PREVALENCE OF NOSOCOMIAL INFECTION IN PAEDIATRIC INTENSIVE CARE UNIT AT PIETERSBURG HOSPITAL IN LIMPOPO, SOUTH AFRICA

by

MAKHWANYA TSHIMANGADZO MILDRED

Mini-dissertation submitted in fulfilment of the requirements

for the degree

Master of Medicine in Paediatrics and Child Health

Department of Paediatrics and Child health

School of Medicine

Faculty of Health Sciences

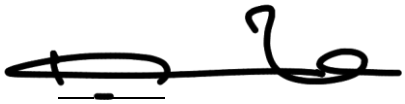
UNIVERSITY OF LIMPOPO

SUPERVISOR: Prof. SM Risenga

October 2020

DECLARATION

I, **Tshimangadzo Mildred Makhwanya,** declare that the submitted work on the prevalence of nosocomial infection in paediatric intensive care unit Pietersburg hospital Limpopo South Africa is my work and that I have not used any other than permitted reference sources or materials nor engaged in any plagiarism. All references and other sources used or quoted by me have been appropriately and duly acknowledged using complete references. I further declare that the work has not been submitted for academic examination, either in its original or similar form, anywhere else.

Signed: 

Tshimangadzo Mildred Makhwanya

Date: 07 January 2021

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude and appreciation to God for walking with me throughout this journey and ensuring that I never give up no matter how tough it was.

My gratitude goes to the late Prof. Nancy Shipalana for allowing me to train at the Polokwane Mankweng complex. If it was not for this opportunity given, it would not have been possible to deliver this study.

My heartfelt gratitude goes to my supervisor Prof. Samuel Risenga for constructive, inexorable guidance, support, and patience. Thank you, Prof. Risenga for support and for your confidence in me until the completion of this study.

I wish to take this opportunity to thank my dearest husband Dr. ME Makhwanya for his unwavering support even in the toughest of all times. Your support has made this journey easier and worth it. From the bottom of my heart, I would like to say thank you.

To my children, Murangi, Vhudi, and Masana thank you for your continuous support and love. The sleepless nights have eventually paid off.

I wish to thank my colleagues from the Department of Health, Tshilidzini, and Pietersburg hospitals for allowing me to study and contributing directly to my value-adding personal development. Giving me this opportunity will indeed not only benefit me personally but the hospital and the community I am going to serve. Pietersburg Hospital, allowing to access patient's information has made it possible for me to conduct this study and without this access, this study would not have been possible.

To my Mother, Mrs Naume Ramakulukusha, and mother in law Mrs Phophi Makhwanya, thank you for always believing in me and giving me the courage to keep going. Your support had always been amazing and gave me hope to work even harder.

My siblings, sisters, brothers, and friends, no words could ever express my appreciation of your patience with me throughout my academic life. For this, I would like to say thank you.

Thank you for all the support.

ABSTRACT

Nosocomial infection constitutes a major health problem associated with high morbidity and mortality. This study is aimed at investigating the prevalence of nosocomial infections in paediatric intensive care unit of Pietersburg hospital, Limpopo, South Africa and identify the pathogens responsible for such infections and determine their anti-microbial activity. The study applied a retrospective quantitative descriptive study design to execute the objectives of the study. Convenience sampling was applied to select 98 participants that met the selection criteria to collect the data set from the hospital files between 1st January 2017 to 31st December 2017 in a self-designed template.

Results shows that the prevalence of nosocomial infections in children admitted from 1st January 2017–31st December 2017 at Pietersburg hospital was 13.27% where majority were females at 61,5% with the remaining 38,5% being male. Majority of participants that developed HAI were below 24 months of age (69%). Hospital stay was a mean of 23 days. The underlying conditions in participants who developed HAI were mostly HIV in 4 of 13 (31%) and had association with hospital stay (Chi-square = 140,14; pvalue=0,0034). Majority of patients that acquired HAI were admitted for a respiratory condition n=12; (92%) mainly Pneumonia and Bronchiolitis. Potential risks factors for developing HAI were endotracheal intubation, mechanical ventilation; central venous catheter (Chi- square =21,195; p value= 0,0035); Peripheral vascular catheter (Chisquare = 17,106; p-value= 0,0167); urethral catheter (Chi-square = 20,013; p-value= 0,0055) and surgery since admission (Chi-square = 27,649; p-value= 0,0003). There was a strong correlation between hospital stay and mortality rate (r=36%; p- value<0.0001).

Klebsiella pneumonia was the most identified pathogen from the respiratory site (50%). *Coagulase-negative staph aureus* was the most identified organism in the bloodstream. The study found that the development of HAI was associated with increased length of hospital stay and an increased rate of mortality.

Keywords: Nosocomial infections; Cultured organisms; Pathogens; Hospital stay.

TABLE OF CONTENTS

DECLARATION ..... **i**

ACKNOWLEDGEMENTS ..... **ii**

ABSTRACT ..... **iii**

TABLE OF CONTENTS ..... **iv**

LIST OF FIGURES ..... **viii**

LIST OF TABLES ..... **ix**

DEFINITION OF CONCEPTS ..... **x**

ABBREVIATIONS ..... **xii**

CHAPTER 1: INTRODUCTION AND BACKGROUND **1**

1.1 Background and overview of the study 1

1.2 Problem statement 2

1.3 Aim, Objectives, and Research Questions of the study 3

1.3.1 Aim of the study 3

1.3.2 Objectives of the study 3

1.3.3 Research questions 3

1.3.4 Hypothesis 4

1.4 Significance of the study 5

1.5 Research report layout 6

1.6 Conclusion 6

CHAPTER 2: LITERATURE REVIEW **7**

2.1 Introduction 7

2.2 Understanding Nosocomial infections 7

2.3 Causes of NI 7

2.4 Symptoms and causative *organisms* of NI 11

2.5 The prevalence rate of NI 12
2.6 Risk factors of NI 16
2.7 Complication of NI 19
2.8 Conclusion 19
CHAPTER 3: RESEARCH METHODOLOGY 20
3.1 Introduction 20
3.2 Research design 20
3.2.1 The population of the study 20
3.2.2 Study setting 21
3.2.3 Sampling 21
3.2.4 Inclusion criteria 21
3.2.5 Exclusion criteria 22
3.2.6 Sample size calculation 23
3.2.7 Response rate 23
3.3 Data collection 23
3.4 Data analysis 24
3.5 Validity and reliability 25
3.6 Bias 26
3.7 Ethical consideration 26
3.8 Conclusion 26
CHAPTER 4: RESULTS AND INTERPRETATION 28
4.1 Introduction 28
4.2 Patient details and demographical information of participants 28
4.2.1 Age distribution of participants 29
4.2.2 Hospital stay 30
4.2.3 Diagnosis of participants 31

4.2.4 Underlying conditions 31
4.2.5 Risk factors 32
4.2.6 Mortality (Outcome) 32
4.3 Incidence and types of NI 33
4.3.1 Demography of patients with HAI 34
4.3.2 Diagnosis of patients with HAI 35
4.3.3 Risk factors of participants with HAI 36
4.3.4 Underlying conditions in participants with HAI 37
4.3.5 Cultured organisms in participants with HAI 37
4.3.6 The outcome of participants with HAI 39
4.4 Comparing the average length of stay and mortality rate for patients 40
4.5 Correlation analysis 40
4.6 Chi-square results 42
4.6.1 Chi-square results between a hospital stay and Risk factors, Condition of interest, Antimicrobials use, and Type of Nosocomial Infection 42
4.6.2 Chi-square results between Mortality rate and Risk factors, Condition of interest, Antimicrobials use, and Type of Nosocomial Infection 44
4.6.3 Chi-square results between microorganisms and its sensitivity 45
4.7 Conclusion 46
CHAPTER 5: DISCUSSION RECOMMENDATIONS AND CONCLUSION 47
5.1 Introduction 47
5.2 Discussion of results 47
5.2.1 Prevalence of nosocomial infections 47
5.2.2 Prevalence of nosocomial infections by demographic information of participants 48
5.2.3 Types of nosocomial infections 52
5.2.4 Organisms causing nosocomial infection 53

5.2.5 Microorganism sensitivity 54
5.2.6 Mortality Rate and Length of stay 54
5.3 Recommendations of the study 55
5.4 Conclusion of the study 55
5.5 Limitation of the study 57
5.6 Further study 57
REFERENCES 59
ANNEXURE A: DATA COLLECTION SHEET 67
ANNEXURE B: ETHICS CLEARANCE 73

LIST OF FIGURES

Figure 4. 1: Gender of the participants 41

Figure 4. 2: Participants age group 42

Figure 4. 3: Participants' hospital stay 43

Figure 4. 4: Diagnosis of participants 44

Figure 4. 5: Outcome (Mortality) 45

Figure 4. 6: incidence of nosocomial infections 46

Figure 4. 7: Types of Nosocomial Infection 46

Figure 4. 8:Diagnosis of patients with HAI 49

Figure 4. 9: Underlying conditions in participants with HAI 50

LIST OF TABLES

Table 4. 1: Descriptive statistics: Age 42

Table 4. 2: Hospital stay descriptive statistics 43

Table 4. 3: Underlying conditions 44

Table 4. 4: Risk factors for participants 45

Table 4. 5: Details of participants with HAI 47

Table 4. 6: Age distribution of participants with HAI 48

Table 4. 7: Risk factors of participants with HAI 49

Table 4. 8: Cultured organisms in participants with HAI 51

Table 4. 9: Comparing the average length of stay and mortality rate 53

Table 4. 10: Correlation analysis (Hypothesis 4 and hypothesis 1) 54

Table 4. 11: Chi-square results between a hospital stay and Risk factors, Condition of interest, and Type of Nosocomial Infection and mortality rate 55

Table 4. 12: Chi-square results between mortality rate (outcome) and Risk factors, Condition of interest, Antimicrobials use, and Type of Nosocomial Infection 57

Table 4. 13: Chi-square results between the microorganisms and its sensitivity 58

DEFINITION OF CONCEPTS

Prevalence - The proportion of individuals in a population having a disease or characteristic. Prevalence is a statistical concept referring to the number of cases of a disease that are present in a particular population at a given time. (Hooker and Shiel, 2018)

Nosocomial Infection – These are hospital-acquired infections also known as healthcare-associated infections are nosocomially acquired infections that are typically not present or incubating at the time of admission. These are infections acquired after at least 48hrs of hospital stay. (Monegro, Muppidi, and Regunath, 2020)

Paediatrics - Paediatrics is the speciality of medical science concerned with the physical, mental, and social health of children from birth to young adulthood. Paediatric care encompasses a broad spectrum of health services ranging from preventive health care to the diagnosis and treatment of acute and chronic diseases. (Committee on Paediatric Workforce, 2015)

Intensive Care Unit (ICU) - It is a special care unit for people who are seriously ill. These people include those who have had a sudden, general malfunction (failure of an organ, such as the liver, lungs, (requiring assistance with breathing), or kidneys (requiring dialysis). People who are in shock, who have a severe infection, or who have had major surgery are likely to be placed in an ICU. Large hospitals may have a special paediatric intensive care unit (PICU) for children. (Hooker and Shiel, 2018)

Hospital Admission - is when people are admitted to a hospital only when appropriate treatment cannot be provided in another place such as at home or in an outpatient surgery centre. The main goal of hospitalization is to restore or improve health so that people can return home. (Robert and Porter,2009).

