this study are as follows:

Respect for Persons

This refers to the acknowledgement and protection of a person's autonomy and is ensured through the application of informed consent (The Belmont Report, 2020). Retrospective document analysis is permitted without patient consent provided the analysis is done anonymously (Tablan, Anderson, Besser, Bridges & Hajjeh, 2003). Anonymity and confidentiality are the rights of a participant to expect that any information pertaining to them be kept anonymous and confidential (Brink *et al*., 2018). Informed consent was obtained from the private hospital group, as well as from the private hospital participating in the research and not from the patients themselves. (Annexure A2 & A3). This anonymity and confidentiality will be ensured by assigning numbers to patient records, therefore eliminating, and avoiding patient identification as well as the participating hospital in every way, ensuring respect for persons and the hospital involved.

Beneficence

The Belmont Report refers to beneficence as the obligation and recognition of health care professionals to treat their patients ethically and to respect their decisions, thereby protecting them from harm, subsequently ensuring maximising possible benefits and minimising harm to the patients. (Ryan *et al*., 2018). Beneficence protects the patient's well-being. The study did not involve any interaction or experimentation on patients and all measures were taken to protect the identity of the patient records as well as the participating hospital. Thus, no physical, emotional, or psychological harm will be posed

to the patients as retrospective electronic records had been used and the reputation of the hospital will be protected.

Justice

Justice represents fair selection and treatment of the participants of the study and that all agreements made between the researcher and the participant be honoured. All the applicable patients were selected from the retrospective period to improve the accuracy of the statistics and avoid risks to fair representation in the collection of the clinical records (Polit and Beck, 2017a).

The commencement of the study was also delayed due to changes made to the original proposal of the study to comply with the rights and wishes of the hospital and hospital group, as required by the principle of justice.

Benefits of the study

Understanding trends of incidences of HAI, like VAP, is important, because it would serve as a key indicator of understanding quality of nursing care in the hospital. Real time, accurate reports of VAP-rates at the touch of a button through an information technology software system, can serve as an early warning system, of nursing practice that has to be re-evaluated, because through following evidence base practice principles, incidences of VAP will be avoided, so if there are a sudden increase of VAP-incidence, the source of this should be investigated and corrective action should be taken.
Therefore, understanding the reliability of the process of VAP-reporting is an important part of managing the quality of nursing practice in a hospital.

1.12. SUMMARY

Chapter 1 provided an orientation to the study, focusing on the background to the problem, problem statement, aim and objectives, definition of terms as well as the theoretical framework used to guide the study. Chapter 2 supports the importance of research, applying evidence-based information found in literature, as well as enabling the researcher to explore and discuss the observed results.

2. LITERATURE REVIEW

2.1. INTRODUCTION

In Chapter 1 an overview of the study was provided. Chapter 2 provides an in-depth discussion on literature related to the VAP incidence reporting process. The themes highlighted, include the effect that a hospital-associated Incident (HAI) like VAP has on patient outcome and cost of care. Long-term mechanical ventilation is a hospital treatment that might lead to a VAP incidence, the process and importance of the prevention of VAP is discussed. The researcher will then discuss the evidence-based clinical practice processes that will work towards researched quality nursing practices that prevent incidences of VAP.

The literature supporting the reasoning and importance of identifying and reporting on VAP incidence as part of quality insurance processes in clinical practice are then described, with some reference to how other hospitals report on VAP incidence globally. Reference is also made on legal and ethical considerations when it comes to the accuracy of the reporting process on VAP incidence in hospitals. Accurate up to date record keeping and reporting is a well-defined legal requirement of quality nursing care and regulated by the documented Scope of Practice defined by the South African Nursing Council (SANC) (South African Nursing Council, 2005. Nursing Act No 33. [Online]

2.2. RATIONALE

A literature review is a summary of published information on the topic of the research report, aiming to create a better understanding of what is known about this subject that is addressed in the report (Polit & Beck, 2017). A literature review is also described as the exploration, critical assessment and production of current information appropriate to the stated research problem (Hart, 2016).
The Intensive care environment is a specialist nursing area where medical interventions are necessary to maintain the physiology of the patient and create time for pharmaceutical, surgical and other medical interventions to either rectify a medical problem or allow for time so that the body can heal itself (Clemons & Kearns, 2016).

Many interventions in the Intensive care environment, use invasive devices, which increases the risk of hospital-associated Incidents (HAI) (Edwardson & Cairns, 2019). HAI can take the form of infections, for example, VAP. Infections are an issue in Intensive care, because not only, are the patient's physiological condition more compromised than the general hospital population, there is an increase in the use of devices, like endotracheal tubes, which will compromise the natural defence mechanism in the patients' airway allowing pathogens to enter the patient's lungs and cause a VAP incident if the infection is not prevented through proper evidence-based nursing care (Goligher, Ferguson & Brochard, 2016). Clinical Nursing practice therefore has to take these additional risks to patient outcome into consideration and provide evidence-based guidelines to support these specialised medical interventions and allow for nurses to act within their scope of practice and give holistic care to the patient, to work towards the best possible patient outcome (SANC Regulations: Scope of Practice, 1978).

The speciality of Infection Prevention and Control focuses on the identification and reporting of the incidence of HAI. Especially the reporting process related to VAP incidence, as part of the quality assurance process, has become a widely researched topic in intensive care (Mitchell & Gardner, 2014). International and national healthcare organisations used findings from the literature, to provide guidelines in the form of 'Care-Bundles', that have proven to decrease incidences of VAP (Speck *et al*., 2016). Accurate electronic record keeping, and analysis enables early detection and reporting on possible VAP. Reporting on VAP incidence is important in the management and improvement of the quality of preventative strategies in nursing practice in intensive care (Mitchell & Gardner, 2014).
The Infection Prevention and Control department have to use specific methodologies to determine VAP rates, to enable comparability against a 'gold standard' or at least measure the success of implemented intervention strategies (Mitchell & Gardner, 2014).

2.3. HOSPITAL-ASSOCIATED INCIDENTS

Hospital-associated incidents (HAIs) are complications that are associated in healthcare settings where patients are admitted for reasons unrelated to the complication or infection that were acquired while they were receiving care in the hospital (Fernando, Gray & Gottlieb, 2017).

HAI is associated with increased length of stay, as well as increased costs, and in some cases, it may also influence the mortality and morbidity of the patient negatively (Mitchell & Gardner, 2014). Improving nursing practices may contribute to avoiding incidences of HAI and therefore improve patient outcomes (Ferreira, Pina, Sousa-Uva, & Sousa-Uva, 2017).

Monitoring and reporting on incidences of HAI are therefore also used as an indication of the quality of nursing care in a hospital (Wright, Decker, Allen-Bridson, Hebden & Leaptrot, 2018). Understanding reporting processes and prevention strategies are very relevant in supporting evidence-based nursing practice (Curtis *et al*., 2017).

2.4. LONG-TERM MECHANICAL VENTILATION AND VENTILATOR-ASSOCIATED PNEUMONIA

Mechanical Ventilation and the intensive care speciality are realities that go hand in hand. Mechanical ventilation is not a natural respiratory process, it is, however, an intervention that can be life-sustaining, by mechanically replacing the function of normal physiological ventilation, once the patient is unable to sufficiently maintain their airway or oxygenate effectively (Cinel & Dellinger, 2019). The human body needs to ventilate, to enable the intake of oxygen, which diffuses into the bloodstream, via the alveoli, where it attaches to the haemoglobin, which then transports the oxygen particles to metabolising cells to the rest of the body. The whole process is called respiration (Loss *et al*., 2015). Patients who require mechanical ventilation are usually patients with higher mortality and acuity since their condition necessitates the mechanical management of respiration (Loss *et al*., 2015). Conditions that can cause this need can vary from a loss of neurological function to abnormal cardiac function (especially left-sided pathology), to infective respiratory diseases as well as physical-mechanical trauma or surgery to the thoracic area (Lim *et al.*, 2015; Goligher *et al.,* 2016).

The process of positive-pressure mechanical ventilation should aim to provide sufficient ventilation for metabolic processes needed while causing minimal harm, preferably no harm (Clemons & Kearns, 2016). Mechanical ventilation can be administered invasively or non-invasively. The non-invasive option has fewer side effects, but is less controllable, in the support and management of sufficient ventilation and respiration (Goligher *et al.*, 2016). Patients in need of long-term mechanical ventilation usually present with a lack of ventilation or respiratory control, necessitating control over the variables controlling parameters of ventilation, necessitating invasive mechanical ventilation (Walaszek, Gniadek, Kolpa, Wolak & Kosiarska, 2017).

Invasive Ventilation enables greater control and support over the ventilation process. An invasive device like an endotracheal tube/tracheostomy is inserted to access the lower airways, with as few obstacles as possible (Walaszek *et al*., 2017). It is known that invasive procedures increase the risk of infections (Edwardson & Cairns, 2019). VAP is not the only hospital-associated complication that patients receiving mechanical ventilator treatment are exposed to. Mechanical ventilation is not a

natural way of breathing, therefore the use of positive inspiratory pressure, is directly opposite to the natural negative pressure that enables natural inhalation. Lung injury due to Barotrauma or Volutrauma should be considered when setting the supported breathing support. Invasive devices can injure the trachea and airways, causing tracheal stenosis (Loss *et al*., 2015).

However, for the purpose of this study, the practices preventing VAP is the focus. VAP remains a major cause of increased mortality and morbidity (Arthur, Kizor, Selim, Van Driel, & Seoane, 2016; Larsson *et al*., 2017). VAP is defined as a lung infection caused by a pathogenic organism acquired while receiving mechanical ventilator treatment more than forty-eight hours after endotracheal intubation and initiation of mechanical ventilation. VAP mortality rates can range between 20% to 50% and as high as 70% when the lung infection is caused by a high-risk pathogen. This trend is in contrast to hospital-associated infections of more frequently involved organs (e.g., urinary tract and skin), for which mortality is low, ranging between 1% to 4% (Arthur *et al*., 2016; Goligher *et al.,* 2016).

The VAP rate in patients with acute respiratory distress syndrome (ARDS) tends to be higher than in patients receiving mechanical ventilation due to other conditions. Patients with acute respiratory distress syndrome (ARDS) are also reported to have an increased risk for the development of sepsis, multiple organ failure and death (Arthur *et al*., 2016). Despite the advances in the identification, treatment, and prevention of VAP, it continues to be a major cause of morbidity and mortality among long-term mechanically ventilated critically ill patients (Salgado Yepez *et al*., 2017). Several risk factors may predispose patients to either colonization of the respiratory tract with pathogenic microorganisms and/or aspiration of contaminated secretions. Knowledge of the accurate incidences of VAP and their associated risk factors are imperative for the development and implementation of improved preventative measures (Othman *et al*., 2017).

It is therefore reasonable to expect the use of evidence-based practices when it comes to nursing and caring for a patient on long-term mechanical ventilation treatment and prevent known complications as far as possible (Mogyoródi, Dunai, Gál,& Iványi, 2016).

2.5. ETIOLOGY AND TREATMENT OF VENTILATOR-ASSOCIATED PNEUMONIA

Ventilator-associated pneumonia (VAP) is a hospital-associated infection that increases the patient's morbidity and/or mortality rates despite advances in identification and management techniques (Othman *et al*., 2017). According to the Infectious Diseases Society of America / American Thoracic Society (IDSA/ATS) guidelines (2016), VAP is preventable pneumonia that develops more than 48–72 hours after endotracheal intubation (Othman & Abdelazim, 2017; Othman *et al.*, 2017). The international standard reported VAP rate is between 1–4 per 1000 long-term mechanical ventilator treatment days, but it has been reported as high as 10 per 1000 long-term mechanical ventilator treatment days (Al-Thaqafy, El-Saed, Arabi & Balkhy., 2014; van der Kooi *et al.*, 2017).
VAP increases the mortality of the patient, in addition to the underlying disease, particularly in event of infection caused by high-risk pathogens, such as *Pseudomonas aeruginosa* and *Acinetobacter* species or in those incidents where initial antibiotic therapy proves to be ineffective (Arthur *et al*., 2016).
According to literature, the predominant organisms responsible for VAP would be *Staphylococcus aureus, Pseudomonas aeruginosa*, and *Enterobacteriaceae*, although etiologic agents differ widely according to the population of hospital patients, duration of hospital stay, and prior antimicrobial therapy (Othman & Abdelazim, 2017).

Appropriate antibiotics may improve the survival rates of patients who acquired VAP, but using broad-spectrum antibiotics prematurely, without a confirmed diagnosed infection, is potentially harmful, facilitating colonisation and superinfection with multi-resistant microorganisms. Any strategy designed to evaluate patients suspected of having developed VAP therefore should be able to withhold antimicrobial treatment in patients without an identified pneumonia (Arthur *et al*., 2016).

Starting new antibiotics should be carefully considered as even a few doses of a new antibiotic can negate the results of microbiologic cultures. All pulmonary secretions, for Microbiological Culturing and Sensitivity screening (MCS), in patients suspected of having developed VAP should preferably be obtained before new antibiotics are administered (Arthur *et al*., 2016). Once the pathogenic organism and the microbiologic sensitivity information is available, antimicrobial therapy should be re-evaluated to avoid prolonged use of a broader spectrum antibiotic. Therapy can be narrowed or even reduced to a single agent in light of the susceptibility pattern of the causative pathogens without risking inappropriate treatment (Arthur *et al*., 2016).

2.6. PREVENTING INCIDENCES OF VENTILATOR-ASSOCIATED PNEUMONIA

VAP is a preventable hospital-associated complication, which is caused by nursing and other healthcare interventions (Mitchell & Gardner, 2014). An incidence of VAP would cause an increase in length of stay and cost of care in the hospital. VAP can be prevented, therefore there is the question of possible negligence in nursing care if there is an increased length of stay and subsequently an increase in cost. Therefore, the rules for identifying VAP are clearly defined by the CDC and used internationally (NHSN - Patient Safety Component Manual, 2019) and hospitals are expected to provide VAP rate reports. In an event where an infection was identified on a patient on mechanical ventilator treatment, the hospital must provide empirical data proving that the necessary and utmost precautions were taken, to prevent VAP (Nasrabadi, Peyrovi & Valiee, 2017).

Considering the risk factors associated with VAP, evidence-based guidelines have been published over many years aiming to reduce VAP incidence. VAP is mainly caused by pathogens that colonise in the oropharynx and trachea, which subsequently gains access to the lower respiratory tract. The first step in the prevention strategy to limit or stunt the colonisation of pathogens is therefore to start the prevention strategy in the upper respiratory tract (Arthur *et al.*, 2016; Curtis *et al.*, 2017). The awareness and research on the possibilities to prevent hospital-acquired infections date back 150 years to the time of Ignaz Semmelweis and Florence Nightingale (Mitchell & Gardner, 2014). Semmelweis and Nightingale (1863) established that through improved environmental and hand hygiene, coupled with good sanitation practices, incidents of conditions presenting with fever were visibly decreased (Mitchell & Gardner, 2014). Furthermore, Nightingale was the first person to propose that hospital-acquired infections should be surveyed and managed, which created the recognised nursing speciality of infection prevention and control (Mitchell & Gardner, 2014).

Infection prevention and control processes should follow clinical trends to track incidences of VAP and report on it (Mitchell & Gardner, 2014). The resulting reporting on the clinical trends are then used to create preventative strategies, with improvement and implementation plans to improve the quality of clinical practice and decrease incidences of VAP (Safdar *et al*., 2016). The success of these improvements and implementation plans are then assessed through comparative VAP incidence reporting (Mahomed *et al*., 2017)

Literature states that ‘bundles of care’ are evidenced-based practices that are grouped to enable consistency in the delivery of these practices. ‘Bundles of care’ is a group of specific evidence-based steps in nursing practice, which should be adhered to, to prevent a care-related complication. The

private hospital in this study uses guidelines supplied by 'Best Care Always' a South African organisation that states that their focus is 'systematic, evidence-based approaches to preventing hospital-associated complications, like VAP, through responsible infection control processes and antibiotic stewardship.' (Best Care – Always, 2019). According to the BCA organisation, the clinical practices or VAP bundle, if adhered to, will prevent or decrease incidents of VAP is (Best Care – Always, 2019) (Annexure B1):

- When possible, the elevation of the head of the bed to 45°, otherwise an attempt to maintain the head of the bed greater than 30° should be considered
- Daily evaluation of readiness for extubation.
- The utilisation of endotracheal tubes with subglottic secretion drainage.
- Oral care and decontamination with Chlorhexidine.
- Initiation of safe enteral nutrition within 24–48 hours of ICU admission.

In recent years, it has been observed that the application of single focus intervention strategies, like focusing on hand hygiene and a clean environment alone is not enough to stop the incidence of VAP (Yazici & Bulut, 2018). The target outcome is zero infection (zero VAP rate). A multimodal synergistic implementation plan is suggested, including strategies such as identification and reporting on abnormal clinical trends, using evidence-based practice algorithms, training, implementing the 'bundles of care', antibiotic stewardship, cleaning environment strategies and even implementing isolation precautions (Fernando *et al.*, 2017; Lim *et al.*, 2015).

Regardless of the known efficacy of many of these practices, compliance with infection prevention activities by healthcare workers remains sporadic, contributing to the incidences of VAP and constant revisiting of prevention strategies (Aaron *et al.*, 2018; Timsit *et al.*, 2017). Many local and international hospitals are implementing internal quality initiatives, as part of a global requirement to manage and control infections and especially preventable hospital-associated incidents like VAP (Aaron *et al.*, 2018; McQuoid-Mason, 2019; Rosenthal, 2016). As mentioned before, the private hospital's Infection Prevention and Control department uses the guidelines for best practice, by using the five steps of the VAP bundle as described by the BCA organisation (Best Care – Always, 2019).

However, the World Health Organization (WHO) states that a key component of the core of an infection prevention and control process is understanding the threats to a safer healthcare environment through identification, measurement and reporting (Mitchell & Gardner, 2014). Accurate VAP reporting processes are instrumental in providing information for effective monitoring of the implemented VAP preventative interventions and strategies. (Mitchell & Gardner, 2014). The ability to access information

and report on the trends of the clinical records linked to VAP would serve as an early warning system, which could aid in the planning and evaluation of intervention strategies in clinical practice (El-Saed *et al.*, 2016; Mitchell & Gardner, 2014).

Despite this global recognition of the importance of infection control and the measurement and reporting on abnormal trends based on evidence-based practice algorithms, there is still a lack of literature on the application of theoretical frameworks to describe and analyse the adoption of comprehensive infection control interventions, with valid, comparable surveillance in the healthcare setting (El-Saed *et al.*, 2016; Lowman *et al.*, 2016; Mitchell & Gardner, 2014; Redondo-Gonzalez, Tenıas, Arias & Lucendo, 2018; Singh & Sittig, 2016).

Mitchell and Gardner (2014) argued that this identification and reporting of VAP is so critical to both designing and evaluating preventative infection control interventions, that it has to be included as an integral part of Infection Control theory.

2.7. THE IDENTIFICATION OF VENTILATOR-ASSOCIATED PNEUMONIA INCIDENCE

The incidence of VAP varies among different studies, depending on the definition, the type of hospital or intensive care unit, the population studied, and the level of antibiotic exposure (Bouadma *et al*., 2015). The lack of consensus regarding the most appropriate method to identify VAP also partly explains why incidence rates vary widely from one study to another (Klompas, 2013; Othman *et al.*, 2017). Identifying trends in clinical records necessitates clearly defined parameters, that can be interpreted validly with statistical control (Lowman *et al.*, 2016; Daniel Rosenthal *et al.*, 2014; Rosenthal, 2016; Torres *et al.*, 2017).

Literature reported that an accurate incidence of VAP is difficult to determine since identification and surveillance definitions have been subjective and nonspecific (Edwardson & Cairns, 2019; Klompas *et al.*, 2014; Lowman *et al*., 2016; Timsit *et al.*, 2017). Reports on ventilator-associated conditions in the National Healthcare Safety Network (NHSN) prior to 2013 were limited to VAP. In 2012, the VAP incidents for various types of hospital units ranged from 0.0–4.4 per 1000 long-term mechanically ventilated days (Ventilator-Associated Event (VAE), 2020). However, there is currently no accurate, reliable definition for VAP, and even the most widely-used VAP criteria and definitions are neither sensitive nor specific (Klompas *et al*., 2014; Timsit *et al*., 2017; *Ventilator-Associated Event (VAE)*, 2020).

One noted difficulty with many commonly-used VAP definitions, including the NHSN pneumonia definitions (revised in 2002), is that they require radiographic findings to identify pneumonia (Timsit *et al*., 2017). The guidelines supplied by Best Care Always (BCA), also indicate the use of chest X-rays to identify VAP (Prevent ventilator-associated pneumonia in adults Definition of VAP, 2012). Evidence suggests that chest radiograph findings do not accurately identify VAP (Timsit *et al*., 2017; *Ventilator-Associated Event (VAE)*, 2020). The subjectivity and variability inherent in chest radiograph interpretation, and reporting make chest imaging ill-suited for inclusion in a definition algorithm to be used for the potential purposes of the identification and calculation of VAP incidence with statistical accuracy (Bouadma *et al.*, 2015; Lowman *et al.*,2016). Historically, between 10%–20% of mechanically ventilated patients were reported to have acquired VAP. Literature is not empirically stating the reason for the trend of lower VAP rates (Ventilator-Associated Event (VAE), 2020), but there is a general consensus that it was most probably due to the stricter application and exclusion of subjective clinical diagnostic criteria (Goligher *et al.,* 2016; *Ventilator-Associated Event (VAE)*, 2020).
However, notwithstanding current surveillance results and incidence rates that hover near zero, by following the stricter application of surveillance data, clinical surveys suggest that between 5%–15% of invasive mechanically ventilated patients still develop VAP (Goligher *et al.,* 2016; Klompas *et al.*, 2014). The Centers for Disease Control (CDC) convened representatives from various applicable speciality areas in 2011–2012 to develop new guidelines for the identification of VAP with the focus on overcoming some of the limitations of previous VAP identification guidelines (Klompas *et al*., 2014). This CDC working group recommended that any new definition should be based on objective data that can be statistically controlled to increase the reliability, reproducibility, comparability and efficiency of surveillance (Klompas, 2013; Klompas *et al.*, 2014; Mahomed *et al.*, 2017). The focus of the surveillance was broadened to not only focus on VAP but complications of mechanical ventilation in general (Kaier *et al*., 2014; Mahomed *et al.*, 2017). This change in focus addressed the lack of specificity in previous surveillance guidelines and show the importance of preventing all complications and not only VAP (Klompas, 2013).

The guidelines supplied by this workgroup of the CDC only focused on identification guidelines for adults and the guidelines clearly state, that further research is necessary to create specific valid guidelines for paediatrics and neonates (Klompas *et al*., 2014). It was found that in the identification of VAP and the planning of prevention strategies it would be better to use, objective algorithms to identify and detect ventilator-associated conditions. Making use of electronic health record systems to automate event detection and identify events that are clinically important and associated with patient outcomes such as Intensive Care Units (ICUs) and hospital length of stay and mortality (Kaier *et al.*, 2014; NHSN, 2019; Rosenthal, 2016).