Bacteraemia - is known as the invasion of the bloodstream by bacteria. This is the presence of viable bacteria in the circulating blood. (Nicholas,2016).

Pneumonia – is a form of an acute respiratory infection that affects the lungs. The lungs are made up of small cells called alveoli, which fills with air when a healthy person

breathes. When an individual has pneumonia, the alveoli are filled with pus and fluid

which makes breathing painful and limits oxygen intake. It is caused by several infectious agents, including viruses, bacteria, and fungi (WHO, 2016).

Urinary tract infection (UTI) - An infection anywhere along the urinary tract, UTI's are often classified as upper or lower according to where they occur along the urinary tract. Lower UTIs are infections of the urethra (urethritis, or bladder(cystitis). Upper UTIs are infections of the kidneys known as pyelonephritis. (Robert and Porter, 2009)

.

ABBREVIATIONS

BSI: : Bloodstream infection

CDC : Centres for Diseases Control

CONS : *Coagulase –Negative Staphylococci*

CVC : Central Venous Catheter

DA : Device associated

DA-HAI : Device-Associated Hospital-Associated Infections

DAR : Device associated rate

HAI : Healthcare-associated Infections

HAI : Hospital-Acquired Infection

ICU : Intensive Care Unit

IHI : Institute of Healthcare Improvement

INICC : International Nosocomial Infection Control Consortium

MDR : Multi-Drug Resistance

NHSN : National Healthcare Safety Network

NI : Nosocomial Infection

NNIS : National Nosocomial Infections Surveillance

NSQIP : National Surgical Quality Improvement Programme

OR : Odds Ratio

PICU : Paediatric Intensive Care Unit

SSI : Supplemental Security Income

TREC : Turfloop Research Ethics Committee

UTI : Urinary Tract Infection

VAP : Ventilator-Associated Pneumonia

WBC : White Cell Count

WHO : World Health Organisation

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 Background and overview of the study

Nosocomial infection constitutes a major health problem associated with high morbidity and mortality. The high morbidity and mortality challenges are coupled with an increase in healthcare costs, especially in paediatric intensive care units (Julian, Orlando, Aglai, Freitas, Paulo, and Rosineide, 2011).

Nosocomial incidences in the ICU have been reported in various tertiary health care institutions around the world (Moolchandani, Sastry, Deepashree, Sistla, Harish, and Mandal, 2017). The study by Mythri and Kashinath (2014) reported that patients in the ICU are a significant subgroup of all hospitalised patients accounting for about a quarter of all hospital infections.

These kinds of infections are reported to be high and are a serious problem for the hospital (Parajuli, Acharya, Mishra, Parajuli, and Pokhrel, 2017). Mythri and Kashinath, (2014) regard Nosocomial infections (NI) as opportunistic and microorganisms of low virulence that can cause disease in hospital patients whose immune mechanisms are impaired and further indicated that the hospital ecosystem, including people, objects, food, water, and air in the hospital can be the source of these opportunistic infections in the hospital ICU.

Recently a new term “, healthcare-associated infections” is used for the type of infection caused by a prolonged hospital stay and it accounts for a major risk factor for serious health issues leading to death. (Hassan, Aftab, and Riffa, 2015; Magill, et al. 2018).

The most-reported nosocomial infections are Urinary Tract Infections, pneumonia, bloodstream infections, skin and soft tissue infections, gastroenteritis, hepatitis, and central nervous system like meningitis (Mahmoud, 2012; Mythri and Kashinath, 2014; Stevens, Herberg, and Levin, 2016; Nguyen, 2018). This being said, the paediatric ICU is not immune.

According to Hassan, Aftab, and Riffa, (2015), Nosocomial infections can be controlled by measuring and comparing the infection rates within healthcare settings and sticking to the best health care practices.

Many studies have focused on the epidemiology, risk factors, and prevention methods in adult patients. However, there have been limited studies on NI in paediatric patients. (Farideh and Mehrdad,2012). Thus it is crucial that the true impact of Hospital associated infections and antimicrobial resistance on healthcare delivery be documented accurately and that strategies be formulated to minimise the level of infection complications. (Brink, Feldman, Duse, Gopalan, Grolman, Mer, Naicker, Paget, Perovica, and Richards, 2006).

1.2 Problem statement

According to studies by Porto, Mantese, Arantese, Freitas, Gontijo and Ribas, (2012) and Ugalde, Hidalgo, Rosenthal, Hernandez, Gutierrez, and Fuentes, (2016), the incidence of NI acquired in ICU is high and associated with extrinsic factors. The study conducted by Mitt, Metsvaht, Adamson, Telling, Naaber, Lutsar, and Maimets, (2014) observed higher rates of nosocomial bloodstream infections (BSI) in the mixed PICU than reported previously. High levels of antimicrobial resistance were also detected by this study.

There is enough evidence that the Paediatric Risk of Nosocomial Sepsis score can reliably classify children into high- and low-risk groups, based on their risk of developing HAIs in the PICU of a resource-limited setting (Saptharishi, Jayashree, and Singhi, (2016). Given its high sensitivity and specificity, diagnostic and therapeutic interventions may be directed away from the low-risk group, ensuring the effective utilisation of limited resources (Saptharishi, Jayashree, and Singhi, (2016).

On average, in the Intensive Care Unit (ICU) specially trained nurses care for one or two patients at a time. Patients may have special equipment in their rooms, depending on their unique situation and condition. Patients are connected to machines to monitor their heart, blood pressure, and respiratory rate. Ventilators (breathing machines) assist some patients with breathing until they can breathe on their own. (Saptharishi, et al., 2016)

Pietersburg hospital Paediatric intensive care unit set up was a small four-bedded ward at the time of this study, that serves as a referral for all hospitals in Limpopo province,

with the nurse to patient ratio of 2:1 at times. The resource-limited setting factor as presented by Saptharishi, et al., (2016) may increase the risk of nosocomial infections in the Paediatric intensive care unit.

Thus given this background and occurrence of Nosocomial infections in various hospitals as presented, this study aimed to investigate the prevalence of nosocomial infection in the paediatric intensive care unit at Pietersburg Hospital, Limpopo, South Africa.

1.3 Aim, Objectives, and Research Questions of the study

1.3.1 Aim of the study

This study aimed to investigate the prevalence of nosocomial infections in the paediatric intensive care unit of Pietersburg hospital, Limpopo, South Africa, and identify the pathogens responsible for such infections and determine their antimicrobial activity.

1.3.2 Objectives of the study

The following are the objectives of the study to achieve the aim:

- To determine the incidence of nosocomial infections in the paediatric intensive care unit of Pietersburg hospital
- To identify microorganisms associated with nosocomial infection and their antimicrobial sensitivity
- To compare the average length of stay and mortality rate between patients with nosocomial infections and those without nosocomial infections
- To identify the most common site of nosocomial infection in patients admitted to the paediatric intensive care unit of Pietersburg hospital

1.3.3 Research questions

The following are the research questions for this study:

- What is the incidence of nosocomial infections in the paediatric intensive care unit of Pietersburg hospital?
- What are the microorganisms associated with nosocomial infection and their antimicrobial sensitivity?

- Is there an association between the average length of stay and mortality rate between patients with nosocomial infections and those without nosocomial infections?
- What is the most common site of nosocomial infection in patients admitted to the paediatric intensive care unit of Pietersburg hospital?

The research questions were answered by testing the following hypothesis:

1.3.4 Hypothesis

Hypothesis 1:

- Null Hypothesis (H_0): There is no association between microorganisms associated with nosocomial infection and their anti-microbial sensitivity.
- Alternative Hypothesis (H_1): There is an association between microorganisms associated with nosocomial infection and their anti-microbial sensitivity

Hypothesis 2:

- Null Hypothesis (H_0): There is no association between the average length of stay and mortality rate between patients with nosocomial infections and those without nosocomial infections.
- Alternative Hypothesis (H_1): There is an association between the average length of stay and mortality rate between patients with nosocomial infections and those without nosocomial infections

Hypothesis 3:

- Null Hypothesis (H_0): There is no association between the average length of stay and Risk factors, Condition of interest, Antimicrobials use, and Type of Nosocomial Infection
- Alternative Hypothesis (H_1): There is an association between the average length of stay and Risk factors, Condition of interest, Antimicrobials use, and Type of Nosocomial Infection

Hypothesis 4:

- Null Hypothesis (H0): There is no correlation between the average length of stay and mortality rate between patients with nosocomial infections and those without nosocomial infections.
- Alternative Hypothesis (H1): There is a correlation between the average length of stay and mortality rate between patients with nosocomial infections and those without nosocomial infections

1.4 Significance of the study

Nosocomial infection is worldwide health care and public health problem, the study will help generate data on the incidence of nosocomial infections in Pietersburg hospital paediatric ICU that can be compared with data from other institutions, and thus reflect the effectiveness of infection control measures in Pietersburg hospital paediatric intensive care unit.

The result of this study will contribute towards improving infection control measures and policies and may lead to a revision of antibiotic protocols in the paediatric intensive care unit of Pietersburg hospital.

Studies have shown that most hospitals in developing countries especially Africa, have no effective infection control program due to a lack of awareness of the problem. The contribution will also be extended to other hospitals with paediatric intensive care units, in raising awareness of Nosocomial infection causes, symptoms, and strategies to minimise these infections.