A prevention strategy should preferably include early warning systems (Connolly & Wright, 2017; Lowman *et al.*, 2016). The workgroup agreed that the first step in recognising a ventilator-associated condition would be sustained increases in ventilator settings after a period of stability ('NHSN - Patient Safety Component Manual', 2019; Timsit *et al*., 2017). Ventilator-associated conditions like VAP, pulmonary oedema, acute respiratory distress syndrome (ARDS), as well as atelectasis, are clinically detected by significant increases in ventilator settings ('NHSN - Patient Safety Component Manual', 2019; *Ventilator-Associated Event (VAE)*, 2020).

The above-mentioned complications are indications of increased length of stay in the intensive care unit, which includes prolonged mechanical ventilation and increased hospital mortality (Clemons & Kearns, 2016; Rawat *et al*., 2017; Yazici & Bulut, 2018). Literature proved that VAP is preventable (Fernando *et al.,* 2017). Objective identification of VAP using the CDC workgroups quantifiable definitions has to be efficient and preferably automatable (Fernando *et al.,* 2017; Klompas *et al.*, 2014; Sullivan, 2015). The Ventilator-associated Events (VAEs) framework supplied by the CDC workgroup, included three different definition guidelines of Ventilator-associated Events (VAEs), like VAP (Klompas *et al.*, 2014; 'NHSN - Patient Safety Component Manual', 2019; *Ventilator-Associated Event (VAE)*, 2020).

2.7.1. VAC

First-Tier of the Definition of a Ventilator-associated event: Ventilator-associated Condition

A Ventilator-associated Condition (VAC) or Ventilator-associated Event (VAE) can be identified after two days of a stable or decreasing daily minimum positive end-expiratory pressure (PEEP) OR daily minimum fraction of inspired oxygen (FiO_2) followed by an increase in daily minimum PEEP greater than or equal to 3 cm of H_2O or daily minimum FiO_2 greater than or equal to 0.20 points sustained for two or more days (Annexure C3) (Klompas, 2013; Lachiewicz *et al.*, 2017; Timsit *et al.*, 2017; *Ventilator-Associated Event (VAE)*, 2020).

2.7.2. IVAC

Second-Tier of the Definition of a Ventilator-associated event: Infection-related Ventilator-associated Condition

The presence of a possible infection would trigger specific infection-related clinical parameters. The Centers for Disease Control and Prevention (CDC) definition described the first possible parameter as an abnormal patient body temperature, being either below 36° C or above 38° C or the other being the

white blood cell count (WBC) (total leucocyte count) from haematological results, being less than or equal to 4000 or greater than or equal to 12 000 cells/mm³. Not only do the guidelines expect one or two of the above parameters, but it also stipulates that added to the clinical parameters, one or more new antibiotic treatments should have been initiated on the day of the event and continued for four or more days after commencement days (Annexure C3) (Klompas, 2013; Lachiewicz *et al.*, 2017; Timsit *et al.*, 2017; *Ventilator-Associated Event (VAE)*, 2020).

The guidelines for reporting Ventilator-associated Conditions (VACs) and Infection-related Ventilator-associated Conditions (IVACs) were developed to be appropriate for public reporting (Klompas *et al*., 2014). There are implications on reporting on incidences of ventilator-associated conditions that have proven to be preventable like VAP, in the form of negligence claims against hospitals (Alshyyab *et al*., 2019; Lowman *et al.*, 2016). There is still an expressed need for further evidence and research of the preventability and comparability of Ventilator-associated Conditions (VACs) and Infection-related Ventilator-associated Conditions (IVACs) between institutions before recommending their adoption for reporting or benchmarking (Klompas *et al*., 2014; Mahomed *et al.*, 2017)

2.7.3. PVAC

Third Tier of the Definition of a Ventilator-associated event: Possible Ventilator-associated Pneumonia

Possible VAP is defined as a Gram stain evidence of purulent pulmonary secretions or a pathogenic pulmonary culture in a patient with an identified event of an Infection-related Ventilator-associated Condition (IVAC). Probable VAP is defined as a Gram stain evidence of purulence plus quantitative or semi-quantitative growth of a pathogenic organism beyond specified thresholds. Probable VAP can also be triggered by positive tests for respiratory viruses, Legionella species, pleural fluid cultures, and suggestive histopathology with or without an abnormal Gram stain result (Aaron *et al*., 2018; Klompas *et al.*, 2014). Possible and probable VAP was developed for healthcare facilities to use for internal quality improvement purposes only. They are not suitable for public reporting or benchmarking because clinicians and hospitals vary widely in when and how they acquire and process pulmonary specimens from ventilated patients (Alshyyab *et al.*, 2019; Klompas *et al*., 2016; Lowman *et al.*, 2016).

Since electronic clinical data is used to diagnose incidences associated with mechanical ventilation, intelligent Hospital Information Technology (HIT) software solutions with built-in algorithms were coded and implemented to speed up the process of identification and management of preventable hospital-associated complications (*Bluebird: Home*, 2019; Fernando, Gray & Gottlieb, 2017; Philips *et al*., 2018;

Resende *et al*., 2013) An example of an intelligent Hospital Information Technology (HIT) software solution designed and programmed with the 'intelligence' to use clinical parameters to identify the incidence of VAP is the Bluebird Electronic Record Management software (Bluebird: Home, 2019), which is used in the hospital applicable to this research study.

2.8. REPORTING ON INCIDENCES OF VENTILATOR-ASSOCIATED PNEUMONIA

VAP is a preventable hospital-associated complication that negatively affects long-term mechanically ventilated patients globally, but it is a greater burden in the developing world (Khan *et al*., 2016). It is a reported fact that to successfully address a problem, one has to have an understanding of the extent of the problem, such an understanding can be achieved with a valid identification and reporting process on VAP incidences (Lowman *et al*., 2016). The efficacy of VAP identification and reporting processes in the Republic of South Africa (RSA) does not get the focus it deserves (Mahomed *et al*., 2017). The actual effect VAP has is uncertain, but there is a belief that the problem is greater in the public sector than in the private sector (Mahomed *et al*., 2017).

A literature review that was completed showed that there were only thirteen studies done in developing countries on the systemic review of hospital-associated complications, like VAP, between the period of 1995-2008, none of these studies were from South Africa (Mahomed *et al*., 2017). This lack of information from South Africa makes it clear that a focus on the identification and reporting processes of VAP incidence in South Africa is necessary, in the national Infection Prevention and Control management (Mahomed *et al*., 2017). A recently published article provides a situational analysis of the current Infection Prevention and Control challenges in South Africa (Mahomed *et al*., 2017). A summary of the challenges reported was:

- In the public sector, surveillance activities are insufficient due to understaffing and the lack of knowledge due to insufficient training.
- In the private sector, human resources focusing on surveillance of hospital-associated complications are often insufficient
- The majority of surveillance activities in both the public and private sectors are laboratory-based, which is not ideally suited to the hospital environment.

South African hospitals will not develop an accurate understanding of the effects of VAP incidences on patient outcomes. An accurate understanding is formed through reliable identification and reporting processes in hospitals. The more is known on a subject, the more successful the preventative strategies

will be (Mahomed *et al*., 2017). South African hospitals also have to deal with the liability that incidences of the preventable hospital-associated complication VAP can pose. The only defence a hospital can offer if an incidence is identified is (McQuoid-Mason, 2019):

- Hospitals should be able to show proof of a formal organisational evidence-based strategy that aims to prevent and control incidences of VAP
- Hospitals should be able to show proof of implementation of the preventative strategy
- Nurses and other healthcare workers failing to comply with the implemented preventative strategy will be held liable for negligence

Neglecting to implement evidence-based infection prevention and control processes may result in harm to patients. Hospitals are required to provide a safe environment, where patients can receive hospital care, it would not only be negligent staff that could be held liable for negligent care, but also the hospital (McQuoid-Mason, 2019). Mahomed *et al* (2017) researched the challenges experienced in the implementation of hospital-associated complication surveillance and reporting processes Intensive Care Units (ICUs). A paper-based surveillance strategy was designed and implemented in eight Intensive Care Units (ICUs) to identify and report on the incidence of VAP, catheter-associated urinary tract infection and central line-associated bloodstream infection. Nurses and healthcare workers involved in the identification and reporting process received extensive training and the detail of the identification and reporting process was communicated to clinical and unit managers (Mahomed *et al*., 2017).

Mohamed *et al* reported the following challenges in the VAP incidence identification and reporting process:

- There were no formal identification and reporting processes found in any of the eight Intensive Care Units (ICUs).
- Clinical and Nursing Management supported the planned identification and reporting processes, however actual implementation of the process met the following barriers:
    - Insufficient human resources: nurses were not always enough to deal with the acuity of the unit and most of the ICUs did not have an administrative person assigned to collect the necessary data for surveillance
    - Inadequate control of the identification and reporting process, as it was implemented, so there was not enough time allocated to gather all the applicable data and follow up on all the tasks that had been allocated and implemented.
    - Ineffectively designed Information Technology, although some of the hospitals were using electronic information systems, the relevant information to recognise VAP, was not retrievable by the hospital staff.

- A paper-based identification and reporting process only increased the nursing workload, resulting in non-compliance to the data collection.
- Insufficient training to all the relevant staff, it is very difficult to train all the relevant staff at once, since an intensive care unit (ICU) has to be staffed 24/7, resulting in a tendency to expect training to be done from one nurse or healthcare worker to the next, one would train the next. Leaving the question of who was trained and who not, without formal allocated training attendance control.
- The actual identification and diagnosis of an incidence of VAP was usually done by the treating clinical physician, this caused a lack of standardisation of the identification and reporting of VAP incidence. The existence of a perception that the criteria provided by the Centers for Disease Control and Prevention (CDC) and the National Health Systems Network (NHSN) were found to be too strict, complicating the identification of VAP incidence.
- Poor quality of data had been reported, in that, not all the applicable clinical records were available electronically.

Hospital Information Technology (HIT) solutions have the potential to improve the quality of nursing care and patient outcomes, by realising the first preventative strategy reported by Fernando *et al.* (2017), which is real-time identification and reporting, resulting in early detection and warning functionalities. Early warning processes identifying deteriorating patient conditions can assist in the implementation strategy to prevent incidences of VAP (Singh & Sittig, 2016).

Real-time accurate, and reliable identification and reporting processes on VAP incidence could allow the hospital to develop valid, feasible strategies to measure safety concerns at the intersection that is made by Health Information Technology and patient safety. The Hospital Information Technology Systems (HITS) framework follows the principle of Quality improvement which is continuous identification, monitoring, and improvement (Fernando *et al*., 2017; Koy, Yunibhand & Angsuroch, 2016; Singh & Sittig, 2016).

2.9. ETHICAL AND LEGAL CONSIDERATIONS FOR HOSPITALS

VAP is a preventable hospital-associated complication. Evidence-based practice has proven that continuous preventative infection control processes and adherence to the VAP bundle of care would lead to a decrease of VAP incidence when caring for a patient receiving long-term mechanical ventilator treatment. The negative effect VAP has on the cost of care as well as patient outcomes can be significant. Hospitals without the proof of preventative strategies have the risk of being held liable for

negligent care (McQuoid-Mason, 2019; Sedevich-Fons, 2014). A preventative strategy should have the following elements and the hospital should be able to show proof of its implementation (McQuoid-Mason, 2019; Othman & Abdelazim, 2017):

- The introduction of evidence-based infection control processes
- The implementation of evidence-based infection control processes
- The hospital will be held vicariously liable for negligent or intentional failures by staff to comply with the implemented infection control processes.

2.10. CONCLUSION

Monitoring both the effectiveness and compliance to Infection Prevention and Control processes, including the identification, and reporting on VAP incidence are required to determine gaps in clinical practice. A hospital aiming to create a safer patient environment should be able to understand when corrective strategies are necessary, in other words, have access to reliable identification and reporting processes when it comes to VAP incidence while caring for a long-term mechanically ventilated patient. As seen from the literature discussed in this chapter, the implementation of an intelligent Hospital Information Technology (HIT) software solution using real-time clinical data, and evidence-based algorithms in the identification of VAP incidence could aid in the hospital's mandate to deliver quality care and work towards better patient outcomes.

3. DESIGN AND METHODS

3.1. INTRODUCTION

In Chapter 2 an in-depth overview of literature related to VAP was provided. Chapter 3 focuses on the research design and methods, including the setting in which the study was conducted.

3.2. RESEARCH DESIGN

A quantitative observational retrospective research design was followed to collect clinical data, using the clinical data from the databases of Bluebird and SAP. Quantitative research is associated with the positivist paradigm (Polit & Beck, 2017). The researcher is using empirical evidence, found in objective reality, with no influence from the researcher. The purpose is to improve the understanding of the real-life situation, following a well-established plan. In this study, the guidelines provided by the Centers for Disease Control and Prevention (CDC) to determine incidences of Ventilator-associated Pneumonia (VAP) was used to analyse the reporting process in the hospital (NHSN - Patient Safety Component Manual, 2019). Retrospective data is known to be used to determine risk, it is also the recommendation of the CDC to use such data from an electronic hospital information system, to minimise influencing the results of the reporting process (Polit and Beck, 2017). The research had been done on the available 'real world' data, which was another characteristic of quantitative research (Polit & Beck, 2017).

3.3. UNIT OF ANALYSIS

The data for Objective 1 is the retrospective electronic clinical information on the reported incidences of VAP in a population of long-term mechanically ventilated patients, collected and reported on by the Infection Control Department of the hospital for the period of 1 November 2018 to 28 February 2019. The specific electronic hospital technology system that is used by the hospital, is the Bluebird System (Bluebird: Home, 2019). Data for Objective 2, was collected by the researcher, from both the Bluebird and the SAP (Hospital controlling with SAP system solution, 2019) systems. The SAP system is the debtor system, used by the private hospital to invoice the patient for the hospital event, which contains data verified by numerous audit processes (Certifications and Compliance | SAP Trust Center, 2019).

Commented [NS1]:

The researcher will select the applicable population for the calculation of a VAP rate for the selected period from the SAP system. The clinical parameters needed to complete the CDC guidelines on the calculation of incidences of VAP (NHSN - Patient Safety Component Manual, 2019) for this selected population was collected from the available information in the Bluebird system.

3.3.1. INCLUSION AND EXCLUSION CRITERIA FOR APPLICATION POPULATION

The population criteria applicable to the reporting of VAP incidences in a hospital is very specific and clearly described by the CDC guidelines (Aljezawi *et al*., 2019; (NHSN - Patient Safety Component Manual, 2019). The population has to be collected from an in-patient adult intensive care unit. Patients younger than eighteen in an adult unit, should be excluded, but patients older than eighteen, who are nursed in a paediatric intensive care units, should be included in the study (NHSN - Patient Safety Component Manual, 2019).

Monitoring of mechanically ventilated patients who had been transferred to another facility or discharged, while still receiving mechanical ventilation treatment should be stopped after leaving the hospital, however technically if a patient should present with a VAP within two days after the discharge or transfer, the incident should be reported as an incident of VAP, that can be associated with the nursing care of the discharging hospital, the additional ventilation days, that had been cared for outside the hospital, does not need to be included in the total number of applicable mechanical ventilation days (NHSN - Patient Safety Component Manual, 2019). An event that can be included as a long-term mechanical ventilation event, if the patient had been receiving the treatment for at least four calendar days, where the day of intubation and initiation of the treatment is counted as day one. The earliest date for the start of a possible incident of VAP would then be day three of the long-term mechanical ventilation event (NHSN - Patient Safety Component Manual, 2019).

A break in mechanical ventilation of at least one full calendar day, followed by reintubation and re-initiation of mechanical ventilation during the same hospitalisation, defines a new episode of mechanical ventilation or a new mechanical ventilation event (NHSN - Patient Safety Component Manual, 2019).
Mechanically Ventilated patients who are receiving high-frequency ventilation, non-invasive mechanical ventilation and/or extracorporeal life support or extracorporeal membrane oxygenation are excluded from the population.

The Mann-Whitney U test was used to compare the number of mechanical ventilation days found in the different information technology systems (therefore for Objective 1 and 2) (Polit & Beck 2017). The Mann-Whitney U test is used to test whether two samples are likely to derive from the same population (i.e., that the two populations have the same shape)**.** The reason for this is to establish whether the samples from the two objectives were similar, especially because that would be what is expected, because the selection parameters for the two objectives are exactly the same (Polit & Beck 2017).

3.3.2. INCLUSION AND EXCLUSION CRITERIA FOR CLINICAL DATA

The clinical data criteria applicable to the reporting of VAP incidences in a hospital is also very specific and clearly described by the CDC guidelines (Aljezawi *et al*., 2019; NHSN - Patient Safety Component Manual, 2019). Figure 3-1 shows the specific applicable clinical data, needed to identify an incident of VAP, in a flow diagram (also view diagram in Annexure C3) (NHSN - Patient Safety Component Mal, 2019)

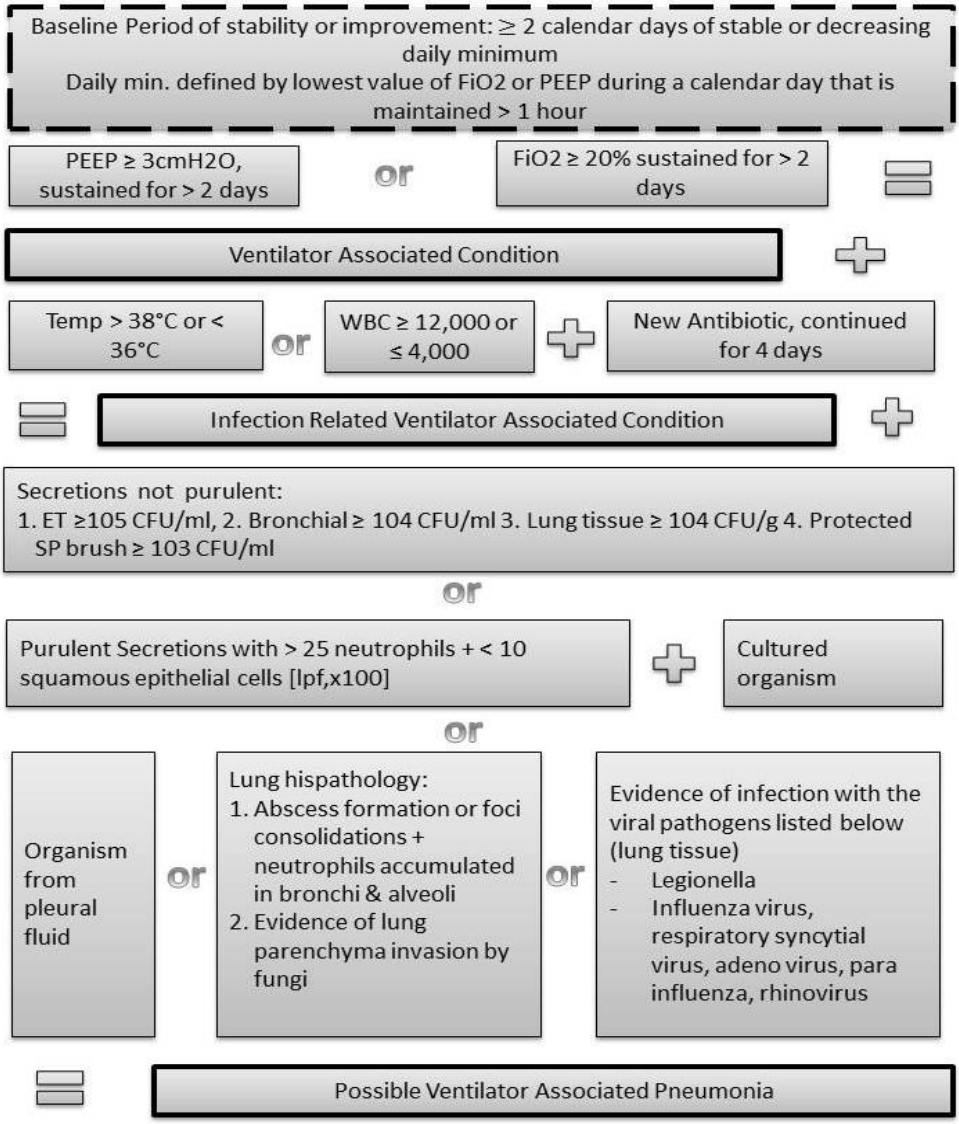


Figure 3-1: Clinical data to identify an incident of VAP

3.4. SAMPLING METHODS

Accurate reporting of VAP incidence should be done on as much information as possible. Since the CDC guideline on the calculation of VAP incidence is based on the principles of using empirical data, which can be captured on electronic information technology systems, total population sampling is indicated. Total population sampling was used, it is a type of purposive sampling where the whole population is of interest and is therefore included, considering the excluding criteria mentioned in the unit of analysis (Total Population Sampling - Statistics How To, 2019). Total population sampling is only possible if the population was a manageable size and the specific characteristics of the population were very clearly defined, which applies to this study (Mitchell & Gardner, 2014; Rosenthal, 2016; Total Population Sampling - Statistics How To, 2019). Both Objective 1, where the Bluebird system calculates the incidence of VAP during the selected period, as well as Objective 2, where the population is selected by the researcher from the SAP system, use the same sampling method, with the same inclusion and exclusion criteria on the available information from the different systems (Bluebird: Home, 2019; Hospital controlling with SAP system solution, 2019).

A total number of 1102 (n = 1102) patients were admitted to the three adult intensive care units (ICUs) of the private Hospital for the retrospective period of 1 November 2018 – 28 February 2019.
For Objective 1: Using the inclusion and exclusion criteria, the sample size was twenty-six (26) as collected from the available data in Bluebird System. A sample size of sixty-one was identified for Objective 2 using the available data in the SAP system.

3.5. DATA COLLECTION

3.5.1. OBJECTIVE 1

Explore and describe the reported VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019) using the existing hospital information technology software, Bluebird (Bluebird: Home, 2019)

The Infection Prevention and Control (IPC) department of the private hospital uses the electronic web-based Hospital Information Technology (HIT) software namely Bluebird (Bluebird: Home, 2019) to report on the incidences of VAP. This software has been programmed and configured by Intelligent Medical Systems (Pty) Ltd, an information technology organisation. The Bluebird database is populated

by specific processes in the hospital, the demographic information of patients are imported electronically into Bluebird from SAP (Hospital controlling with SAP system solution, 2019), the laboratory information is imported from the laboratory systems, the information on antibiotic treatment is also imported from SAP and the device days and vital data are captured by the nurses who care for the long-term mechanical ventilated patients in the unit. Nurses would log on with their employee numbers and a password as can be seen on the screen sample of Annexure D1, thereafter they will access the capture screens where they will capture the device days and applicable clinical information (view Annexure D5 and D6).