This study will open up areas for further research into effective infection control practices which will be of significance to various hospital's Paediatric intensive care units around the world. The findings of this study will be shared in various health-related conferences which will share lessons learned from the study and further add to the body of knowledge regarding the prevalence of nosocomial infection in the paediatric intensive care unit.

1.5 Research report layout

The mini-dissertation is divided into five chapters. Chapter one gives an introduction to nosocomial infection in a paediatric intensive care unit as well as problem statement, aim objectives, hypothesis to be tested, and the significance of the study.

Chapter two gives a comprehensive literature review that seeks to highlight what other authors have established concerning the prevalence of nosocomial infection in a paediatric intensive care unit.

Chapter three presents a detailed methodology of the study on how the study was carried out.

Chapter four presents data analysis and interpret the results of the study.

A detailed discussion and findings of the data collected are presented in chapter five which will also cover recommendations, conclusions, limitations, and suggestions for further study.

1.6 Conclusion

This chapter introduced a study problem regarding nosocomial infection in the paediatric intensive care unit, aim, and objectives. The significance of the study was also presented. The next chapter presents a literature review that seeks to highlight what other authors have established regarding the prevalence of nosocomial infection in a paediatric intensive care unit.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter presents a literature review that seeks to highlight studies related to the prevalence of nosocomial infection in a paediatric intensive care unit. The literature will cover the understanding of Nosocomial infection (NI), causes, symptoms, risk factors complications, and prevalence related to the Paediatric Intensive Care Unit.

2.2 Understanding Nosocomial infections

According to WHO, (2002), Nosocomial infections are also known as hospital-acquired infections (HAI). These are infections acquired during hospital care that are not present or incubating at admission. Furthermore, Nosocomial infections occur at least 48hrs after admission to a hospital (WHO, 2002). Hospital-acquired infections are caused by viral, bacterial, and fungal pathogens (Bamberg; Heinrichs, Nyberg and Parker, 2015); the most common types are bloodstream infection (BSI), pneumonia (e.g., ventilatorassociated pneumonia [VAP]), urinary tract infection (UTI), and surgical site infection (SSI) according to Barrasa-Villar; Aibar-Remón; Moliner-Lahoz, (2017).

Nosocomial infections are a frequent problem, particularly in Intensive Care Units (ICU) (Parajuli, Acharya, Mishra, Parajuli, and Pokhrel, 2017). In Europe, incidences range from 1% in general paediatric wards up to 23.6% in paediatric ICU (PICU) as found by Becerra, Tantalean, Victor, Alvarado, Candela, Urcia, (2010). While in the paediatric intensive care unit, 16% of children develop a nosocomial infection (Stockwell, 2007). This shows that Nosocomial infections had always been a concern for the hospital in general.

2.3 Causes of NI

In a study done in the Mansoura University Children's Hospital neonatal intensive care unit (NICU), it was found that Gram-negative bacteria, especially *Klebsiella spp* were the predominant causes of neonatal NI, as has been described in other studies from developing countries (Abdel-Wahab, Ghoneim, Khashaba, El-Gilany, and Abdel-Hady, 2013).

According to Porto, et al. (2011), Gram-negative bacilli are the most frequent pathogens in these infections, either in adults or children in developing countries.

Organisms that cause hospital-acquired infections are usually transmitted through patient contact with doctors, nurses, physiotherapists, and other hospital personnel (Patel, Engelbrecht, Mc Donald, Morris, Smythe, 2016).

There are several reasons why nosocomial infections are even more alarming in the 21st century when assessing the causes. Revelas, (2012) indicated that causes include amongst others hospitals housing, large numbers of people who are sick and whose immune systems are often in a weakened state, many medical procedures that bypass the body s' natural protective barriers, medical staff moving from patient to patient thus providing a way of pathogens to spread and inadequate sanitation protocols regarding uniforms.

Also, equipment sterilisation, washing, and other preventive measures that may either be unheeded by hospital personnel or too lax to sufficiently isolate patients from infectious agents, and the routine use of antimicrobial agents in hospitals creating selection pressure for the emergence of resistant strains of microorganism add to reasons why nosocomial infections are more alarming (Revelas, 2012).

Substantial morbidity, mortality, and prolonged hospital stay in the paediatric intensive care unit have been linked to Nosocomial infections by various studies (Revelas, 2012). Bacteraemia, urinary tract, and respiratory infections are the most frequent nosocomial infections reported in other studies and are commonly associated with the use of venous and urinary catheters and mechanical ventilation (Mireya, Marti, Serra, Cristina, Antonio (2003). Antibiotic-resistant bacteria prolong hospitalisation, increase the risk of death, and require treatment with potentially toxic and expensive antibiotics (Revelas, 2012).

Other causes include social-economic impacts in a low income-based hospital according to the study by Shahida, Islam, Dey, Islam, Venkatesh, and Goodman (2016). In their study, Shahida, Islam, Dey, Islam, Venkatesh, and Goodman (2016) elaborated that lack of effective infection control program due to lack of awareness of the problem, lack of personnel, poor water supply, erratic electricity supply, ineffective antibiotic policies with the emergence of multiple antibiotic-resistant microbes, poor laboratory backup, poor

funding and non-adherence to safe practices by health workers was amongst the highest causes of NI in hospitals that are in low-income areas. Due to this effect, the study (Shahida, Islam, Dey, Islam, Venkatesh and Goodman, 2016) recommended that the cost of hospital infection control program must form part of the health budget of the country and funds allocated to the infection control committee for routine control purposes and to bear the cost of outbreaks. The study further found that there is need for adequate staffing and continuous education of staff on the principles of infection control, especially hand washing which is the single most important effective measure to reduce the risks of crossinfection (Shahida, Islam, Dey, Islam, Venkatesh and Goodman, 2015).

In their study Kulaylat, et. al. (2016) when measuring surgical site infections in children, their study found that Surgical site infections were observed in 2.24% of patients per National Surgical Quality Improvement Programme (NSQIP) Paediatric definitions, 0.99% of patients per the Nosocomial Infection Marker, and 2.34% per billing claims definitions. Using (NSQIP) Paediatric as the clinical reference, the Nosocomial Infection marker had a sensitivity of 31.7% and positive predictive value of 72.2%, and billing claims had a sensitivity of 48.0% and positive predictive value of 46.1% for detection of a Supplemental Security Income (SSI). Nosocomial Infection Marker and billing claims overestimated the costs of SSIs by 108% and 41%, respectively. However, results found that there is a poor correlation found among SSIs measured using electronic surveillance, administrative claims, and clinically derived measures of SSI in the paediatric surgical population.

Although these measures might be more convenient, clinically derived data, such as NSQIP Paediatric, may provide a more appropriate quality metric to estimate the postoperative burden of SSIs in children. What the study observed according to Kulaylat, Engbrecht, et. al. (2016) is that pneumonia constitutes 84% of the NIs and in this study, most of them had to stay in the hospital for the management of their other comorbidities, such as diarrhoea, SAM, or dyselectrolytemia. Most nosocomial pneumonia could have been a result of viral infection because viruses are the most common causes of NIs in this age group, although no investigation was conducted to evaluate this according to Engbrecht, et. al. (2016). On the other hand, nosocomial pneumonia in our study population may have resulted from the aspiration of bacteria from the oropharynx or stomach into the tracheobronchial tree. The study, Engbrecht, et. al. (2016), also found

that approximately 45% of healthy individuals aspirate during sleep, and aspiration is more frequent in patients with ailments requiring hospitalisation. Mechanical ventilation–associated pneumonia was found to be the other cause of nosocomial pneumonia and very common in the paediatric population in the ICU*,* Engbrecht, et. al. (2016). The rate of developing NI in mechanically ventilated patients was found to be very negligible because of the use of non-invasive continuous positive airway pressure (CPAP) such as bubble CPAP, which significantly reduced the requirement of mechanical ventilation Engbrecht, et. al. (2016). The second type of NI was sepsis from them Engbrecht, et. al. (2016). In this study, there were 9 cases of clinically diagnosed nosocomial sepsis and 9 cases of bacteremia. However, among the 9 cases of bacteremia, only 1 was originally diagnosed as nosocomial sepsis; the other 8 cases were nosocomial pneumonia.
Engbrecht, et. al. (2016).

According to Engbrecht, et. al. (2016)., the Nosocomial UTI diagnosed based on the study definition was not a common form of NI in our study population, although 13 other isolates from urine were found as coinfections with nosocomial pneumonia and the remaining one isolate from urine was from a patient with nosocomial sepsis. UTI might be one of the causes of sepsis and pneumonia in this age group because most of our children were severely malnourished, and breaches in the integrity of the barrier of the bowel mucosa as well as translocation of bacteria from the gut in severely malnourished children could lead to sepsis and pneumonia.

Coagulase-negative Staphylococcus (*CNS*) was the most common pathogen in blood. Although the chance of contaminants of the *CNS* and *Staphylococcus haemolyticus* could not be ruled out, the fulfilment of the definition of NI in these children was critically important. Most of our children were severely malnourished, and in such cases, *CNS* and *Staphylococcus haemolyticus* used to be considered as the common causes of NI. Moreover, these organisms as the causes of NIs in other populations have also been reported earlier. (Kulaylat, Engbrecht, et. al., 2016)

In the study by Kulaylat, et. al., (2016) nosocomial UTIs *Escherichia coli* was the most common bacteria, although the highest number of nosocomial UTIs were caused by Candida. The study indicated that almost three-quarters of children with NIs were severely malnourished, and opportunistic infection with Candida in severely malnourished children is not uncommon. Candida is one of the common causes of nosocomial UTI in well-nourished children has also been reported earlier. Among all the bacterial isolates causing NIs, Gram-negative bacteria were the predominant ones, and this has also been reported earlier, (Kulaylat, Engbrecht, et. al., 2016).

2.4 Symptoms and causative *organisms* of NI

Patients with nosocomial pneumonia may have tachypnoea, cough, fever, purulent sputum, and abnormal chest findings on chest examination and chest x-ray may show infiltrates that were initially not there or worsening infiltrates picture (Mahajan, Tiwari, Arya, Tiwari, Chawla, and Saini, 2016).