Annexure D3 shows the screen where the VAP incidence report can be selected by any user who has access to the functionality, the selected period and applicable unit can be selected from the VAP incidence report and can then either be viewed on the screen or a hard copy of the report can be printed. Annexures D2 and D7 are two more sample screens that allow the user access to view the available information on the database of the Bluebird System (Bluebird: Home, 2019).

To generalise the results of a study and apply them to an identified population, a selection process was required. This selection process, whereby a portion of a population is chosen to represent the whole population, is known as sampling (Polit & Beck, 2017:743). The setting was discussed in Chapter 1, section 1.8.

The sampling of the three ICUs in one private hospital for inclusion in the study was done using purposive sampling. Purposive sampling is where similar characteristics of the participants are determined for inclusion in the sample (Botma *et al*, 2015:126). Purposive sampling draws on the researcher's knowledge about the population to make selections (Polit & Beck, 2017:254). The purposive sampling in this study was based on the researcher's knowledge of the hospital's average patient volumes and nurse categories performing nursing care. Within these settings, the sampling of the unit of analysis was done.

3.5.2. OBJECTIVE 2

Explore and describe the VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019), by combining the electronic information available using hospital information technology software systems used in the hospital, namely SAP (Hospital controlling with SAP system solution, 2019) and Bluebird (Bluebird: Home, 2019).

The researcher used the same inclusion and exclusion factors as the data for Objective 1, using the CDC guidelines. The population was however not selected from the Bluebird data but was extracted from the SAP system database, using the invoicing information for the mechanical ventilation days. The clinical parameters however were extracted using the list of patients with long-term mechanical ventilation events and sourcing the available clinical parameters to determine the incidence of VAP for the period from Bluebird (Bluebird: Home, 2019; Hospital controlling with SAP system solution, 2019; NHSN - Patient Safety Component Manual, 2019). The rationale behind following a well-researched and evidence-based algorithm described in detail by the CDC enabled the use of objective, measurable and comparable data, that was used for the reporting of VAP incidences, with the available data in the electronic hospital information technology systems. (Aaron *et al.*, 2018; Rosenthal, 2016). International and national healthcare governing organisations support the VAP identification algorithm (NHSN - Patient Safety Component Manual, 2019) as supplied by the CDC so that the results of the reporting processes on VAP incidences in different social and economic spheres can be compared and that there would be a 'gold' standard that could guide decisions on whether infection control interventions were successful or needed revision (Aljezawi *et al.*, 2019; Edwardson & Cairns, 2019). The process the researcher followed to collect the data for the population of long-term mechanically ventilated patients for the period 1 November 2018 to 28 February 2019 is shown in figure 3-2.

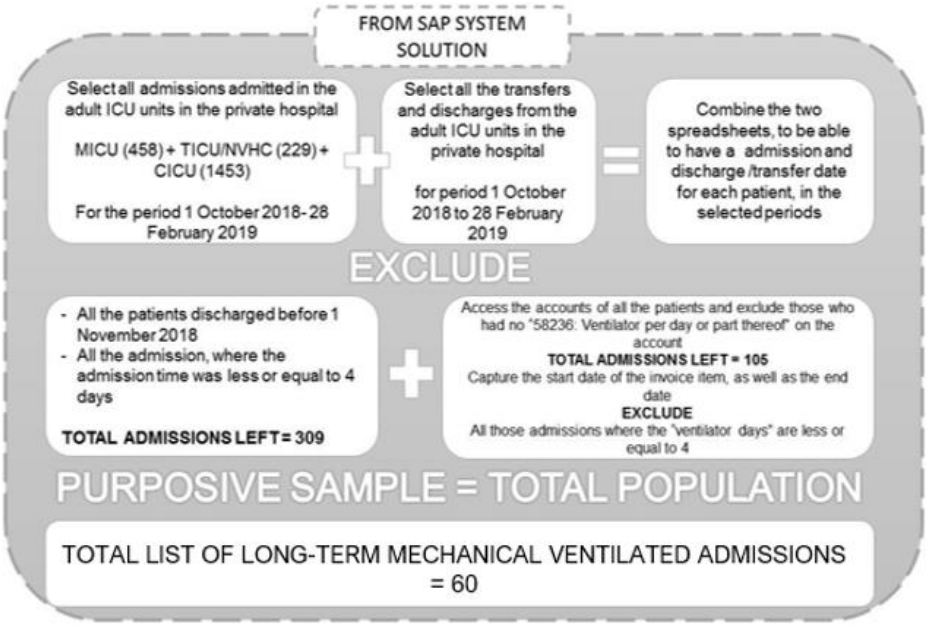


Figure 3-2: Graphical representation of population sample of objective 2

The steps graphically presented in figure 3-2 are as follows:

1. All the patients who had been admitted and discharged in the retrospective period from 1 October 2018 to 28 February 2019 in the three adult ICUs of the private hospital were selected from the SAP system. The reason for the extended period is to make sure that a patient where long-term mechanical ventilation treatment was commenced in October and extended into the selected period, that these patients' applicable ventilation days are not missed. If there were a patient whose treatment had been commenced in September and it continued into November, the selection period had to include September as well, however, there were no such treatment events, hence the selection from 1 October 2018 to 28 February 2019 was sufficient.

2. As per the inclusion and exclusion criteria described by the CDC guidelines (NHSN - Patient Safety Component Manual, 2019) all the long-term invasive mechanically ventilated patients were selected for the period 1 October 2018 to 28 February 2019. These were identified by using the data whereby the mechanical ventilated days were invoiced at a daily rate. Therefore, all the patients who had been invoiced with the code '58236 Ventilator per day or part thereof' for more than four consecutive

days, were selected, making sure the start and end dates were collected, to identify mechanical ventilator days.

3. The sample containing the long-term mechanical ventilation patients was then listed with demographical information indicating the age of the patient, the unit of admission, as well as the speciality of the main diagnosis of the admission event. The clinical data needed to populate the algorithm to determine incidences of VAP, as described by the CDC (Annexure C3; figure 3-1) was then extracted for every patient in the sample using the electronic data available from the Bluebird system (Bluebird: Home, 2019). The clinical data was captured into a datasheet, which can be seen in Annexure C2.
    a. *Note that the form showed in C2 is just the format, the data were captured on different spreadsheets so that multiple values and dates could be captured per patient. For example, every day of mechanical ventilation days should have PEEP and FiO_2 linked to it.*
    b. *Figure 3-3 shows the parameters of clinical data that was extracted for each of the long-term mechanically ventilated patients from the Bluebird system (Bluebird: Home, 2019)*.
4. The researcher realised that to be able to get a better understanding of the research process used to achieve Objective 1, the captured device days on Bluebird should be available for analysis, the report provided by the Bluebird system, does not provide this information, it only provides a VAP rate, so the device days captured for Mechanically Ventilated patients in Bluebird was also collected as part of the clinical data for every patient in the sample.

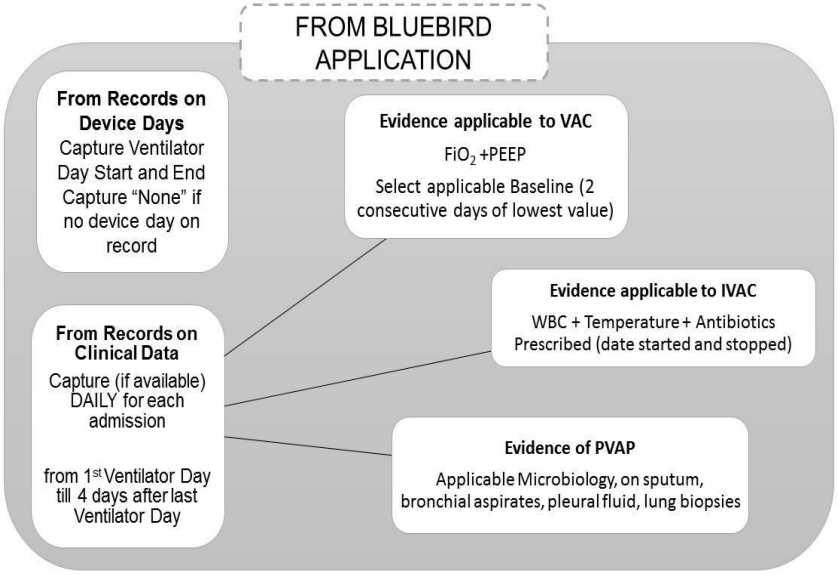


Figure 3-3: Presentation of parameters collected from ©Bluebird

The steps represented in figure 3-3 to extract the clinical data from the Bluebird System were:

1. A mechanical ventilator day count was captured under every day the patient received mechanical ventilation treatment, if there were days where there an interruption in the invoicing days, it meant that the treatment was stopped for a few days and if another set of mechanical ventilation days were invoiced, it meant that a patient had two separate events of long-term mechanical ventilation treatment events in one admission event and the count was restarted at one when the second mechanical ventilation event was commenced.
2. The applicable clinical data was then extracted and organised under the applicable mechanical ventilation treatment day count.
    a. *Fraction of Oxygen (FiO_2) captured per day by the nurses and other healthcare workers in the hospital, into the Bluebird software. An example of the capture screen can be seen in Annexure D6.*
    b. *Fraction of Oxygen (FiO_2) capturing by users was not the only method of populating this clinical information into the software. The phlebotomy nurses who captured the Arterial Blood Gas (ABG) results into the laboratory information technology software, also captured the applicable FiO_2 at the time of the test for the patient at different times of the treatment.*

c. *PEEP (Post End Expiratory Pressure) captured in the day-to-day processes of the hospital VAP incidence identification processes on a screen similar to the one seen on Annexure D6*
d. *The White Blood Cell Count (WBC) results in cells/mm³ imported into the Bluebird software from the information technology software used by the pathology laboratory.*
e. *The body-temperature results captured into the Bluebird software by the nurses and healthcare workers in °C*
f. *The start and end dates of the antibiotic treatment started during the retrospective period, imported from the SAP software, where the dispensing information was being captured by pharmacists during dispensing.*
g. *All available Microbiological Culturing and Screening Sensitivity (MCS) results on respiratory samples, imported into the Bluebird software, from the laboratory information technology software, as well as the quality parameters specified by the CDC (Preventing Healthcare-associated Infections | HAI | CDC, 2019).*

3.6. DATA ORGANISATION

3.6.1. OBJECTIVE 1

Explore and describe the reported VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019) using the existing hospital information technology software, Bluebird (Bluebird: Home, 2019).

The data that is used for the identification of incidence of VAP in the hospital, is imported and captured into the Bluebird (Bluebird: Home, 2019) hospital information technology system as part of the reporting process used in the private hospital, to manage the quality of nursing care, when it comes to preventing incidences of VAP. The CDC described VAP algorithm (NHSN - Patient Safety Component Manual, 2019) was programmed into the intelligence of the information technology system, therefore when the data is imported or captured into the system, it would be ready to be used in the algorithm and a VAP incidence report will be provided using the available data in the system. Electronic data management is a preferred method of assessing the risk of VAP incidence (Mahomed *et al*., 2017; NHSN - Patient Safety Component Manual, 2019; Redondo-Gonzalez *et al*., 2018; Singh & Sittig, 2016; Sullivan, 2015).

3.6.2. OBJECTIVE 2

Explore and describe the VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019), by combining the electronic information available using hospital information technology software systems used in the hospital, namely SAP (Hospital controlling with SAP system solution, 2019) and Bluebird (Bluebird: Home, 2019).

The researcher had to organise and summarise the sample and the clinical data collected for Objective 2, into one Microsoft Excel spreadsheet. The data was listed in a Microsoft Excel spreadsheet, to supply the biostatistician with empirically clear data (NHSN - Patient Safety Component Manual, 2019).
The researcher organised the clinical data collected per patient to list all the clinical data as linked to a specific mechanical ventilation day by creating a spreadsheet for every patient identified as a long-term mechanically ventilated patient during the period of 1 November 2018 to 28 February 2019. A column was created for every day the patient had been receiving mechanical ventilation, until four days after the treatment was discontinued. A day counter was created in the row below the applicable ventilation dates so that the researcher would be able to identify the day of the mechanical event, a clinical record should be applied to. Figure 3-4 shows that day three of this mechanical ventilation event had no clinical values captured or imported into the bluebird system, the specific patient this data belongs to was identified by the identification key, which was the hospital number, which was assigned as the spreadsheet name.

	2018/12/14	2018/12/15	2018/12/16	2018/12/17	2018/12/18	2018/12/19	2018/12/20	2018/12/21	2018/12/22
	1	2	3	4	5	6	7	8	9
FiO_2 as %	100	60	Unknown	60	50	60	35	35	40
PEEP as cmH_2O	12	13	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
WBC as per 1000	13	23.5	Unknown	9	5.2	3.9	5.9	5.9	6.6
Temperature as °C	34.5	35.1	Unknown	36.1	35.6	36.7	37.1	37.1	37.5

Figure 3-4: Patient clinical data from the sample

After the clinical parameters were sorted per the specific mechanical ventilator treatment day, the researcher followed the rules supplied by the CDC as signs of significant clinical deterioration, to be identified and included in a summary spreadsheet, which would provide empirical data that could be analysed by a biostatistician. This process of data organisation will be discussed under Data analysis and interpretation of Objective 2, to attempt a better understanding of the process.

3.7. DATA ANALYSIS AND INTERPRETATION

The data collected for Objective 2 also included the captured device days that were available in the Bluebird system, to get a better understanding of the process of data collection and reporting of Objective 1, because the Bluebird system does not provide a report indicating the exact device days applicable to the calculation of the VAP rate, it only provides the VAP rate after implementing the CDC VAP algorithm.

3.7.1. ANALYSIS OF DEMOGRAPHIC INFORMATION OF SAMPLE

Since the samples used in Objective 1 and 2, were collected respectively from Bluebird and SAP systems, the researcher provided the biostatistician with a spreadsheet, showing the Mechanical Ventilation initiation and discontinued dates for both samples, for analysis and interpretation with descriptive statistics and frequency statistics, including central tendency and variable distribution. This would include mean values, as well as standard deviation. The rationale behind this was to attempt to achieve a better understanding of population distribution, the differences between the two samples for objective 2 were analysed with inferential statistics, as explained in Polit and Beck, 2017. The data was submitted to biostatistician in Microsoft Excel format and the statistical analysis calculations were also done in this application.

Objective 1:

Describe the reported VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019) using the existing hospital information technology software, Bluebird (Bluebird: Home, 2019).

The data analysis for objective 1, is done by the programmed electronic intelligence of the Infection Prevention Control (IPC) functionality of the Bluebird software (Bluebird: Home, 2019) and reported in Chapter 4, as reported by the Bluebird and used by the hospital nursing management and IPC department.

Objective 2:

Explore and describe the VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019), by combining the electronic information available using hospital information technology software systems used in the hospital, namely SAP (Hospital controlling with SAP system solution, 2019) and Bluebird (Bluebird: Home, 2019).

After the clinical data was sorted per mechanical ventilation day, the rules supplied by the CDC Guidelines were applied to the data to create a summary excel spreadsheet, which was discussed and with the CDC VAP algorithm supplied electronically to the biostatistician to assist the researcher with statistical data analysis and interpretation of VAP incidence to answer Objective 2.
Annexure E1 shows a screenshot of the summary data provided to the biostatistician with the Centers for Disease Control (CDC) Algorithm as shown in Annexure C3 to calculate the incidences of VAP from the available data. The steps that were followed to create the summary spreadsheet, providing the clinical information needed to apply the CDC algorithm is the following:(the results of the application of the VAP algorithm are also explained following the same steps under Objective 2 in Chapter 4, to enable continuity in the interpretation).

Step 1: Establishing Baseline per Mechanical Ventilation event

Figure 3-5 shows the summary of the CDC algorithm guideline to identify a baseline needed for identifying incidents of deterioration in clinical condition, needed to report on incidences of VAP.

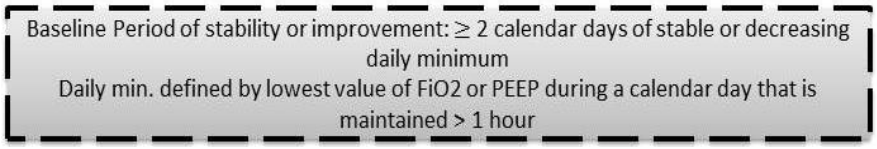


Figure 3-5: Baseline description applicable to CDC VAP Algorithm

The researcher applied the rules to each of the patients in the sample selected for Objective 2 and captured a baseline PEEP and or FiO_2 value on the summary spreadsheet where it was available. Figure 3-6 shows how the baseline values were reported. Note in this sample there was only one value per parameter found per mechanical ventilation event or none. It would be possible to have more than one baseline value, where one value would apply to a set of mechanical ventilator days' clinical data and the other for a different set of mechanical ventilator days, this would happen if the patient's condition improved and deteriorated more than once during a ventilation period, with different baseline values. Also note that the FiO_2 values are captured as fraction values and not percentage values as was done in the spreadsheets, explained under data organisation, to comply with the terminology of FiO_2 which is the fraction of Oxygen and not a percentage.

BASELINE	
FiO2	PEEP
0,6	UNKNOWN
0,6	12
0,4	15
UNKNOWN	UNKNOWN
0,65	UNKNOWN
0,36	5
0,4	10
0,4	UNKOWN

Figure 3-6: Sample VAP Algorithm Baseline values per patient/Mechanically ventilated event

Figure 3-7 shows the parameters provided by the CDC guideline for the VAP algorithm to report on incidences of VAP. The CDC provided more than one parameter that can be used in this step since it is an identified fact that if data is captured manually as in the case of this hospital, there is a possibility that some of the data could be incomplete. Actual treatment protocols may also differ from specialist to specialist, therefore the CDC suggests that both the PEEP as well as the FiO_2 values have to be monitored to identify possible incidences of VAP (Kaier *et al*., 2014; Larsson *et al*., 2017; Mahomed *et al*., 2017; Rosenthal, 2016; Sahlol, Madkour & Soliman, 2016).

The researcher applied this rule on the available clinical data on PEEP and FiO_2 for each of these patients and reported the findings in the summary sheet per patient in the sample. Annexure E1 shows a picture of a sample of the summary sheet.

Figure 3-7: VAP Algorithm parameter needed to identify possible incidents of VAP

VAC	
FiO2	PEEP
4;5;6	UNKNOWN
NONE	UNKNOWN
11;12;13	UNKNOWN
UNKNOWN	UNKNOWN
UNKNOWN	UNKNOWN
UNKNOWN	UNKNOWN
UNKNOWN	UNKNOWN
2;3;4;5	NO;UNKNOWN

Figure 3-8: Sample of incidents where parameters of step two of VAP Algorithm was applicable

Figure 3-8 shows how the applicable mechanical ventilation event days that were adhering to the CDC guidelines were organised on the summary sheet.

Note: As per the CDC guidelines this deterioration of Clinical parameter had to continue for more than two days, to be a valid identifier for a Ventilator-associated Condition, also this deterioration could start after day three of mechanical ventilation event but had to continue for more than two days after. In the first line, the FiO_2 values deteriorated by more than 20% from the baseline on day four, five and six of mechanical ventilation of that event. In the last line, it can be seen that the deterioration started on day two and continued for more than two days, because the deterioration started on day two, it would not be a valid indication of deterioration due to a Ventilator-associated Condition. The researcher differentiated the different days, with semi-colons to enable the biostatistician to easily import the values into an electronic database or formula.

Step 3: Applying VAP algorithm parameters to determine Incidences of Infection-related Ventilator-associated Conditions

The researcher followed a similar process followed in step 2 for step 3, by using the available clinical records per patient and/or mechanical ventilation event in the sample. Figure 3-9 shows the content of this step in the CDC guidelines for identifying and reporting on the incidence of VAP in a hospital.

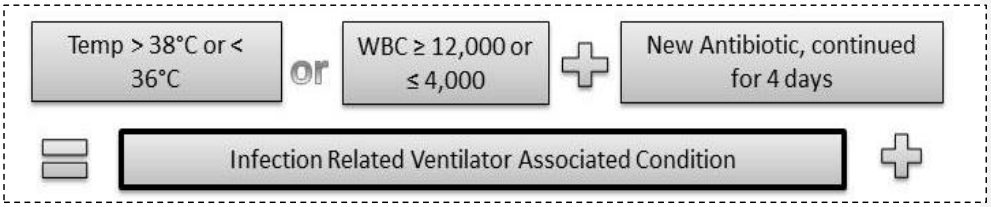
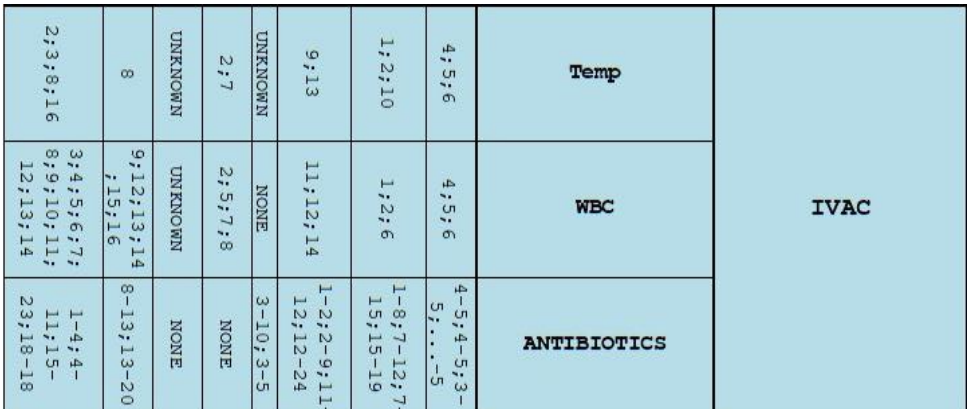


Figure 3-9: Parameters applicable to identify incidents of IVAC

Figure 3-10 is a picture showing the mechanical ventilator days for some of the samples, where the above guidelines applied to the clinical data. The different days were once again separated with a semi-colon to allow for electronic manipulation of data by the biostatistician.