In the study by Lodha, Natchu, Nanda, Kabra, (2001), it is evident that patients with urinary tract infections may have dysuria, frequency of micturition, may or may not have a fever while patients with bloodstream infections may have fever, tachycardia or general malaise. The common pathogens involved are S*taphylococcus aureus, Coagulasenegative staphylococci, Escherichia coli, Pseudomonas aeruginosa, Klebsiella, Enterococci, and Candida*. (Ozkan, Cetinkaya, Koksal, Celebi, and Hacımustafaoglu, (2014).

Patients with sepsis and multiorgan failure, especially those with nosocomial infection or the presence of neutropenia or purpura, have a worse prognosis and should be monitored and treated early according to Pérez, et al., (2014).

A study by Hossein, Alireza, (2009) on the epidemiology of nosocomial infections in a paediatric intensive care unit showed that most causative organisms for nosocomial infections in PICU were *coagulase-negative staphylococci (CONS).* This was followed by *Klebsiella and Pseudomonas aeruginosa* (Hossein and Alireza, 2009). Similar organisms,

Coagulase-negative staphylococci (39%) and *Pseudomonas aerigunosa* (24%) were the most organisms isolated in a study of nosocomial infections in a paediatric intensive care unit conducted by Mireya, Serra, Palomeque, Marti Pons, (2003).

Saiman, et al., (2000) found that in all 2847 infants that were enrolled, 35 (1.2%) developed candidaemia (12.3 cases per 1000 patient discharges or 0.63 cases per 1000 catheter days) including 23 of 421 (5.5%) babies who weighed less or equal to 1000g. After adjusting for birth weight and abdominal surgery, results from Saiman, et al., (2000) demonstrated significant risk factors including gestational age of fewer than 32 weeks, Apgar score of less than 5; shock, disseminated intravascular coagulopathy, prior use of intralipid, parenteral nutrition, central venous catheters, H_2 blockers, intubation or length of stay of higher than seven (7) days before candidaemia (p-value < 0.05). Catheters, steroids, and GI tract colonization were not independent risk factors, but GI tract colonization preceded candidaemia in 15 of 35 (43%) case-patients.

In another study most frequently, isolated organisms were *Haemophilus influenza* (20.1%), *Acinetobacter species* (14.2%), and *Staphylococcus aureus* (17.6%) (Asembergiene, Gurskis, Kevalas, Valinteleze, 2009).

2.5 The prevalence rate of NI

The prevalence rate of hospital-acquired infections in the USA range from 3.5-9.9% according to Patel, Engelbrecht, McDonald, Morris, Smyethe, (2016). In South Africa, about one in seven patients entering the hospital may be at risk of developing a hospitalacquired infection (Patel, Engelbrecht, Mc Donald, Morris, Smyethe, (2016). Furthermore, it is well established that nosocomial infection is associated with high rates of morbidity, mortality, and significant economic cost that tend to represent a larger problem in hospitals in developing countries than in developed countries as established by Julian, et al., (2011). According to Khan, Baig and Mehboob, (2017), nosocomial infections account for 7% in developed and 10% in developing countries.

WHO, (2002) and others have also shown that the highest prevalence of nosocomial infections occurs in intensive care units and acute surgical and orthopaedic wards. (WHO, 2002)

A study by Porto, et al., (2012), demonstrated an overall patient mean of 27.2 per 1,000 patients/day, with an incidence of 22.1% (patients with NI) and paediatric mortality rate of 8.1%.

In Hossein and Nateghian, (2009), 14.7% patients had nosocomial infections according to National Nosocomial Infections Surveillance (NNIS) guidelines, and the mean PICU hospital stay was 16.1 days for the nosocomial infection group versus 8.9% days for the non-NI group and the difference was statistically significant ($p<0.05$).

Different studies have demonstrated the risk factors associated with the development of nosocomial infections. The risk conditions that were most closely related to NI acquisition in one study were, prolonged hospital stays (69.4%), prematurity (60.9%), and exposure to high-risk device procedures (95.4%) according to Iyad, Baoqir, Khursheed, and Shahnaz, (2007).

According to Folgori, et al., (2016) infection control and prevention can limit the spread of MDR strains and improve outcomes. Ugalde, et al., (2016) confirmed that most devise associated (DA) Healthcare-associated Infections (HAI) rates found in this study's ICUs are higher than Centres for Diseases Control and Prevention CDC/National Healthcare Safety Network (NHSN) rates and similar to or higher than International Nosocomial Infection Control Consortium (INICC) rates.

Another study showed a similar distribution of infections. Bacteraemia was (51.7%), respiratory infection (19.0%), and urinary tract infection (17.2%) and were the most frequent nosocomial infections observed, and these were associated with the use of invasive devices according to Mireya, et al., (2003).

In a study to describe the incidence of HAIs in the paediatric medical units at Grey's Hospital, a tertiary government hospital in KwaZulu-Natal, South Africa; Spicer, Green and Dhada (2017) found that in the PICU, there were 20.4 and 15.3 HAIs per 100 admissions, while in the NICU there were 23.9 and 21.6 HAIs per 100 admissions in 2013 and 2014, respectively. In this study, Spicer, Green and Dhada (2017) further revealed that in the non-ICU setting, there were 6.8 HAIs per 1000 patient days in both 2013 and 2014 while in the PICU, there were 27.5 and 33.0 HAIs per 1000 patient days, while in

the NICU, there were 20.3 and 21.5 HAIs per 1000 patient days in 2013 and 2014, respectively.

The results from the study by Oladokun, Muloiwa, Hsiao, Valley Omar, Nuttall, and Eley, (2016) have shown that Nosocomial infections were identified in 9.7 % children. Preexisting medical conditions in 50.0 % of the patients were most commonly prematurity 50.0 % and congenital heart disease by 29.3 %. The most common presenting symptoms were cough in 86.7 % of the patients, difficulty in breathing 50.9 %, and fever in 41.6 %. A case fatality rate of 0.9 % was recorded. The study found that the prevalent genotypes were NA1 (n = 127,70.1 %), ON1 (n = 45,24.9 %), and NA2 (n = 9,5.0 %) for group A while the only circulating RSV B genotype was BA4. Results also showed that there was no significant difference in the genotype distribution between the nosocomial and community-acquired RSV infections. Oladokun, Muloiwa, Hsiao, Valley-Omar, Nuttall and Eley, 2016)

Dramowski, Cotton, and Whitelaw, (2017) reported that healthcare-associated bloodstream infection (HA-BSI) only; an HA-BSI incidence of 4/1 000 and 14/1 000 patient days was reported from two tertiary hospitals – in Cape Town and Johannesburg, respectively. Among paediatric inpatients in Cape Town, HA-BSI rates of 1.6/1 000 patient days was recorded, with excess mortality attributable to the hospital- v. community-acquired BSI (25% v. 16%).

Dramowski, Cotton, and Whitelaw, (2017) further outlined that in 1987, prospective surveillance of two paediatric wards at Chris Hani Baragwanath Hospital, Johannesburg established an HAI prevalence of 14.3%, with a predominance of gastrointestinal and respiratory tract infections.

Another reported HAI was at the PICU at King Edward Hospital, Durban, SA, an HAI prevalence of 43% was reported in 1992.

From a one-day point prevalence study of 2 652 adults and children at six Gauteng hospitals conducted by Dramowski, Cotton, and Whitelaw, (2017) established a pooled HAI prevalence of 9.7% for BSI, urinary tract, respiratory tract, and surgical site infections. In this study, Dramowski, Cotton, and Whitelaw, (2017), children had higher HAI rates overall (16.5%), and a greater prevalence of BSI and respiratory tract

infections. Recent prospective clinical surveillance at Tygerberg Children's Hospital paediatric wards and the PICU documented an HAI prevalence of 24% according to Dramowski, Cotton, and Whitelaw, (2017), with hospital-acquired pneumonia and HA BSI predominating. HAI incidence density was highest in the PICU (94 v. 22/1 000 patient days inwards) as found by Dramowski, Cotton, and Whitelaw, (2017) study.

This study, Dramowski, Cotton, and Whitelaw (2017), indicated that PICU deviceassociated infection densities were double those reported from PICUs in other LMIC. Two-thirds of all in-patient mortality occurred in association with HAI, with crude mortality 6-fold higher (7.4%) than among HAI-unaffected hospitalisations. HAI-affected patients also had three-fold higher rates of hospital readmission within 30 days. HAI events incurred substantial direct costs (ZAR5.6 million) and an excess of 2 275 hospitalisation days, 2 365 antimicrobial days, and 3 575 laboratory investigations in four wards over 6 months. Thus these results are evident that HAI is also prevalent in the South African hospital setting, (Danowski, Cotton, and Whitelaw, 2017).

In a study to document HAI rates, antimicrobial use for HAI, infection prevention staffing, hand hygiene (HH) provisions, and HH compliance rates in neonatal and paediatric wards in two districts and two regional hospitals in the Western Cape Province, SA by Olivier et al., (2018) pooled point and period HAI prevalence was 9.9% (15/151; 95% confidence interval (CI) 6 - 15.8) and 12.6% (19/151; 95% CI 8 - 18.9), respectively. Hospital-acquired pneumonia (5/15, 33.3%), bloodstream infection (3/15, 20.0%) and urinary tract infection (3/15, 20.0%) were predominant HAI types. Risk factors for HAI were a history of recent hospitalisation (8/19, 42.1% v. 17/132, 12.9%; $p<0.001$) and underlying comorbidity (17/19, 89.5% v. 72/132, 54.5%; $p<0.004$). HH provisions (handwash basins/alcohol hand rub) were available and functional. HH compliance was higher in neonatal than in paediatric wards (125/243, 51.4% v. 25/250, 10.0%; $p<0.001$). Overall HH compliance rates were higher among mothers (46/107, 43.0%) than nurses (73/265, 27.8%) and doctors (29/106, 27.4%).

2.6 Risk factors of NI

Khan, Baig and Mehboob, (2017) indicated risk factors as prolonged stay, disability, and economic burden as these infections occur during the hospital stay. The risk of acquiring infections such as central line-associated bloodstream infections, catheter-associated urinary tract infections, surgical site infections, and ventilator associated pneumonia is more prevalent. Nosocomial pathogens include bacteria, viruses, and fungal parasites. Furthermore, Khan, Baig and Mehboob, (2017), estimates that approximately 15% of all hospitalized patients suffer from these infections. During hospitalisation, the patient is exposed to pathogens through different sources of environment, healthcare staff, and other infected patients. The transmission of these infections should be restricted for prevention. A further risk associated factor is the hospital waste which serves as a potential source of pathogens where 20%–25% of hospital waste is termed hazardous.