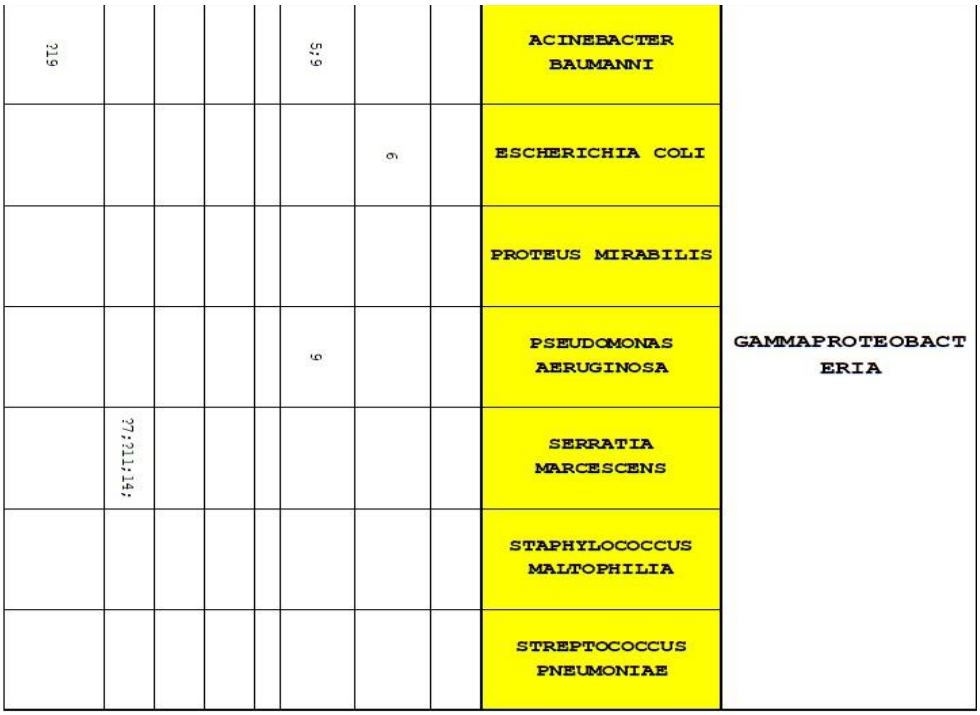


IVAC			
Temp	WBC	ANTIBIOTICS	
4;5;6	4;5;6	4-5;4-5;3-5;...-5	
1;2;10	1;2;6	1-8;7-12;7-15;15-19	
9;13	11;12;14	1-2;2-9;11-12;12-24	
UNKNOWN	NONE	3-10;3-5	
2;7	2;5;7;8	NONE	
UNKNOWN	UNKNOWN	NONE	
8	9;12;13;14;15;16	8-13;13-20	
2;3;8;16	3;4;5;6;7;8;9;10;11;12;13;14	1-4;4-11;15-23;18-18	

Figure 3-10: Sample of Patient/Mechanical ventilation events

Note that in the antibiotic column, the course time was indicated, for example in the first row, there were four different antibiotic treatments received by the patient. One was received only for days four and five of mechanical ventilation treatment, this treatment wouldn't have applied to the VAP algorithm, because the CDC guideline states that it should be continued for more than four days. The one incident was indicated as '…-5', which was explained to the biostatistician to mean that the antibiotic was started before day one of mechanical ventilation and continued until day five of mechanical ventilation, this course of antibiotic is therefore also not applicable to the VAP algorithm. The detail of the specific antibiotic treatment was not listed, because this is not the focus of the reporting process on identifying incidences of VAP.

Figure 3-11 Sample of patients and/or mechanical ventilation events where the clinical data showed the relevant deterioration



?19					5;9			ACINEBACTER BAUMANNI	
						9		ESCHERICHIA COLI	
								PROTEUS MIRABILIS	
					9			PSEUDOMONAS AERUGINOSA	GAMMAPROTEOBACTERIA
	??;?1;14;							SERRATIA MARCESCENS	
								STAPHYLOCOCCUS MALTOPHILIA	
								STREPTOCOCCUS PNEUMONIAE	

Figure 3-11: Sample of Summary sheet showing cultured Micro-organisms per patient/mechanical ventilator event

Table 3-11 shows the resulting organisms from the microbiological screening tests that had been done periodically during the selected period. Identifying specific organisms linked to a VAP is part of the guidelines supplied by the CDC (NHSN - Patient Safety Component Manual, 2019). The table shows a screen shot of the collected data on microbiological screening results. The numbers in the tables indicate the day of ventilation of the sample that had been tested where a specific organism had been identified.

Step 4: Applying the final algorithm guideline to determine the incidence of a Possible ventilator-associated Pneumonia

Figure 3-12 shows the last step of the guideline provided in the VAP algorithm supplied by the CDC.

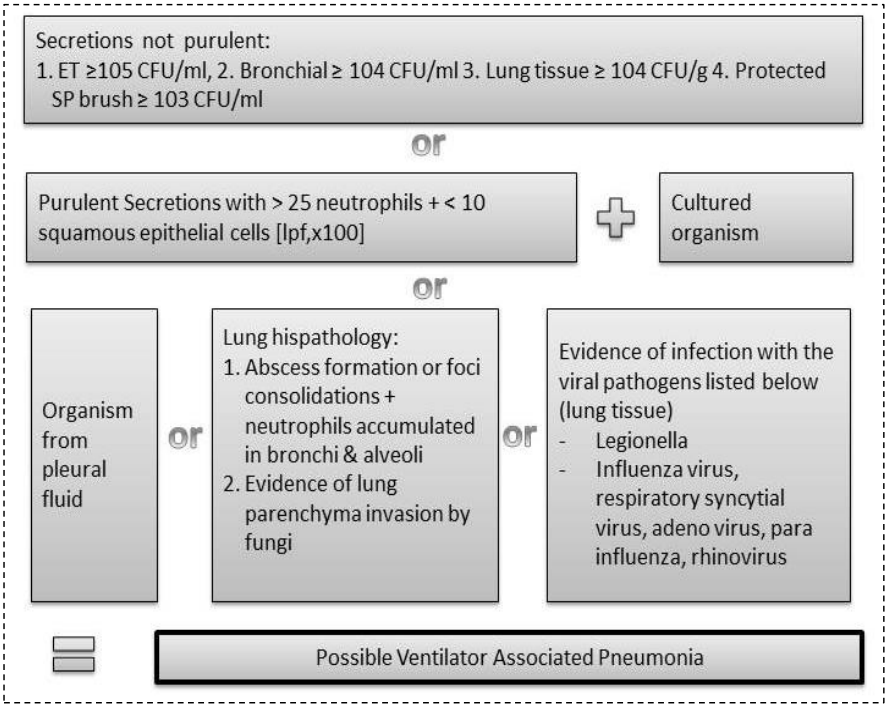


Figure 3-12: Final step of VAP Algorithm

Once again, the researcher listed the applicable mechanical ventilation days in the summary sheet per event. However, given that there are rules applicable to the type of organisms identified, the researcher decided to list the detail of the actual organisms that were found per event. Figure 3-12 shows how this was organised into the summary sheet. Note that there are days which is preceded with a '?', this is where the results identified an organism, but the guideline on the quality of the sample was not adhered to. For example, the purulent secretions had < 25 neutrophils and/or > 10 squamous epithelial cells [lpf, x100].

Calculation of the VAP incidence

The calculation of the VAP incidence for reporting was done with the assistance of a biostatistician by discussing the descriptive statistics from the available clinical parameters, considering the available and missing records and describing as far as possible the impact on the available records of the algorithm specified by the CDC (NHSN - Patient Safety Component Manual, 2019). The researcher was then able to comment and describe the samples found in both objectives, as well as the reporting processes and the available data found from the retrospective period in the Bluebird Hospital Information Technology (HIT) software, as well as the records found in the SAP Hospital Information Technology (HIT) software, using the distribution statistics found in Objective 2 and the discussion of the demographical statistics of the two objectives.

3.8. VALIDITY AND RELIABILITY OF INSTRUMENT

Validity and reliability of the instrument, which is the VAP algorithm (Annexure C3), supplied by the CDC guidelines (NHSN - Patient Safety Component Manual, 2019) had to be followed in the implementation of the research plan, to enable the ability to use the conclusions and recommendations in future research or the use of comparisons against similar research in the same and other hospitals nationally and internationally (Polit & Beck, 2017). For this reason, the researcher had to consider threats to the validity of the research, both internal and external (Polit & Beck, 2017).

3.8.1. INTERNAL VALIDITY

Internal validity should be secured by answering the question of whether the instrument used in the research actually answered the research question (Polit & Beck, 2017). The factors of internal validity that had been considered were:

History

The threat that history could pose to the research would be that external interventions affecting the results, but unrelated to the research could have been implemented at the same time the data was collected, this would influence the reliability of the 'real-world' information that would be important to this study (Polit & Beck, 2017), for example, if there had been an active campaign to improve clinical practice, especially around the adherence of the VAP bundle or if additional personnel were employed to assist with the managing and capturing of relevant data into the electronic healthcare management software, during the retrospective period chosen for the study. The threat of history described above would mean that the result of this study would not represent the 'real-world' and would therefore be an

unreliable representation of the reporting process on incidences of VAP in the Hospital during the retrospective period.

The data collection for this study was done on retrospective data, which was captured during the period 1 November 2018 – 28 February 2019, without any of the nursing and healthcare workers involved in the process of data capturing the clinical parameters, however, when it came to the identification and reporting of VAP incidence they were aware of the research that was going to be conducted on the process. There were no implementation interventions or awareness campaigns focused on improving clinical practice during surveillance of the VAP incidence at the hospital during this period. All the data represented used the available 'real-time/real-life' information gathered/collected from the Hospital Information Technology (HIT) software currently used to report VAP incidents.

Maturation

Maturation would be the threat that the passage of time could have on the outcome of the results. The purpose of this study was to explore the reporting process on VAP incidence while treating adult patients on long-term mechanical ventilator treatment in a private hospital (Polit & Beck, 2017).

If the reporting process in the hospital was initiated during the chosen retrospective period, then it would not be fair to explore the process, because there would always be changes in management processes that would have to be managed with the implementation of a new operational process in the hospital. A study done on the process of a newly implemented process could only be compared against other studies on newly implemented processes in the same clinical operational area.

The VAP incidence identification process had been implemented in the private hospital in 2015 and all the applicable users in the hospitals had the opportunity to receive training and had access to the Hospital Information Technology software, called Bluebird. There were also no reported operational challenges that had been experienced during the selected retrospective period, which would have influenced the threat posed by maturity. The threat posed by long-term mechanical ventilator treatment in that it would be expected that particular clinical parameters and condition improvements would be expected after a particular time was addressed by the specific and clear guidelines provided by the CDC and used in the Hospital to identify incidences of VAP and report on it by using the intelligent Hospital Information Technology (HIT) software called Bluebird (NHLS: Annual Report, 2016)

Differential Selection of Participants

The specific parameters necessary to identify a probable or possible incidence of VAP had been provided by the CDC (Lowman *et al*., 2016). The specifications, as well as the fact that the research design and method had been quantitative using total population sampling, allowed the researcher to include the entire applicable population adhering to the specification of the VAP algorithm (Annexure

C3). Due to time constraints of the study, the chosen cross-section period was only three months, excluding any of the adult long-term mechanical ventilator treatment events would pose a serious threat to the validity of the study when it came to the differential selection of participants (Torres *et al*., 2017).

Testing of the Instrument

The instrument used was a well-researched algorithm that had been developed over years of international collaboration between various infection prevention and control organisations (Polit & Beck, 2017). The algorithm used was the well documented and described Ventilator-associated Events (VAE) algorithm, published by the CDC (Lowman *et al.*, 2016; *Preventing Healthcare-associated Infections | HAI | CDC*, 2019) (Annexure C3)

Attrition (Mortality)

Attrition was a factor that placed a threat to the internal validity of the study (Polit & Beck, 2017). The fact that some of the adult long-term mechanical ventilator treatment patients had been transferred to the private hospital from another hospital, where the treatment was started, had to be taken into consideration because this would mean that the date of admission into the hospital would not be the first day of mechanical ventilator treatment and any pre-existing organisms or complications could not be included as an incidence of VAP for that particular patient, only the incidents of deterioration in condition, as per the parameters of the VAP algorithm after the patient was admitted to the private hospital, would be considered as a possible incident of VAP, that had to be included in the VAP reporting process. The population of this retrospective study only had one such long-term mechanical ventilator event and any incidence of a Ventilator-associated Condition (VAC), within the first four days after the transfer, was not included in the results, to manage this threat, because any deterioration of condition that occurs within the first four days of the transfer could not be attributed with certainty to the clinical practice in the private Hospital.

3.8.2. EXTERNAL VALIDITY

Additional consideration was made for external validity, as it would be essential to note to what extent the results of the study could be generalised or comparable against similar studies across other sections, which could be different retrospective periods in this hospital or other hospitals, nationally or internationally. According to Polit & Beck (2017), described three basic types of external validity, which would have to be considered:

Population validity

The selection parameters for the population in this study were as mentioned before, during the discussion of the internal threat of differential selection, by using the guidelines provided and published by the CDC to determine the inclusion and the exclusion factors applicable to this population. It would also be the exact same parameters that any hospital, nationally or internationally, which report on the VAP incidence in their hospitals, as per the guidelines of the CDC would use (Rosenthal, 2016).

The researcher also used total sampling, because the instrument had clear quantifiable parameters and the data that was used had been selected from the Hospital Information Technology (HIT) software used in the day to day processes of the hospital (Polit & Beck, 2017).

There had been no research bias in the selection of the population, the only choice the researcher made had been on the size of the population and the exact period that had to be included in the retrospective parameters of the study. This choice was guided after an interview and discussion with the biostatistician, Mrs Joyce Jordaan, who indicated that the sample had to consist of at least twenty-five (25) adult long-term mechanical ventilator treatment events and a minimum of a hundred (100) long-term mechanical ventilator treatment days, which had been covered in the chosen retrospective period of 1 November 2018 to 28 February 2019.

Interactions Between Causal Effects

The research question had been answered using descriptive research. Polit & Beck (2017) explained that descriptive research would not attempt to find the cause of a phenomenon, but the objective is to explore and describe a phenomenon.

3.9. SUMMARY

Chapter 3 provided an in-depth discussion on the research methodology that was followed in answering the research question. In Chapter 4 the research findings found following the research design and methods would be discussed.

4. RESULTS

4.1. INTRODUCTION

Chapter 3 focused on the research design and methods used to answer the research aim and objectives. Chapter 4 provides an overview of the study results.

***Note**: The hospital denied access to patient files to verify and add to the data captured in the Bluebird and SAP system.*

4.2. DEMOGRAPHICAL DATA ON RESEARCH SAMPLE

A total number of 1102 (N = 1102) patients were admitted to the three adult intensive care units (ICUs) of the private Hospital for the retrospective period of 1 November 2018 – 28 February 2019.
For Objective 1: Using the inclusion and exclusion criteria, the sample size was twenty-six (26) as collected from the available data in Bluebird System. A sample size of sixty-one (61) was identified for Objective 2 using the available data in the SAP system. Table 4-1 below shows the demographical information for both objectives.

Table 4-1: Summary of Demographical information for objective 1 and objective 2

Variables	Objective 1 Bluebird n=26 (%)	Objective 2 SAP n=61 (%)
Totals		
Number of patients	26	60*
Number of long-term mechanical ventilator treatment events	26	61*
Number of long-term mechanical ventilation days	650	954
P-value comparing number of long-term mechanical ventilation days between objective 1 and 2	0.011	
Mean age (SD) years	52.56 (14.8)	57.16 (17.2)
Unit description (number)		
MICU	12 (46%)	32 (52.5%)
TICU	12 (46%)	23 (37.7%)
CICU	2 (8%)	6 (9.8%)
Diagnostic speciality (number)		
Cardiac condition	3 (11.5%)	7 (11.5%)
Gastro-intestinal condition	0	2 (3.3%)
Medical (infection)	2 (7.7%)	3 (4.9%)
Metabolic condition	1 (3.9%)	4 (6.6%)
Neurological (haemorrhagic)	5 (19.2%)	9 (14.8%)
Neurological (trauma)	3 (11.5%)	3 (4.9%)
Neurological condition	1 (3.9%)	2 (3.3%)
Oncology	0	2 (3.3%)
Post-surgery	2 (7.7%)	6 (9.8%)
Post-trauma	3 (11.5%)	6 (9.8%)
Renal condition	0	1 (1.6%)
Respiratory condition	4 (15.4%)	11 (18%)
Vascular condition	2 (7.7%)	5 (8.2%)

** Note that the difference in number between the number of patients and the number of long-term mechanical ventilation events, are not the same, because one patient had two incidents of long-term mechanical ventilation during one admission period in the hospital, therefore his patient identifier stayed the same, but he had two sets of treatment start and end dates for mechanical ventilation.*

The Non-Parametric Mann-Whitney test explained in Chapter 3 resulted in a reported p-value of 0.011, indicating a statistically significant difference between the two samples, comparing the number of long-term mechanical ventilation days. This is significant because the samples from the two objectives if reliable and complete data should have been exactly the same, because the same selection criteria were used, over the same period, for the same group of patients.

Forty-one per cent (41%) of the long-term mechanical ventilation events had been captured into the Bluebird system, showing that 59% of the events were missed and therefore were not considered by the hospital information technology system Bluebird as information related to incidents of VAP as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019).

4.3. OBJECTIVE 1

Explore and describe the reported VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019) using the existing hospital information technology software, Bluebird (Bluebird: Home, 2019).

The hospital implemented processes in the adult ICUs, where the applicable parameters necessary to monitor for incidences of VAP, have to be captured as part of the day-to-day nursing care processes in all the units. The Bluebird hospital information technology system has been designed to use the CDC guidelines and provide an instant VAP incidence report using the available clinical data (Bluebird: Home, 2019; NHSN - Patient Safety Component Manual, 2019). Annexure D1-7 show examples of screen prints available in the Bluebird system, to allow the reporting on VAP incidents for specific periods in each specific ICU. Table 4-2 shows the reported VAP incidents for the individual ICUs for the selected period.

Table 4-2: VAP incidents reported in ICUs

VAP, 'The Hospital' - Coronary ICU 01/11/2018 - 28/02/2019. ©Bluebird					
	Nov 2018	**Dec 2018**	**Jan 2019**	**Feb 2019**	**Total**
VAP	0	0	0	0	0
VAP, 'The Hospital' - Multi ICU 01/11/2018 - 28/02/2019. ©Bluebird					
	Nov 2018	**Dec 2018**	**Jan 2019**	**Feb 2019**	**Total**
VAP	0	0	0	0	0
VAP, 'The Hospital' - Trauma ICU 01/11/2018 - 28/02/2019. ©Bluebird					
	Nov 2018	**Dec 2018**	**Jan 2019**	**Feb 2019**	**Total**
VAP	0	0	0	0	0

The reported incidence of VAP events as per the retrospective data captured in the Bluebird Hospital Information Technology (HIT) software in the ICUs, showed no identified VAP incidents for the period of 1 November 2019 to 28 February 2019 in all the ICUs (Bluebird: Home, 2019). Internationally hospitals report on incidents of VAP, as a VAP rate, therefore the researcher also extracted the reports from Bluebird Hospital Information Technology (HIT) software, where the software calculated VAP rate per 1000 long-term mechanically ventilated days, which also showed a value of zero for the same period as demonstrated in Table 4-3: VAP rate per month in the ICUs (11 November 2018 to 28 February 2019) as presented by Bluebird *(Bluebird: Home, 2019)* See below table for the VAP rate per month in the ICUs (11 November 2018 to 28 February 2019) as presented by Bluebird *(Bluebird: Home, 2019)*

Table 4-3: VAP rate per month in the ICUs

VAP, 'The Hospital' - Coronary ICU 01/11/2018 - 28/02/2019. ©Bluebird				
	Nov 2018	**Dec 2018**	**Jan 2019**	**Feb 2019**
Infection/1000 device days	0	0	0	0
VAP, 'The Hospital' - Multi ICU 01/11/2018 - 28/02/2019. ©Bluebird				
	Nov 2018	**Dec 2018**	**Jan 2019**	**Feb 2019**

Infection/1000 device days	0	0	0	0
VAP, 'The Hospital' - Trauma ICU 01/11/2018 - 28/02/2019. ©Bluebird				
	Nov 2018	**Dec 2018**	**Jan 2019**	**Feb 2019**
Infection/1000 device days	0	0	0	0

4.4. OBJECTIVE 2

Explore and describe the VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019), by combining the electronic information available using hospital information technology software systems used in the hospital, namely SAP (Hospital controlling with SAP system solution, 2019) and Bluebird (Bluebird: Home, 2019).

The results of Objective 2 are guided by the conceptual framework as described in Chapter 1 (See Figure 1-1).

4.4.1. BASELINE FOR VAP ALGORITHM

The CDC guideline (NHSN - Patient Safety Component Manual, 2019) to determine the baseline values, needed to monitor for incidents of VAP in patients receiving long-term mechanical ventilation treatment is:

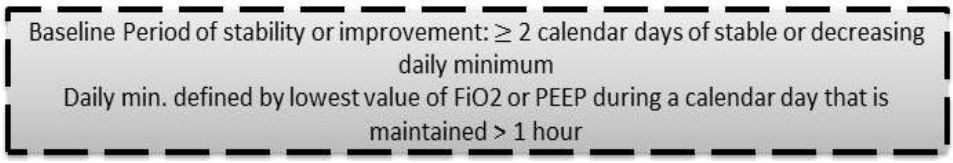


Figure 4-1: CDC baseline period

The available clinical records for the sixty-one long-term mechanical ventilator events were collected from the Bluebird Hospital Information Technology (HIT) software. Patients with no captured mechanical ventilation device days would not have been selected by Bluebird for the VAP report. The clinical data was therefore manually collected. Table 4-4 shows the number of FiO_2 and PEEP values

that had been available for the calculation of the baseline, to determine possible VAP incidence using the sample selected in Objective 2.

Table 4-4: Baseline information availability

AVAILABILITY OF BASELINE INFORMATION		
	FiO_2 n (%)	**PEEP n (%)**
At least one baseline value found	51 (83.6%)	16 (26.2%)

The baseline values to determine incidences of VAP, as per the CDC guideline, was incomplete, especially the PEEP values, which have to be captured manually by the nurses in the ICUs. The FiO_2 values are more complete because the applicable values could be sourced from the arterial blood gas (ABG) results that are imported into the Bluebird system, from the laboratory electronic information management systems.
The information as described in 4.4.1 guided the next step discussed in 4.4.2.

4.4.2. VENTILATOR-ASSOCIATED CONDITION (VAC)

The Ventilator-associated Condition (VAC) incident measurement guidelines supplied by the CDC state that if the patient's condition deteriorated to the point where the mechanical ventilation treatment had to be adjusted by either increasing the PEEP or FiO_2 values, it would be an indication of a possible Ventilator-associated Condition (VAC) (NHSN - Patient Safety Component Manual, 2019).

Figure 4.2: VAC Incident measurement guidelines

Table 4-5 shows the availability of the parameters necessary to identify a possible VAC for the sample of Objective 2.