Hernandez, Martin, and Simkins, (2015) also found that in liver transplant there is a high risk of infectious complications. The study, Hernandez, Martin, and Simkins, (2015), found that screening strategies applied to determine the risk of infection after transplantation and the use of prophylactic antimicrobial therapy have reduced the incidence of OIs after OLT.

With the rate of Nosocomial infection in paediatric ICU, an easy-to-use, dynamic, bedside risk stratification model for classifying children based on their risk of developing HAIs during their paediatric intensive care unit (PICU) stay, has been developed by Saptharishi, Jayashree, and Singhi (2016) to aid judicious resource utilisation. In their study of children aged below 5 years, Saptharishi, Jayashree, and Singhi (2016), results show that paediatric risk of mortality within 24 hours related to the presence of indwelling catheters needs for intubation, albumin infusion, immunomodulator, and prior antibiotic use (≥ 4) were independent predictors of HAIs.

Risk factors significantly associated with NI included the use of a central venous catheter (CVC) ($p=0.001$; odds ratio (OR) =8.77), and length of stay ($p<0.001$), a nasogastric tube ($p=0.0002$; OR=5.00), and use of antibiotics ($p=0.0004$, OR=7.89) in Juliana, et al, (2011) study. Asembergiene, et al., (2009) showed that in a sample of 1239 paediatric patients the incidence of NI was 24.5 per 1000-person day, and the length of stay of patients with

NI in ICU was higher compared to patients without the infection. Another study showed a similar distribution of infection. Bacteraemia (51.7%), respiratory infection (19.0%), and urinary tract infection (17.2%) were the most frequent nosocomial infections observed, and these were associated with the use of the invasive device.

Nosocomial infections can be controlled by measuring and comparing the infection rates within healthcare settings and sticking to the best health care practices. (Hassan, Aftab, and Riffa, 2015). A further study by Ugalde, et al., (2016) indicates that Nurses play a pivotal role in preventing hospital-acquired infections (HAI), not only by ensuring that all aspects of the nursing practice are evidence-based but also through nursing research and patient education. As patient advocates, nurses are in a unique position to affect change to improve patient care standards.

Caniza, et al., (2015) indicated that in managing the risk of NI, effective prevention of infections involves decreasing the duration of poor innate host defences against infection, improving acquired immunity through vaccines, practising good hygiene, using antibiotic prophylaxis for specific at-risk patients

Nosocomial infection is worldwide health care and public health problem. This study will help generate data on the incidence of nosocomial infections in Pietersburg hospital paediatric ICU that can be compared with data from other institutions, and thus reflect the effectiveness of infection control measures in Pietersburg hospital paediatric intensive care unit.

Authors Kulaylat, Engbrecht, et. al., (2016) also found 2 enteric bacteria in stool samples of 2 different patients with nosocomial pneumonia because these 2 patients also had new episodes of diarrhoea as coinfection with nosocomial pneumonia. Indeed, these 2 *organisms* are usually found in community-acquired infection, and it is difficult to make inferences as to whether these 2 *organisms* contributed to the development of any nosocomial pneumonia at all.

According to Kulaylat, et. al., (2016), *Moraxella, Pseudomonas* bacteremia, and *Pseudomonas* bacteriuria are not uncommon in ICU patients. These patients were required to initially stay in the ICU for their severe ailment and then transferred to the

general ward after an initial improvement in the ICU (ICU and general ward were termed inpatient departments).

Kulaylat, et. al., (2016), observed a very important finding i.e. SAM, congenital anomaly, invasive diarrhoea, UTI on admission, and use of IV cannula during hospitalisation as independent predictors of NIs is very important because this is the only study that evaluated this information predominantly in a population of children with diarrhoea. (Kulaylat, et. al., 2016).

In Shahunja, et al., (2016), when exploring the experience with nosocomial infection in children under 5 treated in an urban diarrheal treatment centre in Bangladesh. Their observation was that the use of IV cannula as an independent risk factor for developing NI in this study is understandable. Intravenous lines provide both a break in the skin, allowing entry of organisms, as well as a protected site for bacterial growth shielded from immune defences by a biofilm of platelets, fibrin, and bacterial slime. The risk is greater with increasing duration of the line, central and multi-lumen lines, and poor insertion technique or line care, which may lead to infection of the insertion site or hub.

Shahunja, et al., (2016), indicated that malnutrition plays an important role in developing NI. Severely malnourished children have depressed cell-mediated as well as humoral immune responses, and they are more susceptible to infection. Besides, this poor nutritional status has also been associated with nosocomial pneumonia and led to early nutritional support for critically ill patients. Shahunja, et al., (2016) believes that early enteral feeding help maintains the epithelial barrier and prevent pneumonia caused by translocation or migration of bacteria across the gastrointestinal epithelial barrier. Some investigators have postulated that administration of enteral feedings with high pH via the oral gastric tube may increase gastric colonization, volume, pressure, reflux, and pneumonia.

Shahunja, et al., (2016), argued that maintaining the patient in the upright position appears to reduce the frequency of gastric reflux. Also, this study (Shahunja, Ahmed, et al., 2016) shows that care should be taken to prevent contamination of enteral feedings, and vigilance is needed for their administration. Shahunja, Ahmed, et al., (2016) study observed that some predisposing infections or comorbid conditions such as UTIs and

presence of any congenital anomalies (e.g., cleft lips, cleft palates, Down's syndrome, congenital heart diseases) provoked the development of NI, and they are independent predictors of NI in under-5 hospitalized children. Pre-existing infection was a significant risk factor for NI. This was similar to the findings in a multicentre cohort, in which 45% of NIs occurred in patients with pre-existing infection. From these studies group, pre-existing UTI constituted 14% of the cases, (Shahunja, Ahmed, et al., 2016).

2.7 Complication of NI

There is limited literature addressing complication as a result of HAI however Caniza, et al., (2015) investigated infectious complications in children with acute lymphoblastic leukaemia treated in low-middle-income countries (LMIC) and found that prevention, early recognition, and management of infectious complications is challenging especially in LMIC because of disease and poverty-related factors, as well as the shortage of trained personnel, supplies, diagnostic tools, and adequate organizational infrastructure. The study further found that children in LMIC who are frequently underweight, are at increased risk of community-acquired pathogens, nosocomial multidrug-resistant pathogens, and opportunistic microorganisms.

The reason why patients with pre-existing UTI develop NI is not clear according to Shahunja, Ahmed, et al., (2016). However, it might be a result of the translocation of bacteria from the urinary tract, with the development of systemic manifestation later. On the other hand, some cases had a symptom-free period of pre-existing UTI, which eventually became evident after 48 hours of hospitalisation. According to Shahunja, Ahmed, et al., (2016), patients with congenital anomalies may have some difficulties in their normal body physiologies, which is often associated with compromised immunity, and may be susceptible to new infections in hospital settings. Thus complications reported may be due to morbidities Shahunja, Ahmed, et al., (2016), although they (Shahunja, Ahmed, et al., (2016)) reported that patients with morbidities have a high risk of developing new infections in hospital settings.

2.8 Conclusion

This chapter presented a comprehensive literature review related to nosocomial infection in a paediatric intensive care unit.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents a research methodology by outlining how the study was carried out. In this chapter, the following is presented: Research design, research setting, target population, sample size and sampling method, data collection, and data analysis method.

3.2 Research design

A research method is a strategy used to implement that plan according to Cohen, et al., (2011). The research design refers to the overall strategy that one chooses to integrate the different components of the study coherently and logically, thereby, ensuring that one effectively address the research problem; it constitutes the blueprint for the collection, measurement, and analysis of data (Cohen, et al., 2011).

The study employed a retrospective descriptive research design. The method used to carry out the study was the Quantitative research method. Quantitative research is the process of collecting and analysing numerical data. It can be used to find patterns and averages, make predictions, test causal relationships, and generalize results to wider populations (Creswell, 2017). The study applied descriptive research in a quantitative approach to describe the current status of the nosocomial infection in Pietersburg hospital. To collect the data, the study developed a data collection template to capture all the information of all the variables needed to meet the objectives of the study from the patient's records admitted to Pietersburg PICU from 1st of January 2017 to 31st of December 2017 were evaluated. The following were the population of the study, study setting, sampling method, and size calculation used in this study design:

3.2.1 The population of the study

The population is the entire group that one wants to conclude. In Maxwell, (2012), the target population is the total group of individuals from which the sample is drawn. In this study, the population of the study was all patient's records admitted to Pietersburg PICU

from 1st of January 2017 to 31st of December 2017. On average Pietersburg PICU admits about 25 patients per month, therefore a population of 290 participants was expected.

3.2.2 Study setting

The study was conducted at Pietersburg Hospital Paediatric Intensive Care Unit which is located in Polokwane City, Limpopo Province, which serves as a referral hospital for all public hospitals in Limpopo Province. Pietersburg PICU was a 4 bedded unit, during the study period, that admitted children from age of 29 days to 13 years, this age group excludes neonates. Since the study is retrospective and involved the hospital records, the researcher requested access to the patients' records and obtained access to where the files were stored for evaluation to take place. These files were stored within the hospital registry department and the selection of patients files to be evaluated took place in this department.

3.2.3 Sampling

The probability sampling method involves random selection, allowing a researcher to make statistical inferences about the whole group. In random sampling, all objects have an equal chance of being selected (Creswell, 2017).

In this study, convenience sampling was applied to select participants of the study only on patients admitted in Pietersburg PICU from 1st of January 2017 to 31st of December 2017. Convenience sampling is a nonprobability sampling in which people or documents are selected because it is convenient for researchers to use them as a source of data, (Lavrakas, 2008). This sampling technique was used only in participants that meet the selection criteria and have records that can derive meaning enough to meet the objective of the study.

3.2.4 Inclusion criteria

- All patients admitted in Pietersburg PICU from 1st of January 2017 to 31st of December 2017
- Patients who stayed at the hospital for more than 48 hours and developed a nosocomial infection.
- Participants who were at the age of ≤13yrs.

- The diagnosis of nosocomial infections was according to Centres for Disease Control and Prevention criteria which are described below:

Pneumonia patient must have at least one of the following; fever(>38), leukopenia <4000 WBC MM^3 or leucocytosis (12,000 WBC/MM^3 and at least two of the following, new onset of purulent sputum, or change in the character of sputum, or increased respiratory secretions, or increased suctioning requirements, new-onset or worsening cough, or dyspnoea, or tachypnoea, rales or bronchial breath sounds, worsening gas exchange(e.g., oxygen desaturation), e.g. PAO2/FiO2<240 increased oxygen requirements, or increased ventilator demand, or following chest radiological features: two or more serial chest radiographs with at least one of the following: new or progressive and persistent infiltrates, consolidation, cavitation, or pneumatocoeles. In infants less than one year, one definitive chest radiograph is acceptable in patients without an underlying pulmonary or cardiac disease.

Bloodstream infections were classified as a patient who has a recognised pathogen cultured from one or more blood cultures and an organism cultured from blood is not related to an organism at another site.

Urinary tract infection was defined as a positive urine culture of >105 CFU/ml with no more than 2 species of uropathogenic microorganism and a positive blood culture with at least one matching uropathogenic microorganism to the urine culture, or at least matching blood cultures drawn on separate occasions if the matching pathogen is a common skin commensal.

3.2.5 Exclusion criteria

Patients who stayed in the unit for less than 48hrs were excluded from the study. The control was patients who stayed for more than 48hrs and do not develop a nosocomial infection.

From the 135 patients, 37 files were excluded because of less than 48 hours' participants stay in PICU and missing notes.

3.2.6 Sample size calculation

A sample is the specific group of individuals that one collects data from. This study applied Yamane (1967) to determine and calculate the sample size of the study. From the study population estimated 290, and the margin of error of 0.05 the following is the sample size for the study.

$$n = \frac{N}{1+N(e)^2} \quad \text{..... equation (3.1)}$$

where e is the level of precision (0.05), N is the population size (290) and n is the corrected sample size

$$n = \frac{290}{1+290(0.05)^2}$$

n =168

3.2.7 Response rate

The sample size recommended for the study was 168. Patients' record meeting the selection criteria were 135 however of the 135, 37 files were excluded because of less than 48 hours' participant stay in PICU and missing notes which could not form part of the sample of the study. The total sample of the study that met the inclusion criteria, was 98 participants. All the data set to be analysed were based on the 98 participants.

3.3 Data collection

The data collection method used was to obtain records of patients admitted from 1st January 2017 to 31st December 2017 from the Pietersburg hospital PICU admission book and records which were retrieved from the hospital filing system. The secondary data set was obtained from patient records.

The diagnosis of nosocomial infections was according to Centres for Disease Control and Prevention Criteria. The data collection sheet, which was self-designed, and was used to collect the information of participants who were sampled for the study. Participants'

information was captured in the self-designed template and analysed using SPSS statistical software.

The data collection sheet contained the following information:

- Patient details including demographic data (these entails gender, age in years and months, date of admission, diagnosis, date of discharge, number of days in ICU, and outcome).
- A section detailing Risk factors (which entails Surgery since admission, surgery in the last 24 hours, central vascular catheter, peripheral vascular catheter, urethral catheter, intubation, and use of antibiotics and underlying disease).
- Antimicrobials use (which entails route, reason, indication, duration, and name of the antibiotic.
- Type of Nosocomial Infection (NI) or (Hospital-acquired infection data (HAI) which entails, NI 1: Urinary, NI 2: Bloodstream, and NI 3: Pneumonia.

The data set was captured in a data capturing tool developed in Microsoft excel were all the 98 data points were prepared for analysis. The data was captured according to codes provided in line with the statistical software that was used. Raw data were then exported to Software Package SPSS Version 25 for comprehensive analysis using appropriate statistical analysis procedures to answer the objectives of the study.

The next section presents how data was analysed.

3.4 Data analysis

Quantitative Descriptive statistics were applied to summarise the data set in a meaningful way. This summarised analysis of data helps describe, show, or summarise data in such a way that, patterns might emerge from the data (van Elst, 2013). From descriptive statistics, measures of central tendency (mean, median, and mode) and measures of spread (standard deviation, variance, and the standard error) are applied to best describe the data. Frequency count converted into percentage is also used as part of summarising the data descriptively (Pagano, 2012). These are presented as a tabulated description

(i.e., tables), or graphical description (i.e., graphs and charts), each followed by statistical commentary (i.e., an interpretation and or discussion of the results), (Trochim, 2006).

Inferential statistics were used to describe and make inferences about the population (Pagano, 2012). Inferential statistics are techniques that allow researchers to use samples to make generalisations about the populations from which the samples are drawn (van Elst, 2013).

Chi-Square analysis was employed to assess the level of association between the length of stay and risk factors, condition of interest, antimicrobials use, and type of Nosocomial Infection (Solutions, 2018). Chi-square is used to test if there an association between two categorical variables (Solutions, 2018). The p-value indicates that these variables are not independent of each other and that there is a statistically significant relationship between the categorical variables (Solutions, 2018).

Correlation analysis was also applied to compare the level of association between the average length of stay and mortality rate between patients with nosocomial infections and those without nosocomial infections (Solutions, 2017).

Correlation is a bivariate analysis that measures the strengths of association between two variables. In statistics, the value of the correlation coefficient varies between +1 and -1. When the value of the correlation coefficient lies around ± 1, then it is said to be a perfect degree of association between the two variables. As the correlation coefficient value goes towards 0, the relationship between the two variables is said to be weaker.

To test the level of significance, a p-value of 0.05 was used.

3.5 Validity and reliability

Data were verified and analysed through quantitative techniques. The sampling method applied is a convenience sampling method and relevant statistical analysis was applied to test and validate the data. The sample size was comprised of 98 participants. The higher the sample size the lower the level of bias and therefore increasing the precision

of the results. Correlation analysis was applied to test the level of association between the variables.

3.6 Bias

Bias is a systemic error built into the study design, it cannot be always eliminated, but it should be recognized and if possible minimized. Recognising Bias in a study assists with the interpretation of the study results (avoids" jumping to conclusions"). In this study selection bias was minimised by convenience sampling technique. Furthermore, information bias was minimised by diagnosing nosocomial infection according to Centres for disease control and prevention criteria. Since this study is quantitative, the level of bias was minimised by applying quantitative techniques to analyse the results. All laboratory tests were performed by the National Health Laboratories at Pietersburg Hospital which is a SANAS accredited laboratory.

3.7 Ethical consideration

There is no potential human harm associated with this study since a secondary data set was used. Confidentiality of research participants was maintained by anonymising participants' details and information that is going to be transformed into a data set for the study. No participant 's name or any identifying information was recorded, they were each assigned a number based on the chronological order, and gathered information were treated confidentially.

Permission to conduct the study was requested from the University of Limpopo Turfloop Research Ethics Committee (TREC). Once a clearance certificate was obtained, permission was requested from the Limpopo Department of health and the Pietersburg hospital authorities. Informed consent was not obtained for this study since it was retrospective.

3.8 Conclusion

This chapter presented the research methodology that was applied to carry out the study. These include detailing the study research design, the target population, sampling method and sample size, study setting, data collection, and data analysis method. In this chapter

level of minimising bias and ethical considerations were also presented. The next chapter presents results and interpretation.

CHAPTER 4: RESULTS AND INTERPRETATION

4.1 Introduction

This chapter presents the results and interpretation of the study. The results were analysed using quantitative techniques presented in the previous chapter. A total of 135 files of patients that were admitted to Pietersburg hospital PICU from 1st January 2017 to 31st December 2017 were retrieved and 98 files met the criteria for this study. 3 files had missing data and 34 participants did not meet the inclusion criteria . The results are based on 98 participants.

4.2 Patient details and demographical information of participants

Patient details with demographic data entail gender, age in years and months, date of admission, diagnosis, date of discharge, number of days in ICU, and outcome. The results are as follows.

4.2.1 Gender

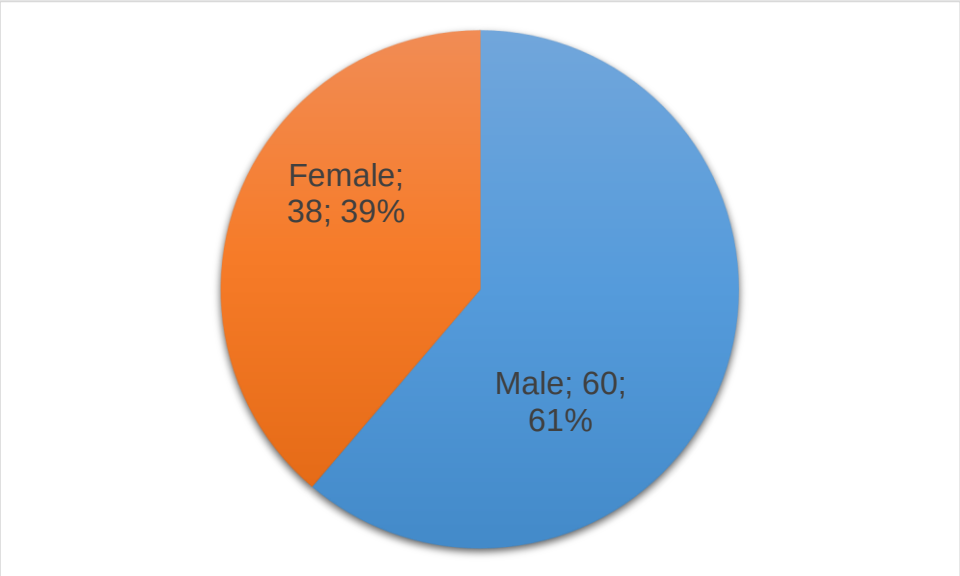


Figure 4. 1: Gender of the participants

Of the 98 participants 61% (n=60) were males and 39% (n=38) were females. In this study, there was more male than female participants as shown in Figure 4.1.