Table 4-5: Parameter availability

Criteria	Clinical parameters	
	FiO_2 (%)	**PEEP n (%)**
Events with long-term mechanical ventilator days, where $FiO_2 \geq 20\%$ or PEEP ≥ $3cmH_2O$ * The next two rows, is a further breakdown of this total of events found.	16 (26.2%)	4 (6.6%)
Events where the rule of clinical deterioration were sustained for > 2 days	**7 (11.5%)**	0
Events where available deteriorated values were not sustained for > 2 days	9 (14.8%)	4 (6.6%)
Events that had comparable values available, but none adhered to the guidelines of increased care	22 (36.1%)	5 (8.2%)
Events with no values to compare	23 (37.7%)	52 (85.2%)
Total Events to be surveyed for VAC	61 (100%)	61 (100%)

Based on the baseline values found, seven events could be identified as a possible VAC. The results of this information are described in section 4.4.3

4.4.3. INFECTION-RELATED VENTILATOR-ASSOCIATED CONDITION (IVAC)

The next step in the identification and monitoring of a possible VAP was to survey for signs of an infection during the period of treatment. The CDC define that the patient's temperature and white blood cell count (WBC) are the clinical parameters that would give unbiased evidence that the patient had acquired an infection, as depicted in figure 4-2. (NHSN - Patient Safety Component Manual, 2019).

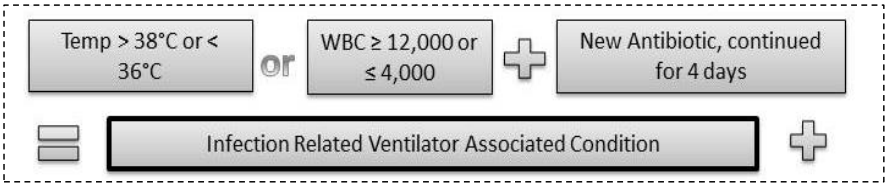


Figure 4-2: IVAC Incident guideline

According to the algorithm, only those events that had been identified as VACs (Section 4.4.2) are to be considered for a possible Infection-related Ventilator-associated Condition (IVAC).
The CDC defined that if a patient's temperature was more than 38° C or less than 36° C at any time during the day or the measured haematological white blood cell count (WBC) was more or equal to 12 000 cells/mm³ or less and equal to 4000 cells/mm³, the particular event should be 'flagged' as a possible infection-related condition, depending on the Antibiotic treatment that followed the clinical trend (NHSN - Patient Safety Component Manual, 2019).

Table 4-6: Events that adhered to the CDC guideline for an IVAC

Number of events that adhered to the rules of an IVAC	**(n) from the seven identified IVAC**
Number of events	3

The VAP baseline, as well as the incidences of possible VAC was done on incomplete clinical data from the Bluebird system, therefore further exploration on all the available clinical data had been done using the guidelines to determine IVAC.

Table 4-7 shows the results on all the available retrospective data of the temperature and white blood cell count (WBC) results of the patients who received long-term mechanical ventilation during the period of 1 November 2018 and 28 February 2019.

Table 4-7: Analysis of the clinical data of the sample of Objective 2 to determine possible infection-related complications (n = 61)

Table 4-7: Analysis of the clinical data

Criteria	**Temperature n (%)**	**WBC n (%)**
Long-term mechanical ventilation events that had clinical data available	45 (74)	57 (93)
Long-term mechanical ventilation events that adhered to the first part of CDC guidelines to identify an infection-related condition (antibiotic use still to be considered)	**15 (25)**	**37 (61)**

After collecting the available white blood cell count (WBC) information per long-term mechanical ventilator treatment event the researcher found that (n=57) 93% of the events had comparable WBC

records. (n=37) 61% adhered to part of the clinical deterioration guideline for Infection-related Conditions (NHSN - Patient Safety Component Manual, 2019).
The incidents with available temperature information found that (n=45) 74% of the events had comparable temperature records, only (n=15) 25% adhered to part of the clinical deterioration guideline for Infection-related Conditions (NHSN – Patient Safety Component Manual, 2019).
All fifteen (15) mechanical ventilation events whose records on temperature adhered to the CDC algorithm for an infection related condition, was events that was included in the thirty-seven (37) events found with adhering white blood cell count (WBC) information.
The CDC algorithm continued to specify that the antibiotic script also had to change within the period of identifying the deterioration in the clinical parameters, temperature and WBC, and this antibiotic should be continued for four or more days before the event could be identified as adhering to the guidelines of a possible Infection-related condition (NHSN - Patient Safety Component Manual, 2019).
The researcher collected the information per long-term mechanical ventilator treatment event on antibiotic prescription and administration.

Table 4-8 shows the number of long-term mechanical ventilator treatment events with available antibiotic treatment records.

Table 4-8: Long-term mechanical ventilator treatment events

Inclusion of Antibiotic treatment in Infection-related Condition identification		
Long-term mechanical ventilator treatment events	long-term mechanical ventilator treatment events with antibiotic information n (%)	long-term mechanical ventilator treatment events adhering to IVAC guideline n (%)
	61 (100)	17 (28)

All the long-term mechanical ventilator treatment events had records indicating the starting and discontinued dates for antibiotic treatment, the records indicated details on the script such as tradename, generic name, dosage, administration information, date of order, date antibiotic treatment was started, and date stopped.
Seventeen (n=17) of these records adhere to the CDC guidelines indicating that the antibiotic had been started at the same time as the deterioration of the WBC or body temperature and continued for more than four days. The conclusion was made that (n=17) 28% of the sample presented with signs of

infection-related deterioration of patient condition (note without following the step for VAC, these events cannot be identified as ventilator-associated)

Based on the baseline values found seven events could be identified as a VAC, as well as the three events identified in 4.4.3. as possible IVAC (n=7), this result will inform the calculation of PVAP as described in section 4.4.4

4.4.4. POSSIBLE VENTILATOR-ASSOCIATED PNEUMONIA (PVAP)

The final step provided in the CDC guidelines to determine the incidences of VAP, focuses on microbiological screening and testing of respiratory secretions and lung tissues (NHSN - Patient Safety Component Manual, 2019). The CDC specified that if an event presents with all the clinical and pharmaceutical parameters of a Ventilator-associated Condition (VAC) and an Infection-related Ventilator-associated Condition (IVAC), the next step would be to identify an incidence of a possible VAP. The final step of identifying a possible incident of VAP was to include the respiratory-related Microbiological Culturing and Screening (MCS) results to the algorithm of identifying VAP (NHSN - Patient Safety Component Manual, 2019). A VAP could only be identified if a CDC specified possible bacterial organism was cultured. The respiratory MCS sample should also adhere to specified quality parameters (NHSN - Patient Safety Component Manual, 2019).

Table 4-9 shows the results derived from the Microbiological Culture and Screening Sensitivity testing.

Table 4-9: MCS records to use in CDC Algorithm VAP incidence (n=61)

Description	n (%)
Number of long-term mechanical ventilator treatment events where MCS data were available	48 (79)
Purulent sputum used as MCS sample	47 (77)
Pleural fluid used as MCS sample	1 (2)
Number of events adhering to all the steps as specified by the CDC guidelines to determine incidence of VAP (NHSN - Patient Safety Component Manual, 2019)	3 (5)

Following the guidelines provided by the CDC only three of the events in the sample adhered to the guideline of identifying a VAP. Forty-eight of the events had MCS results, but could not be classified as a possible VAP, since there ***was not adequate clinical data available*** to follow the CDC guidelines through all the steps (NHSN - Patient Safety Component Manual, 2019). Incomplete clinical data could not be obtained from patient files as the hospital did not give ethical approval for this step.

Three possible VAP events had not been identified in Objective 1 (the Bluebird system), because the device days had not been captured, which then meant that the Bluebird system was not able to recognise the events as requiring further monitoring for VAP.

The primary diagnosis, demographics, and time of ventilation for these three long-term mechanical ventilation treatment events can be identified as possible incidences of VAP are listed in Table 4-10

Table 4-10: Detail on the three events with possible VAP

Unit	Age	Speciality	Primary Diagnosis	Organism cultured
MICU	69	Cardiac condition	Chronic Cardiac Failure	*Klebsiella aerogenes*
TICU	80	Neurological (trauma)	Head injury	*Enterobacter cancerogenus*
TICU	40	Post-surgery	Abdominal wound	*Staphylococcus aureus*

The result of 4.4.4 will guide the calculation of the VAP rate as described in section in 4.4.5.

4.4.5. CALCULATING VAP INCIDENCE AND VAP RATE FOR SELECTED PERIOD

After following the CDC guidelines to determine incidence of VAP, the researcher found that with the available clinical data, there were three definitive events that could be identified as incidents of VAP in the selected period.
As previously stated, to be able to compare incidence of PVAP with other hospitals and over different periods is has to be converted to a VAP rate / 1000 long-term mechanical ventilation days. This calculation can be described as follows:

$$VAP - rate = \frac{Number\ of\ PVAP\ for\ Period}{Number\ of\ Long-term\ mechanical\ ventilation\ days} * 1000$$

The VAP rate would then be three divided by 954 days multiplied by 1000.
The VAP rate found in Objective 2 is thus ***3.2 / 1000*** long-term mechanical ventilation days.

4.5. STATISTICAL COMPARISON BETWEEN THE REPORTED VAP RATES OF OBJECTIVE 1 AND 2

VAP rate Objective 1: 0.0 VAP incidents per 1000 mechanical ventilation days
VAP rate Objective 2: 3.2 VAP incidents per 1000 mechanical ventilation days

The p-value between the number of identified mechanical ventilation days, between the two objectives were 0.011, which is a statistically significant difference between the identified samples of the objectives. Especially considering the inclusion and exclusion criteria were identical, the algorithm that was used was identical and the final reported value was reported as a proportional number of incidents per 1000 mechanical ventilation days, as specified by the CDC.

5. DISCUSSION OF RESULTS

5.1. INTRODUCTION

Chapter 4 presented the results for the objectives set in Chapter 1. In this chapter the results reported in Chapter 4 will be discussed and compared with similar studies in research. The discussion will be presented in term of the study objectives.

5.2. POPULATION DEMOGRAPHICS

Despite using similar selection criteria, the same patients, and over the same period, the Mann-Whitney U test results indicated that the populations found on the two different information technology systems had probability values as low as 1.1% between the two. The population found in Objective 2, the larger of the two, is discussed further, describing the demographic information found in this population.

Advanced age is an attributing factor to the mortality of patients, patients over seventy years of age are reported to have an increased risk for acquiring hospital-associated incidents (HAI). (Edwardson & Cairns, 2019; Mehtar, 2015:58). The age ranges from the sample in objective 1 spanned between twenty-one to eighty years and between twenty-one and eighty-five years of age for objective 2. The mean age for the sample of objective 1 was fifty-three. The mean age for the sample of Objective 2 was fifty-seven years.

It is of value to distinguish between the specific incidences of VAP in the different ICUs. Especially if the VAP reporting is done regularly so that a trend of incidents could be established. Incidences of VAP in the different ICUs can be used to assess and manage the effectiveness of the Infection Prevention and Control (IPC) process in the specific units. The environment and the nursing care the patient receives in this environment is a contributing factor to HAI, like VAP (Mehtar, 2015:57). The factors applicable to preventing VAP when considering the quality of nursing practice and environment management are for example poor hand hygiene, staff shortage, poor adherence to the bundles of care (VAP bundle) (Mehtar, 2015:57;225).

The results of the study showed that the Multi-disciplinary ICU (MICU) and Trauma ICU (TICU) were the units where most of the long-term mechanically ventilated patients were being nursed and the Coronary ICU (CICU) had the least. Establishing an up-to-date trend per unit of long-term mechanical

ventilation events, assists in the planning of unit acuity, staff distribution, training needs, infection prevention and control practices, necessary consumables and equipment needed for quality nursing care and prevention of incidences of VAP (Johnson *et al.*, 2016; Phillips, Stalter, Winegardner, Wiggs & Jauch, 2018).

The primary diagnosis of the patient could be a contributing factor that increases the patient's susceptibility to incidences of HAI, like VAP (Lavallée, Gray, Dumville, Russell, & Cullum, 2017). The size of the samples, as well as the cross-sectional period of three months, didn't allow for sufficient data, for statistical analysis on the distribution of incidences per primary diagnosis. Literature and studies that reported on trends per diagnosis category, had been done over significantly longer periods of time enabling reliable quantitative analysis and conclusions on such population trends (Mehta, Syeda, Wiener & Walkey, 2015).

Due to the insignificance of making comparisons on the frequency distribution by an individual primary diagnosis of the population, the primary diagnosis was grouped into a specific speciality group as described in Chapter 4. In this population the speciality areas where there had been the highest frequency of long-term mechanical ventilator treatment events were grouped under the speciality – Neurological Conditions. Long-term mechanical ventilator treatment events grouped under oncology conditions had the least long-term mechanical ventilator treatment events in this population, during this cross-sectional period.

An article regarding the trends of long-term mechanical ventilation on oncology patients concluded that the prognosis of the patient was a large determinant on whether long-term mechanical ventilator treatment had been indicated and started. The patient was already immune-compromised and to add the risks and possible complications of long-term mechanical ventilator treatment events seemed in most events to be contra-indicated. Keeping this result as a comparison with the findings of this study, it seemed to compare positively towards international trends that oncology patients were the least likely to receive long-term mechanical ventilator treatment (Prakash *et al*., 2017).

The lack of comparable data was limitation of this study. The research plan only allowed for the collection of the primary diagnosis as a long-term mechanical ventilator treatment event descriptive factor. The researcher found while analysing the data, that all the patients receiving long-term mechanical ventilator treatment had more than one diagnosis coded to their admission event, which might indicate that most if not all patients could be categorised in more than one of the speciality conditions groups, if all the diagnosis had been taken into consideration. This lack of accurate comparable information could be significant and important in reporting on VAP incidents in the hospital

(Mahomed *et al*., 2017). Reporting on VAP rates between the different diagnostic trends was an important part of managing quality nursing practices and processes (Mahomed *et al*., 2017). The practices and resources necessary for the treatment of specific conditions could predispose a patient to acquiring a VAP, during their period of admission in the Intensive Care Unit (ICU) under long-term mechanical ventilator treatment event (Mehta *et al*., 2015). For example, research done in the United States of America determined that the use of invasive long-term mechanical ventilation had increased from 1993 to 2009, with a decrease in total mortality. It was also interesting to note that there seemed to have been a notable difference in this trend of improved mortality between diagnoses. For example, even though the events with a primary diagnosis of pneumonia and Chronic Obstructive Pneumonia Disease (COPD) had progressively more favourable outcomes to long-term mechanical ventilation, the patients presenting with heart failure showed no improvements in mortality over the same period. (Mehta *et al*., 2015)

5.3. OBJECTIVE 1: VAP INCIDENCE REPORT PROCESS OF THE HOSPITAL (USING BLUEBIRD)

Explore and describe the reported VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019) using the existing hospital information technology software, Bluebird (Bluebird: Home, 2019).

The hospital implemented a hospital information technology system, with the relevant programming to enable nurses to capture the clinical parameters necessary to monitor for possible incidents of VAP, namely the Bluebird system. Monitoring processes supported by information technology is supported by evidence-based practices to be the most effective way to monitor for evidence of deterioration in clinical condition, using CDC guidelines of well documented clinical parameters. The fact and accurate recognition of possible deterioration in clinical condition can serve as an early warning system to assist in preventative strategies and improving the quality of nursing care in the hospital (Robinson *et al*., 2018; Singh & Sittig, 2016). The reported VAP incidence for the three adult Intensive Care Units in the hospital was however zero per 1000 Long-term mechanical ventilator treatment days (Table 4-6). The VAP rate per 1000 long-term mechanical ventilator treatment days, were also reported as zero for all three units during all three months in the cross-sectional period. (Table 4-7).

5.4. OBJECTIVE 2: VAP INCIDENCE REPORT PROCESS OF THE HOSPITAL (USING SAP & BLUEBIRD)

Explore and describe the VAP incidence as per CDC guidelines (NHSN - Patient Safety Component Manual, 2019), by combining the electronic information available using hospital information technology software systems used in the hospital, namely SAP (Hospital controlling with SAP system solution, 2019) and Bluebird (Bluebird: Home, 2019).

The number of long-term mechanical ventilator treatment events, as per the captured device days in the Bluebird system (Objective 1) was twenty-six, while the number of events identified in the SAP system (Objective 2) was sixty-one. This means that thirty-five long-term mechanical events had no device days in the Bluebird System and these events would not have been identified as long-term mechanical ventilation events, therefore Bluebird excluded these events from the algorithm. The available long-term mechanical device days captured in the Bluebird System, used for the calculation of the VAP rate in Objective 1 were 650 days. However, using the billing information from the SAP system, the number of long-term mechanical ventilation device days calculated was 954 days.

5.4.1. REPORT ON VAP ALGORITHM BASELINE INFORMATION

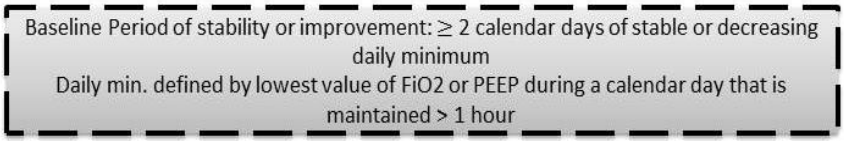


Figure 5-1: VAP Algorithm

The available PEEP clinical records had not been an ideal parameter to use to calculate the baseline for the CDC VAP algorithm, merely because the records had not been captured into the Bluebird system and were therefore not available, only 26% of the mechanical ventilation events had captured PEEP values to use in the calculation of a baseline for the monitoring of VAP. However, the CDC guideline for VAP incidence identification supplies an alternative clinical parameter, which can be used if a PEEP value is not available. This value is the fraction of oxygen (FiO_2), which the long-term mechanical ventilated patient was treated with on a specific treatment day, 84% of the events had available FiO_2 values available to determine baselines for the VAP algorithm for the long-term mechanical ventilation events. Note that at this point, 16% of the long-term mechanical ventilated events were excluded by

the Bluebird system, from this point forward for the surveillance of possible VAP, due to incomplete clinical records in the Bluebird system.

5.4.2. VENTILATOR-ASSOCIATED CONDITION

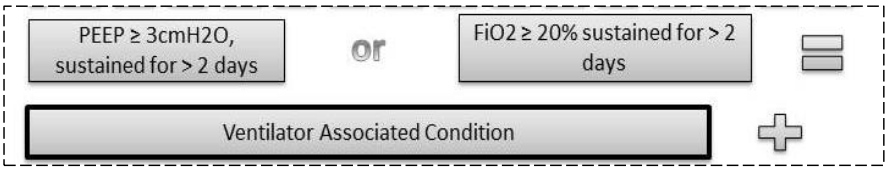


Figure 5-2: VAC

The conclusion for this step in the CDC algorithm had been that at least seven (7) incidents of Ventilator-associated Conditions (VAC) could be identified in the sample, using the available clinical data in the Bluebird System. These seven identified events adhering to the CDC algorithm guideline to identify incidence of VAC, will then be used to continue the discussion in section 5.4.3.

5.4.3. INFECTION-RELATED VENTILATOR-ASSOCIATED CONDITION (IVAC)

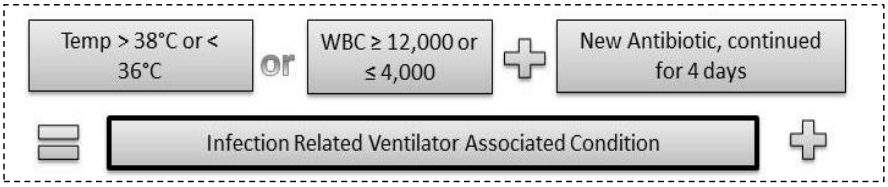


Figure 5-3: IVAC

Considering the available clinical parameters necessary to determine incidence of IVAC as guided by the CDC, three (3) incidents of IVAC were identified. Fifty-seven (57) of the long-term mechanical ventilation events had various WBC values on different treatment days available. Due to the CDC algorithm indicating that only incidents of VAC can be used to identify an IVAC, fifty-four (54) of the long-term mechanical ventilator treatment events were excluded from this step to identify an infection-related condition, related to ventilator treatment. The process that facilitated the population of the WBC values per treatment event, was an electronic import of laboratory test results. Testing WBC daily is a part of the daily protocol of the monitoring process of long-term mechanically ventilated patients.

Forty-five of the long-term mechanical ventilation events had comparable body temperature records. Populating the parameter fields for body temperature, however, is a manual process, where the treating nurses should manually capture the applicable temperatures into the Bluebird system. However, some temperature values could be found in a data field, imported together with the arterial blood gas results, however, there is no indication whether it would be the highest or lowest temperature for the treatment day. All the applicable antibiotic treatment information was available because the data is an automated import of dispensing information from the SAP system, as captured by the applicable pharmacist dispensing and invoicing the information. However, there was no monitoring of the accuracy of administration in the unit.

5.4.4. POSSIBLE VENTILATOR-ASSOCIATED PNEUMONIA (VAP)

The third and last step specified in the CDC guidelines in identifying a VAP is done through Microbiology Culturing and Sensitivity screening (MCS). MCS screening was done on Mondays and Thursdays as part of the treatment protocol applicable to nursing and monitoring a patient on long-term mechanical ventilation treatment. Some MCS results were done as needed, by request of the physician or due to an assessed deterioration of patient condition by the shift leading registered nurse.

All the possible MCS results were available electronically because they were imported from the laboratory information technology system. Except for one MCS sample that had been done on extracted pleural fluid, all the MCS samples for the population, were done on purulent and mucoid sputum, collected from bronchial suctioning, while the patient was on long-term mechanically ventilated treatment. Three of the events had an incident each that adhered to the CDC guidelines for identifying a possible VAP. The CDC guidelines dictate that to enable comparable VAP incidence results, the incidents of VAP should be reported as a rate per 1000 days of long-term mechanical ventilation. Considering that the number of long-term mechanical ventilation days for the sample in Objective 2 are 954 days, the calculated VAP rate was 3.2 / 1000 long-term mechanical ventilator treatment days.

5.5. ETHICAL CHALLENGES

A hospital with responsible Infection Prevention and Control (IPC) processes, would need accurate, fast, and reliable reporting on VAP incidence in the adult Intensive Care Units (ICUs). VAP is known to

be a preventable hospital-associated complication, and to avoid legal complications, as well as unnecessary complications on patient conditions, the best possible process should be followed to identify possible incidences of VAP (Mahomed *et al*., 2017). Non-conformity to accurate recordkeeping is against the regulations provided by the South African Nursing Council (SANC), which could result in medico-legal risks, that could be deleterious to the hospital, the staff, and the patients (SANC, 1978).

The aim of the reporting on incidences of VAP would be to measure the success of implemented prevention strategies when it came to the nursing practice of preventing hospital-associated complications when it came to the care of a patient on long-term mechanical ventilator treatment. The findings concluded that the reported VAP rate found in Objective 1 could not be accepted as reliable, this could have implications to the hospital in that possible gaps in clinical practice would not be identified, due to incomplete records (Mahomed *et al*., 2017). Non-conformity to accurate recordkeeping is also against the regulations provided by the South African Nursing Council (SANC), which could result in

Not only was the availability of clinical records for reporting a challenge, but so is discussing process changes. The reason for this was that the top management of the hospital had undergone changes in the period just before and after the retrospective period of the study. Change is known to cause challenges even in well-established processes (Mahomed *et al*., 2017). The VAP reporting process had already been implemented since 2015 in the hospital, but the change in management should be considered as an added factor that could have affected the unreliability of the processes through the cross-sectional period.