4.2.1 Age distribution of participants

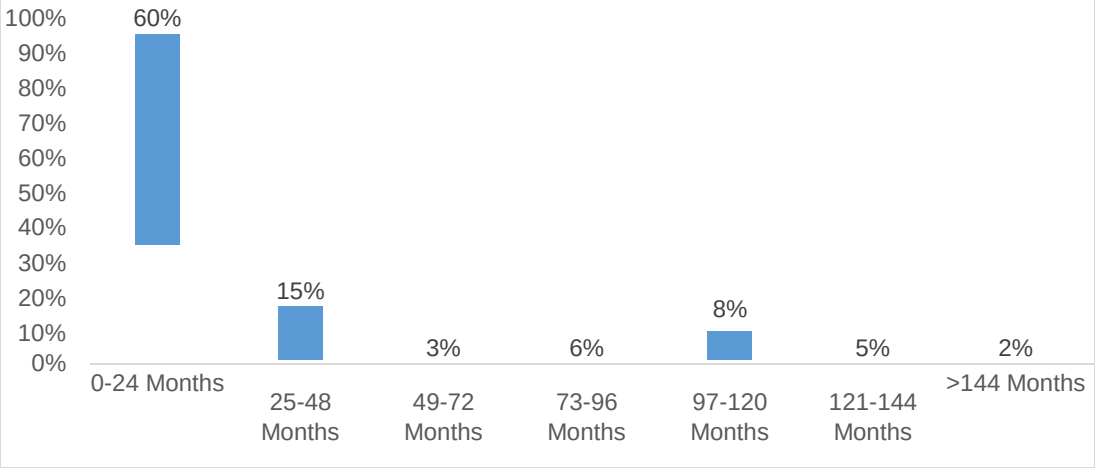


Figure 4. 2: Participants age group

Table 4. 1: Descriptive statistics: Age

Description	**Age statistics**
Valid N	98
Mean	35,96 months
Confidence(-95,000%)	27,15 months
Confidence(+95,000%)	44,77 Months
Median	12 months
Minimum	1 month
Maximum	155 months
Lower Quartile	4 months
Upper Quartile	43 months
Standard deviation	43,94
Standard Error	4,44
Skewness	1,30
Kurtosis	0,31

From the 98 participants, the youngest participant was 1 month old and the eldest was 13 years old (155 months) as shown in Table 4.1 where the age descriptive statistics are shown. The average age was 36 months which is equivalent to 3 years. The majority of participants (60%) were less than 2 years as indicated by Figure 4.2.

4.2.2 Hospital stay

Table 4. 2: Hospital stay descriptive statistics

	Hospital stay
Valid N	98
Mean	9,04
Confidence(-95,000%)	7,48
Confidence(+95,000%)	10,60
Median	6
Minimum	3
Maximum	39
Lower Quartile	5
Upper Quartile	9
Standard deviation	7,76
Standard Error	0,78
Skewness	2,62
Kurtosis	6,56

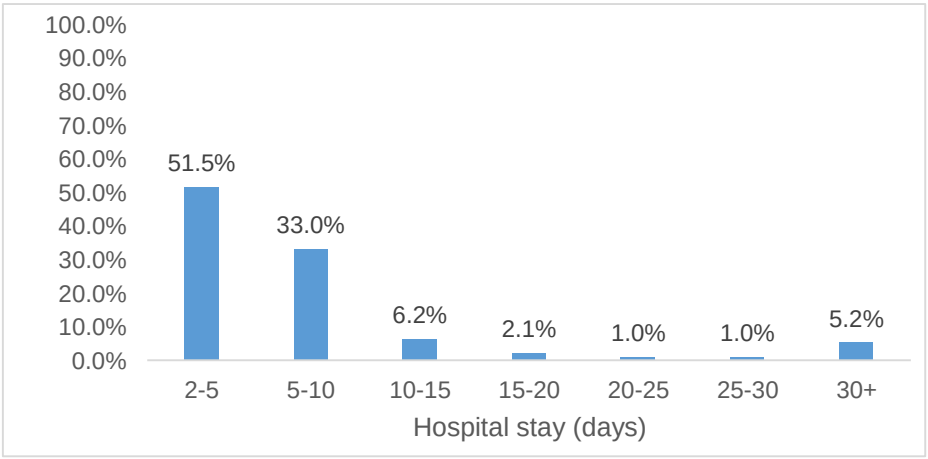


Figure 4. 3: Participants' hospital stay

The average hospital stay for the 98 participants was 9 days, the minimum was 3 days, and a maximum of 39 days as indicated in Table 4.2 where the hospital stay of the total participants was shown. In Figure 4.3 most participants (51.5%) stayed between 2 and 5 days while 33% of the participants stayed between 5 and 10 days and 5.2% stayed for more than 30 days.

4.2.3 Diagnosis of participants

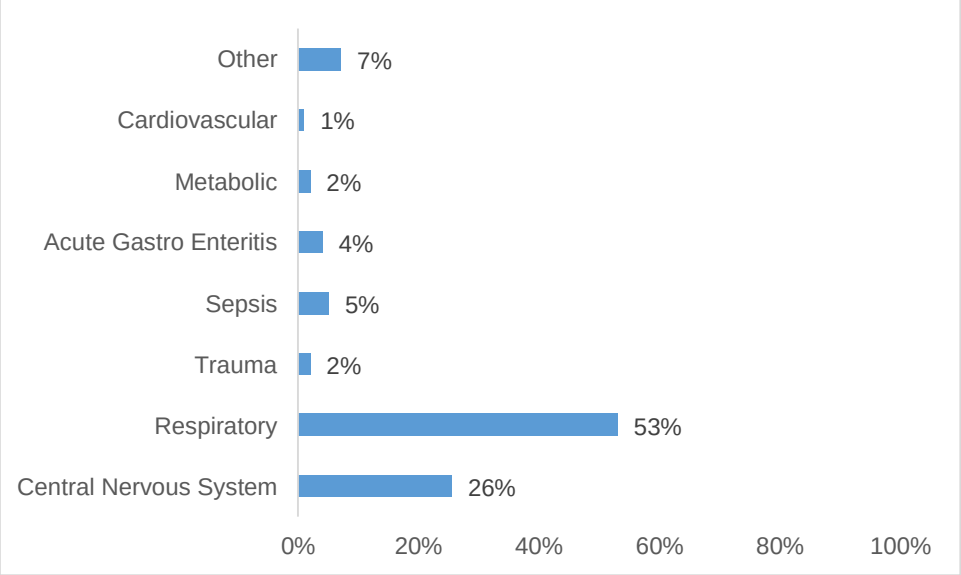


Figure 4. 4: Diagnosis of participants

The most common reason for admission according to Figure 4.4 to PICU was Respiratory related illnesses, mainly Pneumonia and Bronchiolitis. Respiratory conditions constituted 53% of the total admissions followed by Central nervous system conditions that contributed 26% to the total admissions.

4.2.4 Underlying conditions

Table 4. 3: Underlying conditions

	Frequency	%
HIV	11	11,2%
None	66	67,3%
Congenital heart disease	6	6,1%
AV malformation	1	1,0%
Polycystic kidneys	1	1,0%
HIV exposed	7	7,1%
Delayed milestones	1	1,0%
Nonfatal disease	1	1,0%
Posterior Urethral valves	1	1,0%
Suspected Congenital heart disease	1	1,0%
Tuberculous Meningitis	1	1,0%
Cerebral palsy	1	1,0%
Total	98	100%

The majority of participants (67%) in Table 4.3 had no identified underlying disease while 6% had underlying congenital heart disease and 11% were HIV positive. There were 7% of participants with HIV exposure.

4.2.5 Risk factors

Table 4. 4: Risk factors for participants

	No		Yes		Total	
Risk factors	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Surgery since admission	88	89,80%	10	10,20%	98	100,00%
Surgery in the last 24 hours	96	100,00%	0	0,00%	96	100,00%
Central vascular catheter	93	94,90%	5	5,10%	98	100,00%
Peripheral vascular catheter	7	7,14%	91	92,86%	98	100,00%
Urethral catheter	75	76,53%	23	23,47%	98	100,00%
Intubation	9	9,18%	89	90,82%	98	100,00%

In Table 4.4, the majority of participants had a peripheral vascular catheter (94.9%) and only 5% had a central venous catheter, 89 out of 98 (90.8%) were intubated and only 23.4% had urethral catheter compared to 76.6% that did not have a urethral catheter. No participant had surgery in the last 24 hours and 88 0f 98 (89.98%) did not have surgery since admission. Antibiotics were administered to 99% of the participants.

4.2.6 Mortality (Outcome)

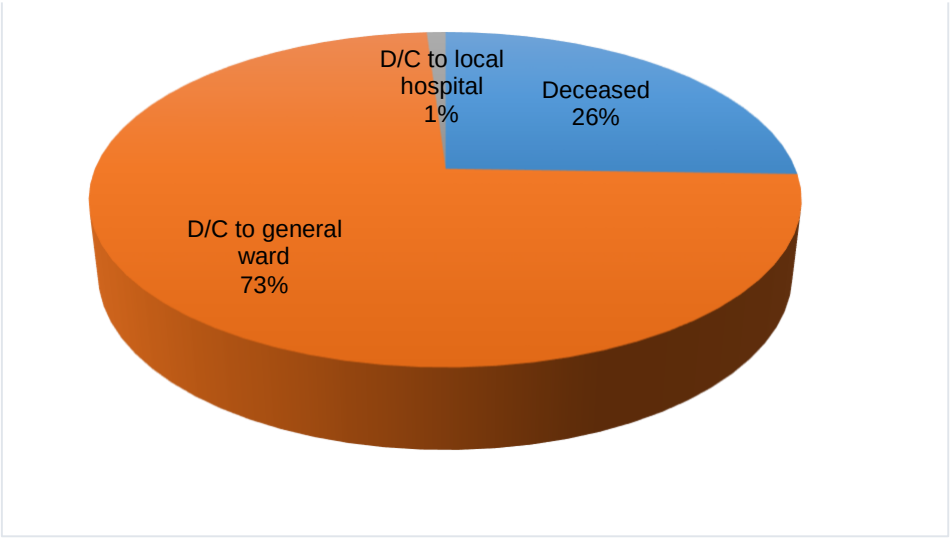


Figure 4. 5: Outcome (Mortality)

Figure 4.5 depicts the outcome distribution of participants. Most participants 73 of 98 (73%) were discharged from PICU to the general ward, one percent (1%) of the participants were discharged to a local hospital and 25 of 98 participants (26%) demised while in PICU.