6. CONCLUSIONS, RECOMMENDATIONS, LIMITATIONS AND REFLECTION

6.1. INTRODUCTION

Chapter 5 summarised the findings reported in Chapter 4, the purpose of Chapter 6 is to discuss these findings within the real-life context referring to research reported on similar topics.

6.2. CONCLUSIONS

6.2.1. OBJECTIVE 1: VAP INCIDENCE REPORT PROCESS OF THE HOSPITAL

The Bluebird Hospital Information Technology system did not provide the functionality of identifying possible ventilator-associated conditions (VACs) and infection-related ventilator-associated conditions (IVAC), which could serve as early warning signs to prevent incidences of VAP. Another reason why identifying possible VAC or IVAC is important, is that VAP is not the only complication that can be associated with long-term mechanical ventilation, for example, injuries caused by barotrauma or volutrauma.

Research aimed at improving nursing practice when it comes to nursing a patient on long-term mechanical ventilation, tend to still focus on incidents of VAP, because of its major deleterious effect on patient mortality and morbidity. However, the CDC identified the need for increased accuracy in identifying nursing care-related complications with long-term mechanical ventilation. The steps to identify VAC and IVAC were therefore created.

Monitoring the incidence of hospital-associated complications is necessary to determine the quality of nursing practice. Evidence-based practice research provides practice guidelines like the VAP bundle. The principle of quality management is that if the monitoring of VAP and reporting process identifies incidences of VAC, IVAC and/or VAP, it would mean that management should re-assess the implementation of the VAP bundle in practice. Inaccurate monitoring and reporting incidents of VAC, IVAC and VAP would render this process insufficient and ineffective. The ineffective monitoring of the incidence of VAP could have legal implications because VAP could be linked to practices of negligence

since VAP is preventable if the necessary nursing processes of the VAP bundle are in place and practised. (Lowman *et al.*, 2016; Mahomed *et al.*, 2017).

Accepted guidelines to measure the quality of infection prevention and control processes when it came to nursing a patient on long-term mechanical ventilator treatment events had been under discussion globally since the early 2000s and the current CDC guidelines foundation had been established in 2013 and it was stated as important that hospitals needed to implement a reliable VAP incident reporting process, supported by a hospital information technology software solution. The implementation of VAP incident reporting software could provide the hospital with the ability to do regular re-evaluation of infection prevention and control strategies, to continually improve compliance and the drive towards a safer hospital information technology software-enabled healthcare environment ('NHSN - Patient Safety Component Manual', 2019; Singh & Sittig, 2016).

6.2.2. OBJECTIVE 2: VAP INCIDENCE REPORTING PROCESS USING SAP AND BLUEBIRD SOFTWARE

The clinical information used to identify and report on incidences of VAP in Objective 1 and 2 was from data available in the Bluebird System. The only differences between the two processes were the identification of the long-term mechanical ventilation events and the calculation of the VAC, IVAC and VAP in Objective 2 and were done by the researcher, wherein Objective 1 the calculation was done by the Bluebird system. The invoicing process captured by the case managers into the SAP system provided a larger sample size than the device days captured in the Bluebird system by the nurses in the ICUs. All the events from the Bluebird system were present in the sample selected from the SAP system. Although the clinical parameters available to assess for incidents of VAP was incomplete in the Bluebird system, the larger sample of Objective 2, found seven possible incidents of VAC and three possible incidents of IVAC and VAP, which is already a different picture from the reported VAP incidence of zero obtained from the Bluebird system for the same period. The quality of nursing practice cannot efficiently be measured or managed without accurate and efficient reporting on the incidence of hospital-associated complications like VAP.

6.3. COMPARABILITY OF THE VAP RATES BETWEEN OBJECTIVES 1 AND 2

The reported U-value from the Mann-Whitney U test used in the research indicated that although the VAP rates were calculated using exactly the same CDC-algorithm as well as inclusion and exclusion criteria for the populations, there were a significant statistical difference in the two values reported. This adds to the concern of the reliability of the processes in the hospital used to populate the data fields of the electronic information systems, which was designed and implemented to assist with the management of Nursing Quality and monitoring preventable complications caused by nursing care.

6.4. RECOMMENDATIONS

6.4.1. NURSING MANAGEMENT

The monitoring and assessment of the level of nursing care in the hospital is an integral part of the nursing management process, just as the assessment of the patient is to the nursing process. Fast, accurate reporting using information technology is an answer to this need in nursing management. If an information technology system is not used as it was designed, the reports produced by the system will be unreliable and will give a skewed view of the situation. Nursing management, therefore, must have clearly defined policies and procedures on how an information technology system should be implemented in the units. The planning of the staffing and equipping of the ICUs should include the process of data capturing, so that adherence to the data capturing policies is realistic and possible.
Weaknesses in the information technology software design, for example, the inability to print reports on possible incidents of VACs and IVACs, should be discussed and addressed with the developers of the Bluebird system. Regular interaction between the nursing personnel responsible for infection prevention and control and the software developers is suggested so that the system functionality could keep up with the needs of the hospital and provide useful reports that can be used to monitor, plan, and manage nursing processes.

If the Bluebird system could also provide an auditing process on the completeness of the necessary captured clinical parameters, it could serve as an early warning to nursing management, in finding the reason for the gap in the adherence to the process of data capturing and take corrective action, while the patients and clinical records are still in the ICUs and information can easily be verified and captured. A responsible and available resource should be part of the staff planning to manage this process.
Accurate reporting would create an understanding of the threats to quality nursing care in the hospital. Hospital-associated complications like VAP are preventable. Not implementing sound Quality

Assurance and Infection Prevention and Control (IPC) processes could expose a hospital to legal implications, related to neglecting to provide a safe environment for patients who receive long-term mechanical ventilation treatment (Mahomed *et al*., 2017).

6.4.2. NURSING EDUCATION

Information technology and electronic records are an irrefutable part of nursing practice. Information technology and management of electronic information technology systems and the reports it provides is not an integral part of nursing education curricula. Nursing education does include the availability of information and the use of the world wide web. There is also a trend towards using information technology in the classroom for distance learning, especially during the lock-down periods implemented during the time of the COVID pandemic.
It is proposed that curricula should be designed with a focus on the competencies related to the use of information technology in clinical practice and for practitioners to be able to critically assess the appropriateness of used technology, to be able to integrate this information tool in day-to-day nursing practice effectively and accurately.

It is also not only the newly qualifying nurses who need to be educated on the management and use of information technology, the older generation nurses should be updated by means of in-service training and educated on the benefits and limitations of using information technology in the management of patient records, trends, and practice management. Very few hospitals are entirely paperless when it comes to the records of patient clinical information, especially in developing countries like South Africa. There is a process in which increasingly more hospitals will attempt to implement hospital information technology systems, which would allow the entire clinical record of the patient to be electronic. However, until all the nurses who need to implement these systems are educated on the use and importance of compliance to the nursing processes in the use and capturing of patient records, it will remain an inefficient and unreliable patient record.

Evidence-based practice indicates that effective management of preventable risks like VAP, in clinical practice could be effectively managed, through fast, accurate, and reliable reports on the warning signs of VAC, IVAC and VAP, using the CDC guidelines and the clinical records of the patients on a daily and real-time basis. It is suggested that nursing education can consider adapting and adjusting the level of knowledge and competency testing when it comes to understanding and using information technology in nursing practice to improve the adherence and accuracy of record-keeping through information technology.

6.4.3. NURSING PRACTICE

Monitoring and assessing the incidence of hospital-associated complications like VAP is a recommended method of determining the quality of nursing care in practice, especially if the specific complication has proven to be preventable if nursing practice adheres to the evidence-based guidelines provided in nursing practice theory, namely the steps in the VAP bundle. Focusing on the reporting process on incidents of VAP in ICU could benefit the quality of nursing practice greatly, especially if it is followed by creating strategies to improve the implementation of evidence-based guidelines like the VAP bundle. Reliable reports, which can be accessed at any time, easily and quickly, on possible incidents of VAC, IVAC and VAP could serve as early warning systems, to intervene and prevent further complications in specific patient treatment events. If this process is clearly defined in policies and procedures as mentioned in the suggestions under nursing management it could serve as a quality process to assist in the event of legal or account queries, in those cases where pneumonia was present during an event of long-term mechanical ventilation, in that all the necessary precautions were taken to follow evidence-based practice and prevent a VAP as far as possible. Nursing practice should therefore consider creating a bigger focus on allocating specific time and responsibilities to the capturing of clinical data into the information technology system to improve the adherence and accuracy of clinical data capturing.

6.4.4. FUTURE RESEARCH

It is important to constantly improve nursing practice and find better ways through evidence-based research on how to change the way we do things so that we could have better patient outcomes. Monitoring and surveillance of preventable hospital-associated complications is a process of gathering and analysing data, following a conceptual framework, like the CDC guidelines to determine incidence of VAP.

The principle is widely accepted and there are information technology systems, like the Bluebird system in place to assist with this quality management process. Most hospitals have access to the infrastructure and equipment necessary to be able to capture clinical data into information technology, although in South Africa, a great portion of the patient clinical records are still on paper and not readily available electronically, especially in the nursing units in hospitals. In more developed countries the electronic patient record is part of nursing practice and guidelines provided by organisations like the CDC, it specifies that accurate quality control of preventable complications should be done with the assistance of information technology.

The following questions need to be answered:

- *What is happening in South Africa to move towards the electronic patient records?*
- *Can South Africa's infrastructure and support systems manage linked networks between healthcare providers?*
- *How will the security and privacy of patient records be managed?*
- *How should the legal and constitutional rights of the patient be secured, if all these records are available on, for example, a data cloud that can be shared between healthcare providers?*

The level of knowledge and understanding of infection prevention and control principles about what exactly should be monitored to determine the incidence of VAP in hospitals should be investigated. It is possible that the non-adherence to the infection prevention and control policies in the hospital could be linked to a lack of understanding of the practising nurses in the ICU.
Another issue in the meantime is do healthcare providers really understand and know what the situation is in their specific ICUs when it comes to the incidences of VAP? If a hospital with an implemented information technology system to manage and report on incidences of VAP, like the Bluebird might still be focusing on an inaccurate picture, due to incomplete clinical records.
Furthermore, one cannot get a full picture of the situation by focusing on a period of three months.

The reporting processes, focused on quality control are to be implemented continuously, and the results of these reports are to be compared with each other on multiple levels, such as:

- between different units
- between different periods within the same unit
- between different hospitals in the same country and different hospitals in other countries, to mention a few.

An extended study that focuses on the true impact and situation of hospital VAP Rates, the accuracy of data-capturing, and quality of nursing practice would be recommended. If research establishes that VAP incidences are a real problem in the ICUs of the hospital, intervention studies to improve adherence to clinical practice, like the VAP bundle is suggested. Research can also be done on the level of knowledge of nurses in practice in ICUs when it comes to the steps in the VAP bundle. The steps of the bundle are well defined, therefore a research project focusing on the adherence of the steps in specific ICUs and determining where the weaknesses in clinical practice might be, if at all present and how it relates to a lack of VAP incidents or the presence thereof.

6.5. LIMITATIONS

The researcher initially planned to do intervention research with the aim to improve nursing practice and decrease incidence of VAP in the adult ICUs in the hospital. On closer investigation, the VAP incidence report for an extended period didn't show any possible incidents of VAP. The researcher realised that whether this picture is true or not, it cannot be trusted, even though there is a clearly defined conceptual framework and process available in the hospital, to monitor incidences of VAP.
The time period for this report wasn't sufficient to get a true picture through the surveillance and monitoring of all the physical clinical records of the patients. It was therefore decided to do a retrospective study to understand the accuracy of the reported VAP incidence in the hospital. The hospital denied the researcher access to the physical clinical records of the patients but permitted the researcher to use the clinical records from the information technology systems, namely the Bluebird and the SAP system. The incomplete electronic clinical data in the Bluebird system resulted in that the final three VAP incidents found in Objective 2, are possibly inaccurate as well, although it did indicate that the process of VAP reporting should be improved.

6.6. SUMMATIVE CONCLUSION

Information technology and the management of the quality of nursing through fast and accurate reporting, is key to ensuring the quality of nursing care. The lack of available data revealed a weakness in the system. It indicated the need to improve processes where the relevant clinical records are captured into the Bluebird system to enable better monitoring and management of the nursing practice when it comes to the care of long-term mechanically ventilated patients.

Monitoring and reporting on incidents of VAP is an integral part of the management of the quality of nursing care when it comes to caring for a patient on long-term mechanical ventilation. There should be a clear focus on working towards an accurate and reliable process to report on the incidence of hospital-associated complications, like VAP. It would benefit the patient, the hospital, as well as the quality management of nursing practice.

REFERENCES

Aaron, A, Brink, A, du Plessis, D, Faure, K, Govender, NP, Govender, S, Johnson, Y, Mehtar, S, *et al*. 2018. *Guidelines for the Prevention and Containment of Antimicrobial Resistance in South African Hospitals*. Pretoria, Republic of South Africa. Available from: 2019SAGuidelineAMRHospitals.pdf [Accessed 1 December 2019].

Akdogan, O, Ersoy, Y, Gdem Kuzucu, C¨, Gedik, E, Togal, T & Yetkin, F. 2017. Assessment of the effectiveness of a ventilator associated pneumonia prevention bundle that contains endotracheal tube with subglottic drainage and cuff pressure monitorization. *Brazilian Journal of Infectious Diseases*. 21(13):276–281. doi.org/10.1016/j.bjid.2017.01.002.

Al-Thaqafy, MS, El-Saed, A, Arabi, YM & Balkhy, HH. 2014. Association of compliance of ventilator bundle with incidence of ventilator-associated pneumonia and ventilator utilization among critical patients over 4 years. *Annals of thoracic medicine*. 9(4):221–6. doi.org/10.4103/1817-1737.140132.

Aljezawi, M, Al Qadire, M, Alhajjy, MH, Tawalbeh, LI, Alamery, AH, Aloush, S & ALBashtawy, M. 2019. Barriers to Integrating Research Into Clinical Nursing Practice. *Journal of nursing care quality*. 34(3):E7–E11. doi.org/10.1097/NCQ.0000000000000371.

Alshyyab, MA, FitzGerald, G, Dingle, K, Ting, J, Bowman, P, Kinnear, FB & Borkoles, E. 2019. Developing a conceptual framework for patient safety culture in emergency department: A review of the literature. *International Journal of Health Planning and Management*. 34(1):42–55. doi.org/10.1002/hpm.2640.

Arthur, L, Kizor, R, Selim, A, Van Driel, M & Seoane, L. 2016. Antibiotics for ventilator-associated pneumonia (Review) SUMMARY OF FINDINGS FOR THE MAIN COMPARISON. *Cochrane database of systematic reviews (Online)*. (10):1–97. doi.org/10.1002/14651858.CD004267.pub4.www.cochranelibrary.com. Antibiotic treatment for ventilated patients with pneumonia | Cochrane

Best Care – Always! 2019. Available from: https://www.bestcare.org.za/ Best Care – Always! [Accessed 6 December 2019].

Bluebird: Home. 2019. Available from: http://www.bluebird.co.za/ Bluebird: About Us [Accessed 16 September 2019].

Bouadma, L, Sonneville, R, Garrouste-Orgeas, M, Darmon, M, Souweine, B, Voiriot, G, Kallel, H, Schwebel, C, *et al*. 2015. Ventilator-Associated Events: Prevalence, Outcome, and Relationship with Ventilator-Associated Pneumonia. *Critical Care Medicine*. 43(9):1798–1806. doi.org/10.1097/CCM.0000000000001091.

CDC Global Health - South Africa. n.d. Available from: https://www.cdc.gov/globalhealth/countries/southafrica/default.htm [Accessed 5 September 2020].
CDC Organization | About | CDC. 2020. Available from: CDC Organization | About | CDC [Accessed 5 September 2020].

Certifications and Compliance | SAP Trust Center. 2019. Available from: Certifications and Compliance | SAP Trust Center?infl=ab5f5612-2c6c-47f4-8cee-fdfea4f4b326 [Accessed 26 December 2019].

Cinel, I & Dellinger, RP. 2019. General Principles of Mechanical Ventilation. In: *Critical Care Medicine: Principles of Diagnosis and Management in the Adult*. 5th ed. J.E. Parillo & R.P. Dellinger, Eds. Elsevier Inc. 129–143. doi.org/10.1016/B978-032304841-5.50011-X.

Clemons, J & Kearns, M. 2016. Invasive Mechanical Ventilation. *Hosp Med Clin*. 111(12):746–753. doi.org/10.14423/SMJ.0000000000000905.

Connolly, D & Wright, F. 2017. *The nursing quality indicator framework tool*. doi.org/10.1108/IJHCQA-08-2016-0113.

Curtis, K, Fry, M, Shaban, RZ & Considine, J. 2017. Translating research findings to clinical nursing practice. *Journal of Clinical Nursing*. 26(5–6):862–872. doi.org/10.1111/jocn.13586.

Daniel Rosenthal, V, George Maki, D, Mehta, Y, Leblebicioglu, H, Ahmed Memish, Z, Hassan Al-Mousa, H, Balkhy, H, Hu, B, *et al*. 2014. International Nosocomial Infection Control Consortiu (INICC) report, data summary of 43 countries for 2007-2012. Device-associated module. *YMIC*. 42:942–956. doi.org/10.1016/j.ajic.2014.05.029.

Darawad, MW, Sa'aleek, MA & Shawashi, T. 2018. Evidence-based guidelines for prevention of ventilator-associated pneumonia: Evaluation of intensive care unit nurses' adherence. *American Journal of Infection Control*. 46(6):711–713. doi.org/10.1016/j.ajic.2017.11.020.

Edwardson, S & Cairns, C. 2019. *Nosocomial infections in the ICU*. V. 20. doi.org/10.1016/j.mpaic.2018.11.004.

El-Saed, A, Al-Jardani, A, Althaqafi, A, Alansari, H, Alsalman, J, Al Maskari, Z, El Gammal, A, Al Nasser, W, *et al*. 2016. Ventilator-associated pneumonia rates in critical care units in 3 Arabian Gulf countries: A 6-year surveillance study. *American Journal of Infection Control*. 44(7):794–798. doi.org/10.1016/j.ajic.2016.01.042.

Eom, JS, Lee, MS, Chun, H-KK, Choi, HJ, Jung, S-YY, Kim, YS, Yoon, SJ, Kwak, YG, *et al*. 2014. The impact of a ventilator bundle on preventing ventilator-associated pneumonia: A multicenter study. *American Journal of Infection Control*. 42(1):34–37. doi.org/10.1016/j.ajic.2013.06.023.

Fernando, SA, Gray, TJ & Gottlieb, T. 2017. Healthcare-acquired infections: prevention strategies. *Internal Medicine Journal*. 47(12):1341–1351. doi.org/10.1111/imj.13642.

Ferreira, E, Pina, E, Sousa-Uva, M & Sousa-Uva, A. 2017. Risk factors for health care–associated infections: From better knowledge to better prevention. *American Journal of Infection Control*. 45(10):e103–e107. doi.org/10.1016/j.ajic.2017.03.036.

Goligher, EC, Ferguson, ND & Brochard, LJ. 2016. doi.org/10.1016/S0140-6736(16)30176-3.

Hart, C. 2016. *Doing a literature review: releasing the social science research imagination*. Thousand Oaks, CA: Sage.

Hospital controlling with SAP system solution. 2019. Available from: IT provider for healthcare | Telekom Healthcare Solutions (telekom-healthcare.com) [Accessed 1 December 2019].

Jakimowicz, S & Perry, L. 2015. A concept analysis of patient-centred nursing in the intensive care unit. *Journal of Advanced Nursing*. 71(7):1499–1517. doi.org/10.1111/jan.12644.

Johnson, AEW, Ghassemi, MM, Nemati, S, Niehaus, KE, Clifton, D & Clifford, GD. 2016. Machine Learning and Decision Support in Critical Care. *Proceedings of the IEEE*. 104(2):444–466. doi.org/10.1109/JPROC.2015.2501978.

Kaier, K, Lambert, M-L, Frank, UK, Vach, W, Wolkewitz, M, Tacconelli, E, Rello, J, Theuretzbacher, U, *et al*. 2014. Impact of availability of guidelines and active surveillance in reducing the incidence of ventilator-associated pneumonia in Europe and worldwide. *BMC Infectious Diseases*. 14(1):199. doi.org/10.1186/1471-2334-14-199.

Khan, R, Al-Dorzi, HM, Al-Attas, K, Ahmed, FW, Marini, AM, Mundekkadan, S, Balkhy, HH, Tannous, J, *et al*. 2016. The impact of implementing multifaceted interventions on the prevention of ventilator-associated pneumonia. *American Journal of Infection Control*. 44(3):320–326. doi.org/10.1016/j.ajic.2015.09.025.

Klompas, M. 2013. Complications of Mechanical Ventilation - CDC's New Surveillance Paradigm. *n engl j med*. 36816(18):1472–1475. doi.org/10.1056/NEJMp1301694.

Klompas, M, Lee, G, Priebe, GP, Yokoe, DS, Branson, R, Eichenwald, EC, Greene, LR, Howell, MD, *et al*. 2014. Strategies to prevent ventilator-associated pneumonia in acute care hospitals: 2014 update. *Infection Control and Hospital Epidemiology*. 35(8):915–936. doi.org/10.1017/S0899823X00193894.

Van der Kooi, T, Sax, H, Pittet, D, van Dissel, J, van Benthem, B, Walder, B, Cartier, V, Clack, L, *et al*. 2017. Prevention of hospital infections by intervention and training (PROHIBIT): results of a pan-European cluster-randomized multicentre study to reduce central venous catheter-related bloodstream infections. *Intensive Care Medicine*. 44(1):48–60. doi.org/10.1007/s00134-017-5007-6.

Koy, V, Yunibhand, J & Angsuroch, Y. 2016. The quantitative measurement of nursing care quality: a systematic review of available instruments. *International Nursing Review*. 63(3):490–498. doi.org/10.1111/inr.12269.

Kunzmann, H, Dimitriades, K, Morrow, BM & Argent, AC. 2016. Reducing paediatric ventilator-associated pneumonia – a South African challenge! *Southern African Journal of Critical Care*. 32(1):17. doi.org/10.7196/sajcc.2016.v32i1.243.

Lachiewicz, AM, Weber, DJ, van Duin, D, Carson, SS, DiBiase, LM, Jones, SW, Rutala, WA, Cairns, BA, *et al*. 2017. From VAP to VAE: Implications of the New CDC Definitions on a Burn Intensive Care Unit Population. *Infection control and hospital epidemiology*. 38(7):867–869. doi.org/10.1017/ice.2017.63.

Larsson, J, Itenov, TS & Bestle, MH. 2017. doi.org/10.1016/j.jcrc.2016.09.003.

Lavallée, JF, Gray, TA, Dumville, J, Russell, W & Cullum, N. 2017. The effects of care bundles on patient outcomes: a systematic review and meta- analysis. *Implementation Science*. 12. doi.org/10.1186/s13012-017-0670-0.

Van Lill, H. 2015. *Hospital VAP-rate*.

Lim, K-P, Kuo, S-W, Ko, W-J, Sheng, W-H, Chang, Y-Y, Hong, M-C, Sun, C-C, Chen, Y-C, *et al*. 2015. Efficacy of ventilator-associated pneumonia care bundle for prevention of ventilator-associated pneumonia in the surgical intensive care units of a medical center. *Journal of Microbiology, Immunology and Infection*. 48(3):316–321. doi.org/10.1016/j.jmii.2013.09.007.

Loss, SH, de Oliveira, RP, Maccari, JG, Savi, A, Boniatti, MM, Hetzel, MP, Dallegrave, DM, Balzano, P de C, *et al*. 2015. The reality of patients requiring prolonged mechanical ventilation: a multicenter study. *Revista Brasileira de terapia intensiva*. 27(1):26–35. doi.org/10.5935/0103-507X.20150006.

Lowman, W, Mitchell, BG, Gardner, A, Halperin, JJ, Moran, S, Prasek, D, Richards, A, Ruggiero, C, *et al*. 2016. Hospital-Acquired Pneumonia (Nosocomial Pneumonia) and Pneumonia. *International Journal of Health Planning and Management*. 25(6):42–55. doi.org/10.1016/j.ajic.2016.01.005.

Mahomed, S, Mahomed, O, Sturm, AW, Knight, S & Moodley, P. 2017. Challenges with Surveillance of Healthcare-Associated Infections in Intensive Care Units in South Africa. *Critical Care Research and Practice*. 2017:1–7. doi.org/10.1155/2017/7296317.

McQuoid-Mason, D. 2019. South African Medical Journal , Vol 102 , No 6 Hospital-acquired infections – when are hospitals legally liable ? Failure by the hospital or hospital management to introduce best practices to prevent hospital- acquired infections. *South African Medical Journal*. 102(6):353–354. doi.org/10.7196/SAMJ.5664.

Mehta, AB, Syeda, SN, Wiener, RS & Walkey, AJ. 2015. Epidemiological Trends in Invasive Mechanical Ventilation in the United States: A Population-Based Study HHS Public Access. *J Crit Care*. 30(6):1217–1221. doi.org/10.1016/j.jcrc.2015.07.007.

Mehtar, S. 2015. *Understanding Infection Prevention and Control*. 2nd reprin ed. Cape Town: Juta and Company Ltd.

Mitchell, BG & Gardner, A. 2014. Addressing the need for an infection prevention and control framework that incorporates the role of surveillance: A discussion paper. *Journal of Advanced Nursing*. 70(3):533–542. doi.org/10.1111/jan.12193.

Mogyoródi, B, Dunai, E, Gál, J & Iványi, Z. 2016. Ventilator-associated pneumonia and the importance of education of ICU nurses on prevention - Preliminary results. *Interventional Medicine and Applied Science*. 8(4):147–151. doi.org/10.1556/1646.8.2016.4.9.

Nasrabadi, AN, Peyrovi, H & Valiee, S. 2017. Nurses' Error Management in Critical Care Units. *Critical Care Nursing Quarterly*. 40(2):89–98. doi.org/10.1097/cnq.0000000000000145.
NHLS: Annual Report. 2016. South Africa.

"NHSN - Patient Safety Component Manual". 2019. In: *Device Associated Module*. CDC. 1–45. Available from: Ventilator-associated Event (VAE) (cdc.gov) [Accessed 11 September 2019].

Othman, AA & Abdelazim, MS. 2017. Ventilator-associated pneumonia in adult intensive care unit prevalence and complications. *The Egyptian Journal of Critical Care Medicine*. 5(2):61–63. doi.org/10.1016/j.ejccm.2017.06.001.

Othman, HA, Gamil, NM, Elgazzar, AEM & Fouad, TA. 2017. Ventilator associated pneumonia, incidence and risk factors in emergency intensive care unit Zagazig university hospitals. *Egyptian Journal of Chest Diseases and Tuberculosis*. 66(4):703–708. doi.org/10.1016/J.EJCDT.2017.08.004.

Peet, J, Theobald, K & Douglas, C. 2019. Strengthening nursing surveillance in general wards: A practice development approach. *Journal of Clinical Nursing*. doi.org/10.1111/jocn.14890.

Phillips, JM, Stalter, AM, Winegardner, S, Wiggs, C & Jauch, A. 2018. Systems thinking and incivility in nursing practice: An integrative review. *Nursing Forum*. 53(3):286–298. doi.org/10.1111/nuf.12250.

Polit, DF & Beck, CT. 2017a. *Nursing research: generating and assessing evidence for nursing practice. 10th edition. New York: Wolters Kluwer.* 10th editi ed. New York: Wolters Kluwer.

Prakash, SS, Rajshekar, D, Cherian, A & Sastry, AS. 2017. Care bundle approach to reduce device-associated infections in a tertiary care teaching hospital, South India. *Journal of laboratory physicians*. 9(4):273–278. doi.org/10.4103/JLP.JLP_162_16.

Prevent ventilator-associated pneumonia in adults Definition of VAP. 2012. Available from: www.ihi.org [Accessed 6 December 2019].

Preventing Healthcare-associated Infections | HAI | CDC. 2019. Available from: Preventing Healthcare-associated Infections | HAI | CDC [Accessed 2 December 2019].

Rawat, N., Yang, T., Ali, K. J., Catanzaro, M., Cohen, M. D., Farley, D. O., Lubomski, L. H., Thompson, D. A., Winters, B. D., Cosgrove, S. E., Klompas, M., Speck, K. A., & Berenholtz, S. M. (2017). Two-State Collaborative Study of a Multifaceted Intervention to Decrease Ventilator-Associated Events. *Critical Care Medicine*, *45*(7), 1208–1215. https://doi.org/10.1097/CCM.0000000000002463

Redondo-Gonzalez, O, Tenıas, JM, Arias, A & Lucendo, AJ. 2018. Validity and Reliability of Administrative Coded Data for the Identificatio...: EBSCOhost. *Health Services Research*. 53(3):1919–1957. doi.org/DOI: 10.1111/1475-6773.12691.

Resende, M. M., Monteiro, S. G., Callegari, B., Figueiredo, P. M. S., Monteiro, C. R. A. v, & Monteiro-Neto, V. (2013). Epidemiology and outcomes of ventilator-associated pneumonia in northern Brazil: an analytical descriptive prospective cohort study. *BMC Infectious Diseases*, *13*(1), 119. https://doi.org/10.1186/1471-2334-13-119

Robinson, C, Hoze, M, Hevener, S & Nichols, AA. 2018. Development of an RN Champion Model to Improve the Outcomes of Ventilator-Associated Pneumonia Patients in the Intensive Care Unit. *Journal of Nursing Administration*. 48(2):79–84. doi.org/10.1097/NNA.0000000000000578.

Rosenthal, VD. 2016. International Nosocomial Infection Control Consortium (INICC) resources: INICC multidimensional approach and INICC surveillance online system. *American Journal of Infection Control*. 44(6):e81–e90. doi.org/10.1016/j.ajic.2016.01.005.

Ryan, KJ, Brady, J V., Cooke, RE, Height, DI, Jonsen, AR, King, P, Lebacqz, K, Louisell, DW, *et al*. 2018. *Read the Belmont Report | HHS.gov*. Available from: https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/read-the-belmont-report/index.html Read the Belmont Report | HHS.gov [Accessed 14 September 2020].

Safdar, N, Musuuza, JS, Xie, A, Hundt, AS, Hall, M, Wood, K & Carayon, P. 2016. Management of ventilator-associated pneumonia in intensive care units: a mixed methods study assessing barriers and facilitators to guideline adherence. *BMC Infectious Diseases*. 16(1):349. doi.org/10.1186/s12879-016-1665-1.

Sahlol, N, Madkour, L & Soliman, Y. 2016. Ventilator Associated Pneumonia in a Tertiary Care Hospital: Incidence, Risk Factors and Etiological Agents. *British Microbiology Research Journal*. 13(1):1–10. doi.org/10.9734/bmrj/2016/24360.

Salgado Yepez, E., Bovera, M. M., Rosenthal, V. D., González Flores, H. A., Pazmiño, L., Valencia, F., Alquinga, N., Ramirez, V., Jara, E., Lascano, M., Delgado, V., Cevallos, C., Santacruz, G., Pelaéz, C., Zaruma, C., & Barahona Pinto, D. (2017). Device-associated infection rates, mortality, length of stay and bacterial resistance in intensive care units in Ecuador: International Nosocomial Infection Control Consortium's findings. *World Journal of Biological Chemistry*, *8*(1), 95. https://doi.org/10.4331/wjbc.v8.i1.95

SANC Regulations: Scope of Practice. 1978. South African Nursing Council. Available from: https://www.sanc.co.za/regulat/Reg-scp.htm Regulations – SANC [Accessed 10 September 2019].

South African Nursing Council, 2005. *Nursing Act No 33.* [Online] Available at: https://www.sanc.co.za/wp-content/uploads/2020/06/Nursing-Act-2005.pdf [Accessed November 2021].

Sedevich-Fons, L. 2014. Financial indicators in healthcare quality management systems. *TQM Journal*. 26(4):312–328. doi.org/10.1108/TQM-01-2014-0009.

Shime, N. 2014. Hospital-acquired pneumonia and ventilator-associated pneumonia. *Japanese Journal of Chest Diseases*. 73:S123–S132. doi.org/10.1097/mcp.0b013e32835f27be.

Singh, H & Sittig, DF. 2016. Measuring and improving patient safety through health information technology: The health IT safety framework. *BMJ Quality and Safety*. 25(4):226–232. doi.org/10.1136/bmjqs-2015-004486.

Speck, K, Rawat, N, Weiner, NC, Tujuba, HG, Farley, D & Berenholtz, S. 2016. A systematic approach for developing a ventilator-associated pneumonia prevention bundle. *American Journal of Infection Control*. 44(6):652–656. doi.org/10.1016/j.ajic.2015.12.020.

Sullivan, DH. 2015. doi.org/10.1016/j.cnur.2015.07.005.

Tablan, OfC, Anderson, LJ, Besser, R, Bridges, C & Hajjeh, R. 2003. *Guidelines for Preventing Health-Care- Associated Pneumonia, CDC*. Available from: Healthcare-Associated Pneumonia | Guidelines Library | Infection Control | CDC [Accessed 20 April 2019].

The Belmont report. 2020. United States of America: world wide web. Available from: https://www.hhs.gov/ohrp/regulations-and-policy/belmont-report/read-the-belmont-report/index.html Read the Belmont Report | HHS.gov [Accessed 8 February 2020].

Timsit, JF, Esaied, W, Neuville, M, Bouadma, L & Mourvllier, B. 2017. Update on ventilator-associated pneumonia. *F1000Research*. 6. doi.org/10.12688/f1000research.12222.1.

Torres, A, Niederman, MS, Chastre, J, Ewig, S, Fernandez-Vandellos, P, Hanberger, H, Kollef, M, Bassi, GL, *et al*. 2017. doi.org/10.1183/13993003.00582-2017.

Total Population Sampling - Statistics How To. 2019. Available from: Total Population Sampling - Statistics How To [Accessed 2 December 2019].

Urden, LC, Stacey, KM & Lough, ME. 2014. *Critical Care Nursing*. 6th ed. Canada: Elseriver Book Aid International. *Ventilator-Associated Event (VAE)*. 2020.

Walaszek, M, Gniadek, A, Kolpa, M, Wolak, Z & Kosiarska, A. 2017. The effect of subglottic secretion drainage on the incidence of ventilator associated pneumonia. 161(4):374–380. doi.org/10.5507/bp.2017.041.

Wright, MO, Decker, SG, Allen-Bridson, K, Hebden, JN & Leaptrot, D. 2018. Healthcare-associated infections studies project: An American Journal of Infection Control and National Healthcare Safety

Network data quality collaboration: Location mapping. *American Journal of Infection Control*. 46(5):577–578. doi.org/10.1016/j.ajic.2017.12.012.

Yaffa Zisk-Rony, R, Weissman, C & Weiss, YG. 2019. Mechanical ventilation patterns and trends over 20 years in an Israeli hospital system: policy ramifications. *Israel Journal of Health Policy Research*. 8(20). doi.org/10.1186/s13584-019-0291-y.

Yazici, G & Bulut, H. 2018. Efficacy of a care bundle to prevent multiple infections in the intensive care unit: A quasi-experimental pretest-posttest design study. *Applied Nursing Research*. 39:4–10. doi.org/10.1016/j.apnr.2017.10.009.

ANNEXURES

ANNEXURE A1– APPROVAL CERTIFICATE

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences

Institution: The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

- FWA 00002567, Approved dd 22 May 2002 and Expires 03/20/2022.
- IORG #: IORG0001762 OMB No. 0990-0279 Approved for use through February 28, 2022 and Expires: 03/04/2023.

Faculty of Health Sciences **Research Ethics Committee**

13 May 2021

Approval Certificate
Annual Renewal

Dear Miss K Meintjes

Ethics Reference No.: 163/2018
Title: Explore the reporting process on the incidence of ventilator associated Pneumonia in long term mechanically ventilated patients.

The **Annual Renewal** as supported by documents received between 2021-04-28 and 2021-05-12 for your research, was approved by the Faculty of Health Sciences Research Ethics Committee on 2021-05-12 as resolved by its quorate meeting.

Please note the following about your ethics approval:

- Renewal of ethics approval is valid for 1 year, subsequent annual renewal will become due on 2022-05-13.
- Please remember to use your protocol number (163/2018) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, monitor the conduct of your research, or suspend or withdraw ethics approval.

Ethics approval is subject to the following:

- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

On behalf of the FHS REC, Dr R Sommers
MBChB, MMed (Int), MPharmMed, PhD
***Deputy Chairperson** of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria*

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes, Second Edition 2015 (Department of Health)

Research Ethics Committee
Room 4-60, Level 4, Tuwelopele Building
University of Pretoria, Private Bag x323
Gezina 0031, South Africa
Tel +27 (0)12 356 3084
Email: deepeka.behari@up.ac.za
www.up.ac.za

Fakulteit Gesondheidswetenskappe
Lefapha la Dikgaense tsa Maphelo

ANNEXURE A2 – [redacted]

RESEARCH OPERATIONS COMMITTEE FINAL APPROVAL OF RESEARCH

Approval number: UNIV-2021-0028

Ms Kimre Meintjies

E mail: meintjeskimre@gmail.com

Dear Ms Kimre Meintjies

RE: EXPLORING THE REPORTING PROCESS ON THE INCIDENCE OF VENTILATOR ASSOCIATED PNEUMONIA IN LONG-TERM MECHANICALLY VENTILATED PATIENTS

The above-mentioned research was reviewed by the Research Operations Committee's delegated members and it is with pleasure that we inform you that your application to conduct this research at private Hospital, has been approved, subject to the following:

i) Research may now commence with this FINAL APPROVAL from the Committee.

ii) All information regarding the Company will be treated as legally privileged and confidential.

iii) The Company's name will not be mentioned without written consent from the Committee.

iv) All legal requirements regarding patient / participant's rights and confidentiality will be complied with.

v) All data extracted may only be used in an anonymised, aggregated format and for the purposes of this specific study as specified in the proposal. The data may under no circumstances be used for any other purpose whatsoever.

vi) The research will be conducted in compliance with the GUIDELINES FOR GOOD CLINICAL PRACTICE IN HUMAN PARTICIPANTS IN SOUTH AFRICA (2016).

vii) The Company must be furnished with a STATUS REPORT on the progress of the study at least annually on 30th September irrespective of the date of approval from the Committee as well as a FINAL REPORT with reference to intention to publish and probable journals for publication, on completion of the study.

viii) A copy of the research report will be provided to the Committee once it is finally approved by the relevant primary party or tertiary institution, or once complete or if discontinued for any reason whatsoever prior to the expected completion date.

ix) The Company has the right to implement any recommendations from the research.

x) The Company reserves the right to withdraw the approval for research at any time during the process, should the research prove to be detrimental to the subjects/ Company or should the researcher not comply with the conditions of approval.

xi) APPROVAL IS VALID FOR A PERIOD OF 36 MONTHS FROM DATE OF THIS LETTER OR COMPLETION OR DISCONTINUATION OF THE TRIAL, WHICHEVER IS THE FIRST.

We wish you success in your research.

Yours faithfully

[redacted] 22/06/2021

Full member: Research Operations Committee & Medical Practitioner evaluating research applications as per Management and Governance Policy

[redacted]

Dr Shannon Neil
Chairperson: Research Operations Committee
Date: 22/06/2021

This letter has been anonymised to ensure confidentiality in the research report. The original letter is available with author of research

ANNEXURE A3: FROM THE HOSPITAL

[redacted]

[redacted]

Tel: + 27 (0)11 301 0000
Fax: Corporate +27 (0)11 301 0499
76 Maude Street, Corner West Street, Sandton, South Africa
Private Bag X34, Benmore, 2010, South Africa
www.netcare.co.za

RESEARCH OPERATIONS COMMITTEE FINAL APPROVAL OF RESEARCH

Approval number: UNIV-2021-0028

Ms Kimre Meintjies

E mail: meintjeskimre@gmail.com

Dear Ms Kimre Meintjies

RE: EXPLORING THE REPORTING PROCESS ON THE INCIDENCE OF VENTILATOR ASSOCIATED PNEUMONIA IN LONG-TERM MECHANICALLY VENTILATED PATIENTS

The above-mentioned research was reviewed by the Research Operations Committee's delegated members and it is with pleasure that we inform you that your application to conduct this research at [redacted] has been approved, subject to the following:

i) Research may now commence with this FINAL APPROVAL from the [redacted] Research Operations Committee.

ii) All information regarding [redacted] will be treated as legally privileged and confidential.

iii) [redacted]name will not be mentioned without written consent from the Netcare Research Operations Committee.

iv) All legal requirements regarding patient / participant's rights and confidentiality will be complied with.

v) All data extracted may only be used in an anonymised, aggregated format and for the purposes of this specific study as specified in the proposal. The data may under no circumstances be used for any other purpose whatsoever.

vi) The research will be conducted in compliance with the GUIDELINES FOR GOOD CLINICAL PRACTICE IN HUMAN PARTICIPANTS IN SOUTH AFRICA (2016).

vii) Netcare must be furnished with a STATUS REPORT on the progress of the study at [redacted] least annually on 30th September irrespective of the date of approval from the Netcare Research Operations Committee as well as a FINAL REPORT with reference to intention to publish and probable journals for publication, on completion of the study.

viii) A copy of the research report will be provided to the [redacted] Research Operations Committee once it is finally approved by the relevant primary party or tertiary institution, or once complete or if discontinued for any reason whatsoever prior to the expected completion date.

ix) [redacted] has the right to implement any recommendations from the research.

x) [redacted] reserves the right to withdraw the approval for research at any time during the process, should the research prove to be detrimental to the subjects[redacted], or should the researcher not comply with the conditions of approval.

xi) APPROVAL IS VALID FOR A PERIOD OF 36 MONTHS FROM DATE OF THIS LETTER OR COMPLETION OR DISCONTINUATION OF THE TRIAL, WHICHEVER IS THE FIRST.

We wish you success in your research.

Yours faithfully

[redacted] 22/06/2021

Full member: Netcare Research Operations Committee & Medical Practitioner evaluating research applications as per Management and Governance Policy

[redacted] Operations Committee

Date: 22/06/2021

ANNEXURE B1: BEST CARE ALWAYS (BCA) VAP BUNDLE *(BEST CARE-ALWAYS!* 2019*)*

ANNEXURE C1: LETTER OF SUPPORT FROM BIOSTATISTICIAN

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Denkleiers • Leading Minds • Dikgopolo tša Dihlalefi

DEPARTMENT OF STATISTICS

LETTER OF STATISTICAL SUPPORT

26 August 2019

This letter is to confirm that **Ms Kimre Meintjes**, studying at the University of Pretoria, discussed the project with the title "**Evaluating the reporting process on the incidence of ventilator associated pneumonia in long term mechanically ventilated patients**" with me.

I hereby confirm that I am aware of the project and I undertake to assist with the statistical analysis of the data generated from the project.

The data analysis will consist of descriptive statistics such as means, standard deviations, 25th, 50th and 75th percentiles for the WHO VAP rate and also for the VAP rate calculated by the researcher from observed clinical parameters. The two median VAP rates will be compared by performing the non-parametric Wilcoxon signed rank test. Alternatively, if possible the Intraclass correlation coefficient (ICC) between the two types of VAP rates will be computed.

The sample will consist of a convenience sample from the clinical documents and clinical electronic data of approximately 66 long term patients in a hospital in Gauteng, giving information for approximately 1243 ventilation days.

Ms JC Jordaan
Research consultant
Internal Consultation Service
Department of Statistics
E-mail address: joyce.jordaan@up.ac.za

ANNEXURE C2: DATA-SHEET USED TO COLLECT DATA

Note:

- *The clinical data should be captured from the first day of intubation until two days after extubation, to adhere to the guidelines of the VAP algorithm*
- **Note: Capture all available information, missing information should be listed as not applicable or unknown*

APPLICABLE CLINICAL RECORDS PER LONG-TERM MECHANICAL VENTILATION-EVENT			
Long-term mechanical ventilator-event			
Patient ID:		***Admission Date:***	
Death Date:		***Discharge Date:***	
Patient Age:		***Unit of admission:***	
Admission diagnosis:			
Start Date (Bluebird):		***Discontinued Date (Bluebird):***	
Start Date (SAP):		***Discontinued Date (SAP):***	

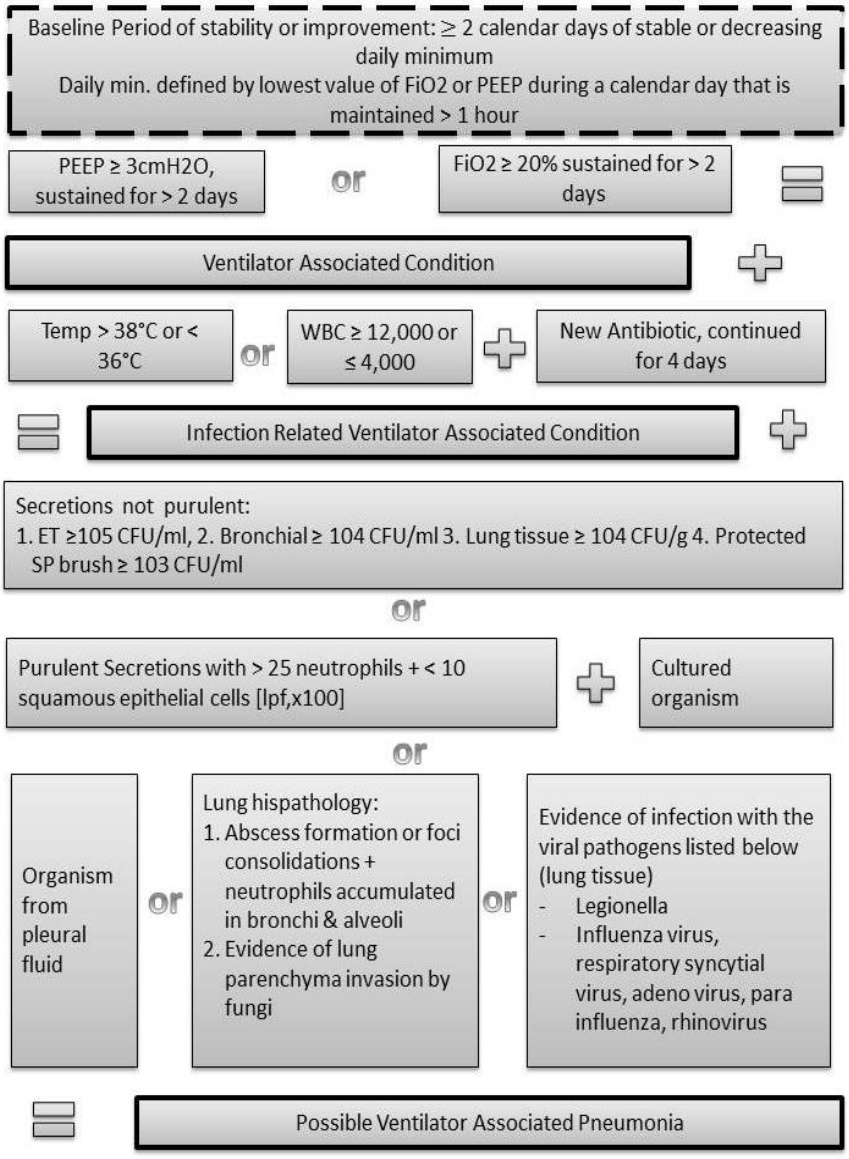
All available clinical records are to be captured per applicable date				
Date	***FiO_2***	***PEEP***	***WBC***	***Temperature***

Antibiotic treatment information		
Antibiotic Description	***Date Started***	***Date Discontinued***

MCS -results				
Date	***Sample type***	***Quality indicator for purulent sputum***	***Quality indicator for clear sputum***	***Organism Cultured***

ANNEXURE C3: EVIDENCE BASED VAP ALGORITHM

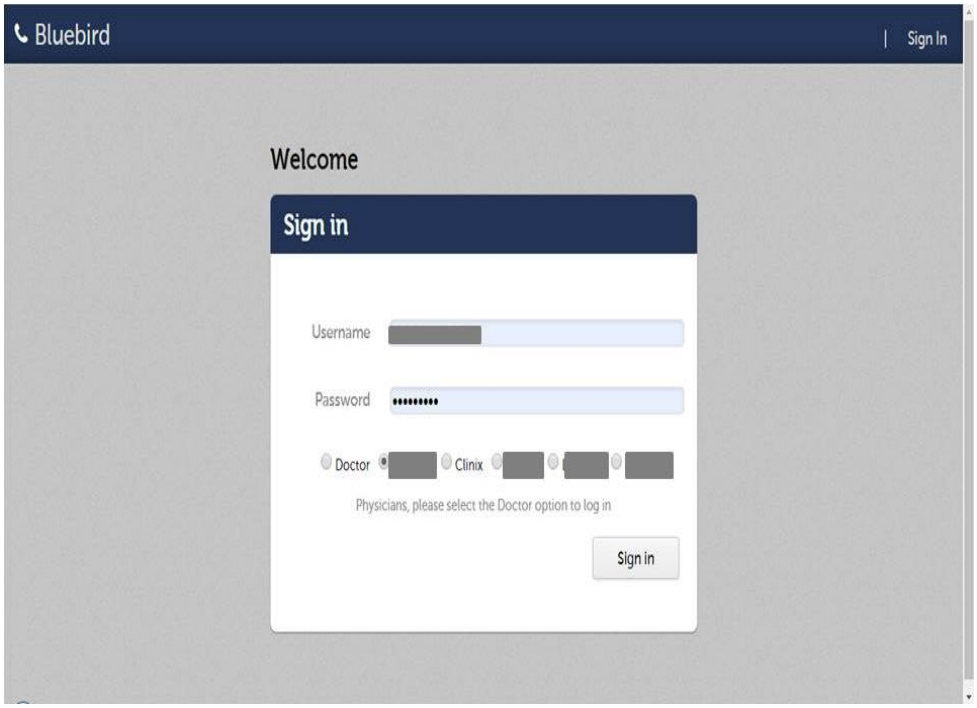
(*Preventing Healthcare-associated Infections | HAI | CDC*, 2019)



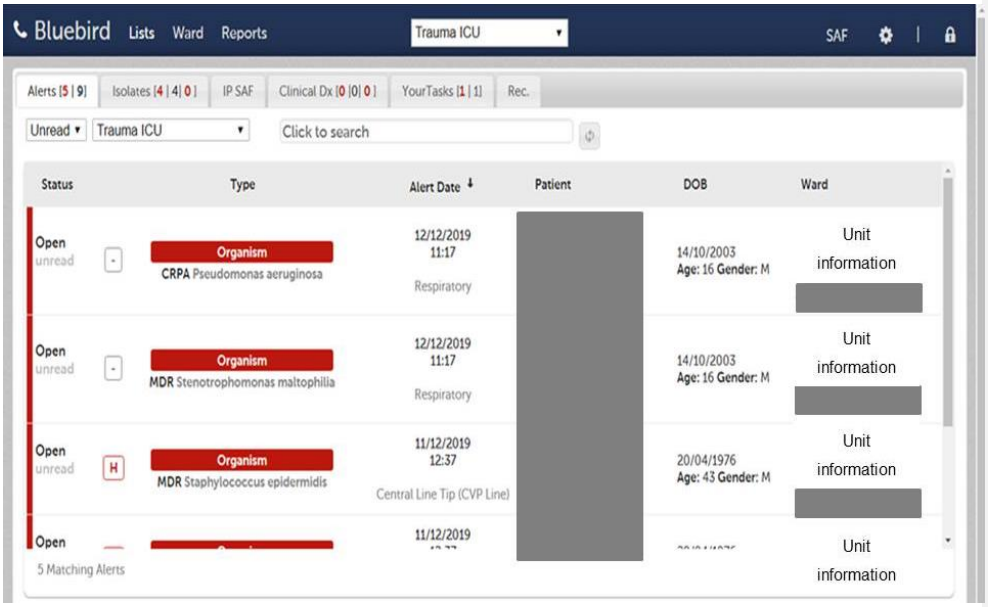
The following set of Annexures are applicable to Chapter 3, 4, 5 and supports the data collection, sorting and analysis of the Objectives and the discussion of the research results.

ANNEXURE D1: ANNEXURES SUPPORTING RESEARCH RESULTS

(*Bluebird: Home*, 2019)



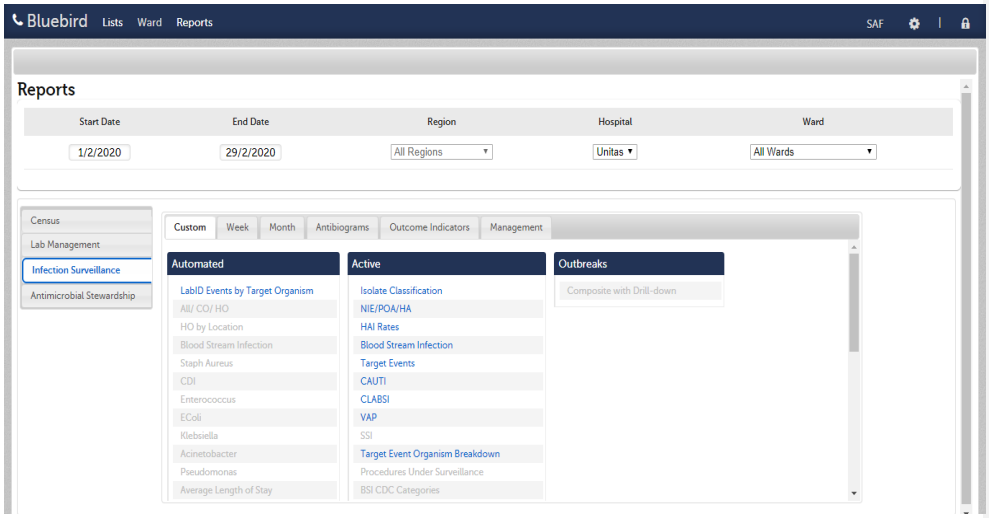
ANNEXURE D2: MANAGEMENT SCREEN FROM WHERE USER CAN ACCESS OTHER FUNCTION SCREENS, LIKE REPORTS (*Bluebird: Home*, 2019)



ANNEXURE D3: SAMPLE SCREEN OF THE LIST OF AVAILABLE REPORTS

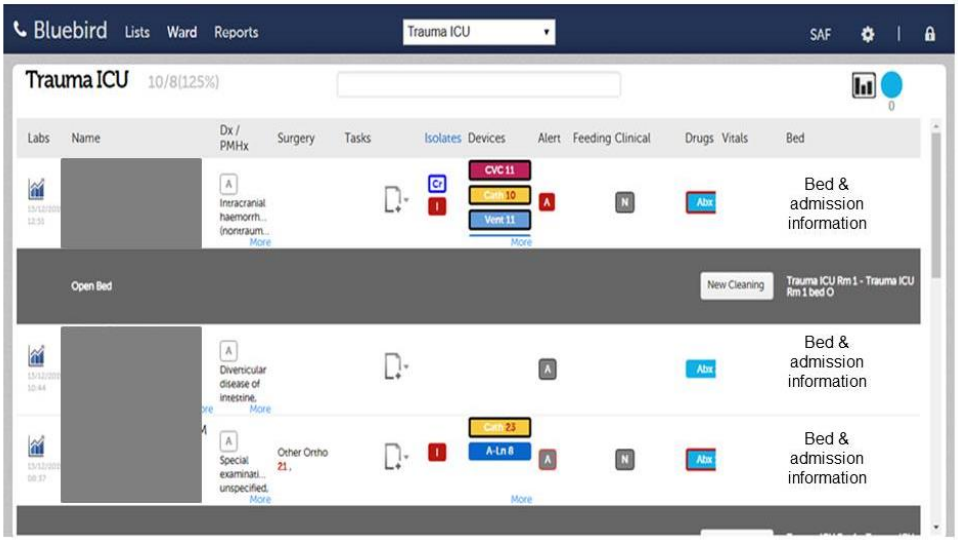
(*Bluebird: Home*, 2019)

Reports can be selected between specific date ranges, regional within the hospital group, or within a specific hospital and even as detailed as for a specific unit.



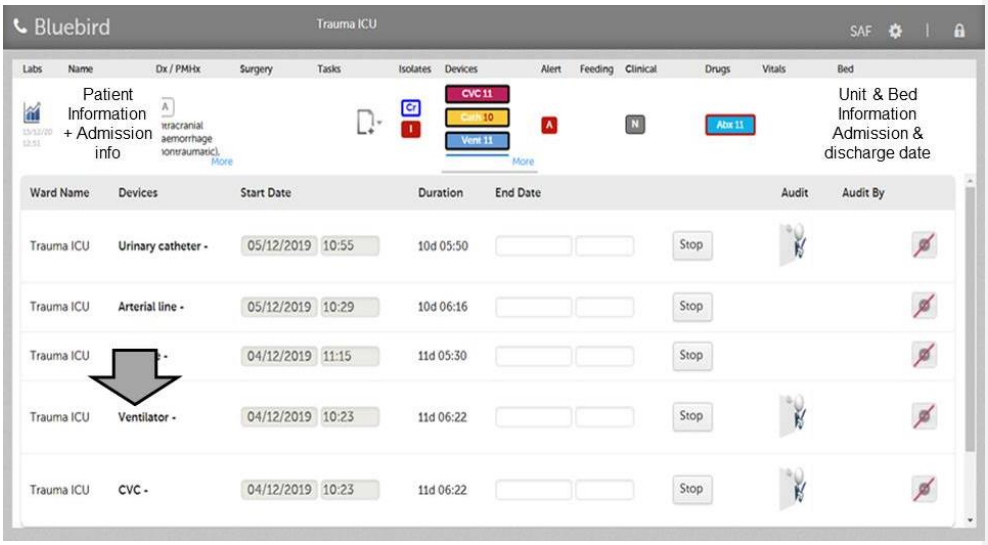
ANNEXURE D4: SAMPLE SCREEN OF CURRENT PATIENTS ADMITTED IN SELECTED UNIT

The Screen shows the patients currently in the unit, at the time of log-in, as per the Hospital Information Technology Systems.

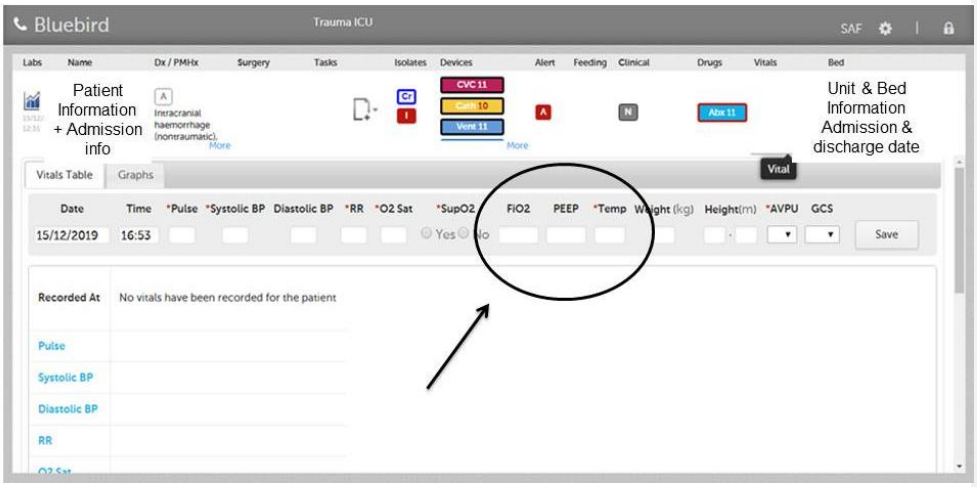


As can be seen from the 'screen-print', the end user will be able to see the patients that are currently in the unit and which beds are open, the open bed, actually shows that the bed needs 'NEW CLEANING' to be done, as part of IPC environment management and this information can then be recorded in the record fields the application provided for it. The End User can now select one of these patients in the unit to whose records need management or additional clinical information recorded, or there is a 'search' functionality from where the user could search for retrospective data records (*Bluebird: Home*, 2019).

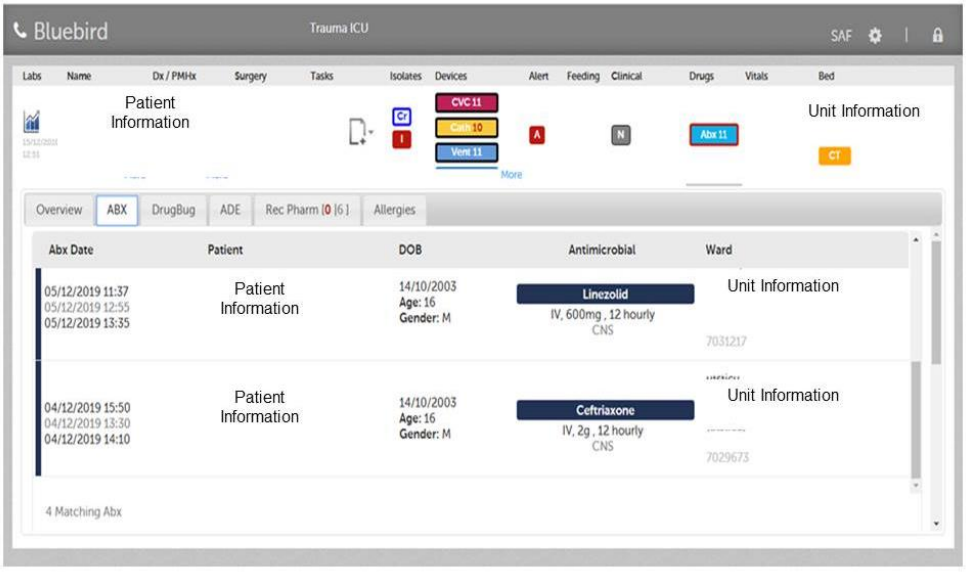
ANNEXURE D5: SAMPLE SCREEN FOR CAPTURING OF DEVICE DAY INFORMATION (*Bluebird: Home*, 2019)

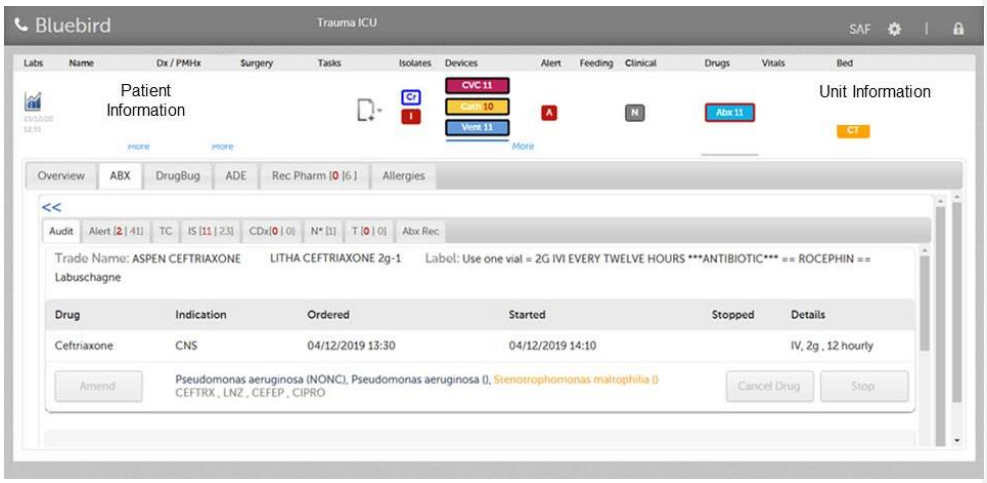


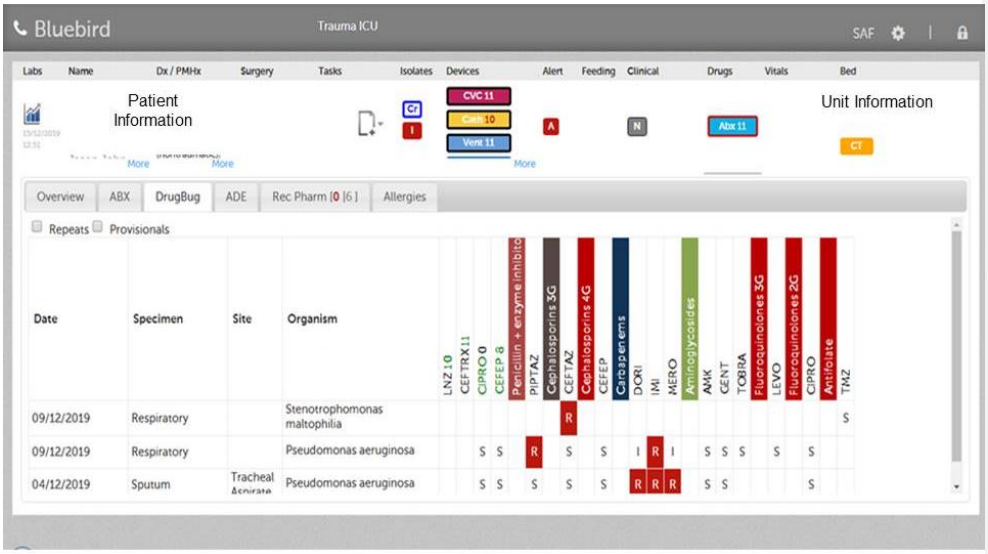
ANNEXURE D6: SAMPLE SCREEN FOR CAPTURING PATIENT-EVENT VITAL (*Bluebird: Home*, 2019)



ANNEXURE D7: THREE SAMPLE SCREENS SHOWING ANTIBIOTIC PRESCRIPTION DETAIL (*Bluebird: Home*, 2019)






Bluebird
Trauma ICU
SAF
Labs
Name
Dx / PMHx
Surgery
Tasks
Isolates
Devices
Alert
Feeding
Clinical
Drugs
Vitals
Bed
Patient Information
Unit Information
CVC 11
Vent 11
Abx 11
CT
More
Overview
ABX
DrugBug
ADE
Rec Pharm [0 |6]
Allergies
Repeats
Provisionals
Date
Specimen
Site
Organism
LNZ 0
CEFTRX 1
CIPRO 0
CEFEP 0
Penicillin + enzyme inhibito
PIPTAZ
Cephalosporins 3G
CEFTAZ
Cephalosporins 4G
CEFEP
Carbapenems
DORI
IMI
MERO
Aminoglycosides
AMK
GENT
TOBRA
Fluoroquinolones 3G
LEVO
Fluoroquinolones 2G
CIPRO
Antifolate
TMZ
09/12/2019
Respiratory
Stenotrophomonas maltophilia
09/12/2019
Respiratory
Pseudomonas aeruginosa
04/12/2019
Sputum
Tracheal
Pseudomonas aeruginosa

ANNEXURE E1: PICTURE SCREEN OF SUMMARY DATA PROVIDED TO BIO-STATISTICIAN

		BASELINE		VAC		IVAC		
		Fio2	PEEP	Fio2	PEEP	Temp	WBC	ANTIBIOTICS
GAMMAPROTEOBACTERIA	ACINEBACTER BAUMANNI	0,6	UNKNOWN	4;5;6	UNKNOWN	4;5;6	4;5;6	4-5;4-5;3-5;...-5
	ESCHERICHIA COLI	0,6	12	NONE	UNKNOWN	1;2;10	1;2;6	1-8;7-12;7-15;15-19
	PROTEUS MIRABILIS	0,4	15	11;12;13	UNKNOWN	9;13	11;12;14	1-2;2-9;11-12;12-24
	PSEUDOMONAS AERUGINOSA	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NONE	3-10;3-5
	SERRATIA MARCESCENS	0,65	UNKNOWN	UNKNOWN	UNKNOWN	2;7	2;5;7;8	NONE
	STAPHYLOCOCCUS MALTOPHILIA	0,36	5	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN	NONE
	STREPTOCOCCUS PNEUMONIAE	0,4	10	UNKNOWN	UNKNOWN	8	9;12;13;14;15;16	8-13;13-20
		0,4	UNKNOWN	2;3;4;5	NO;UNKNOWN	2;3;8;16	3;4;5;6;7;8;9;10;11;12;13;14	1-4;4-11;15-23;18-18