4.3 Incidence and types of NI

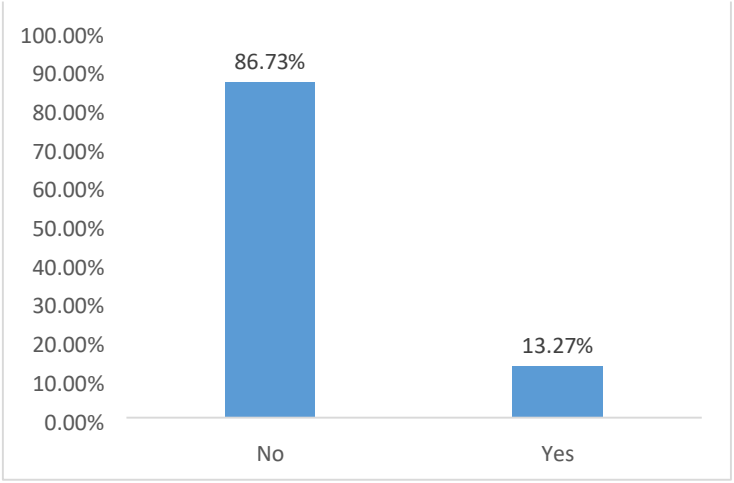


Figure 4. 6: incidence of nosocomial infections

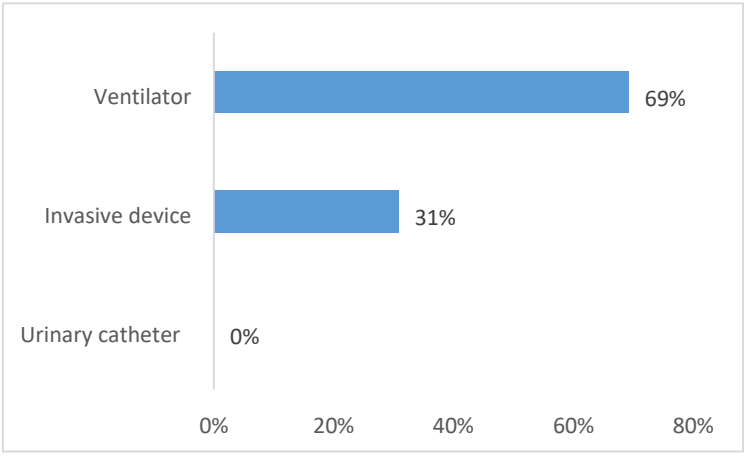


Figure 4. 7: Types of Nosocomial Infection

In Figure 4.6, a proportion of 13 of 98 (13.3%) acquired nosocomial infection or HAI while 85 of 98 (86.7%) of the participants did not acquire any nosocomial infection. Of the 13 participants, the most common nosocomial infection was ventilator-associated

pneumonia followed by bloodstream infections and the least was urinary tract infections as indicated in Figure 4.7

4.3.1 Demography of patients with HAI

Table 4. 5: Details of participants with HAI

Patients details	Description	Frequency	%
Gender	Female	8	61,54
	Male	5	38,46
	Total	**13**	**100**
Age group	0-24 Months (2yrs)	9	69,23
	25-48 Months (4 yrs.)	2	15,38
	97-120 Months (10 yrs.)	2	15,38
	Total	**13**	**100**
Hospital stay (days)	5-10 days	3	23,07
	10-15 days	2	15,38
	15-20 days	2	15,38
	20-25 days	1	7,69
	25-30 days	1	7,69
	>30 days	4	30,76
	Total	**13**	**100**

Table 4.5 depicts details and demographical information of participants with HAI of the 13 patients that acquired nosocomial infection 8 of 13 (61.5%) were females compared to 5 of 13 (38.4%) that were males. Amongst the participants that acquired nosocomial infections 9(69,23%) were between 1- 24 months, 2 (15.38) were between 25-48 months and the other 2(15.38) were between 97-120 months.

The duration of hospital stays in patients that acquired nosocomial infections was more than 30 days in 4 participants, 5-10 days in three (3) participants,10-15 days in 2 participants,15-20 days in another 2 participants, one (1) participant stayed for 20-25 days and the last one (1) participant stayed for 25- 30 days.

Table 4. 6: Age distribution of participants with HAI

	Age months	Hospital stay (days)
Valid N	13	13
Mean	25,08	22,92
Confidence -95,000%	1,1844	15,9389
Confidence +95,000%	48,9694	29,9072
Minimum	1	8
Maximum	112	39
Standard deviation	39,5379	11,5575
Standard Error	10,9658	3,2055

According to Table 4.6, the mean age of the participants with HAI is 25 months, while the hospital stay was 23 days. The minimum age was one (1) month and a maximum of 112 months (9 years) was established from participants with HAI. The Hospital stay for participants with HAI ranged between a minimum of 8 days to 39 days.

4.3.2 Diagnosis of patients with HAI

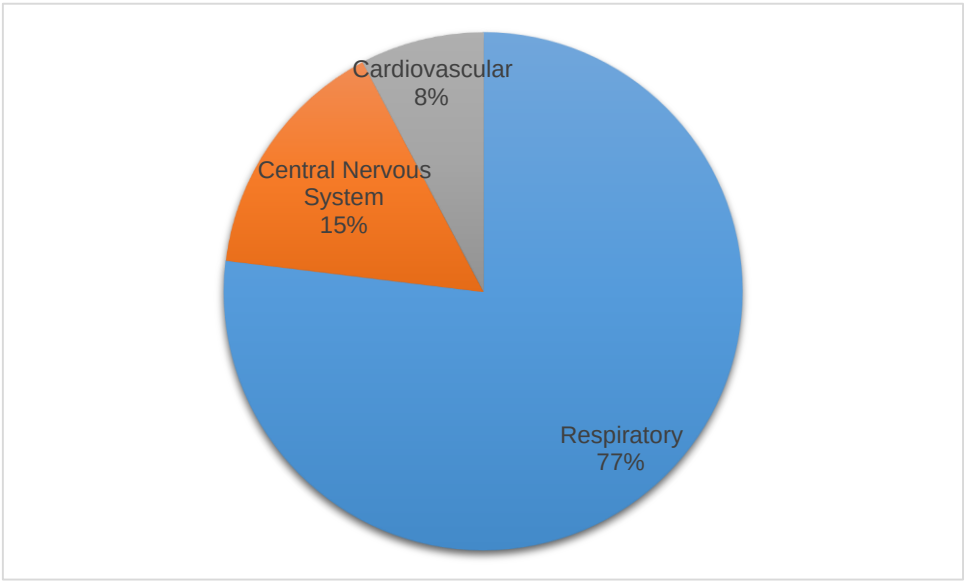


Figure 4. 8: Diagnosis of patients with HAI

Figure 4.8 depicts the diagnosis of patients with HAI. Most of the participants 10 of 13 (77%) that acquired HAI were admitted to PICU for respiratory-related conditions while 2

of 13 (15%) were admitted for a central nervous system-related condition and the other participant 1 of 13 (8%) was admitted for a cardiovascular condition.

4.3.3 Risk factors of participants with HAI

Table 4. 7: Risk factors of participants with HAI

	Yes	%	No	%	Total	%
Surgery since admission	3	23,07%	10	76,69%	13	100%
Surgery in last 24 hours	0	0,00%	13	100%	13	100%
Central vascular catheter	1	0,01%	12	92,31	13	100%
Peripheral vascular catheter	10	76,69%	3	23,07%	13	100%
Urethral catheter	2	15,38%	11	84,62%	13	100%
Intubation	13	100%	0	0,00%	13	100%

In Table 4.7, 3 of 13 (23,07%) participants that acquired HAI had surgery since admission compared to 10 (76,69%) that did not have. None of the 13 participants that acquired HAI had surgery in the last 24hrs of admission to PICU. Furthermore, 10 of the 13 (76,69%) participants with HAI had a peripheral vascular catheter and one participant had a central vascular catheter. All participants that acquired HAI were intubated and fewer participants 2 of 13 (15,38%) had a urethral catheter.

Risk factors for hospital-acquired infections were endotracheal intubation in all the participants. One participant had a central vascular catheter while 13 participants had peripheral vascular catheter 3 of the 13 (23,07%) participants had surgery since admission whereas 10 (76,69%) did not any surgery since admission. Fewer participants 2 of 13 (15,38%) had urethral catheters while all participants 13 (100%) were intubated.

4.3.4 Underlying conditions in participants with HAI

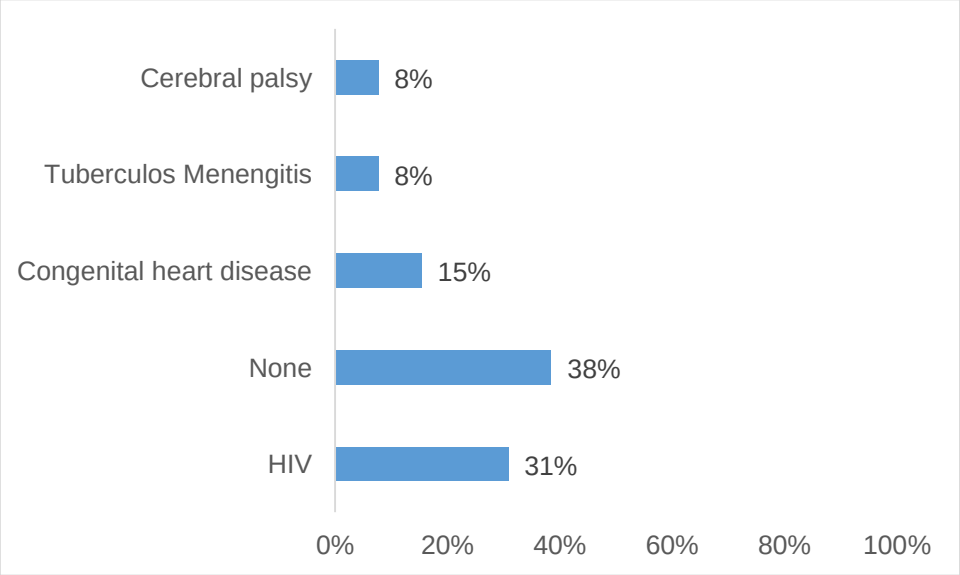


Figure 4. 9: Underlying conditions in participants with HAI

Figure 4.9 shows that the underlying conditions in participants who developed HAI were HIV in 4 of 13 (31%) participants followed by congenital heart disease in 2 of 13 (15%) participants while only 1 of 13 participants (8%) had Tuberculous Meningitis and cerebral palsy.

4.3.5 Cultured organisms in participants with HAI

Table 4. 8: Cultured organisms in participants with HAI

Site of infection	Organism	Frequency (n)	Percentage (%)
Respiratory site only	*Klebsiella pneumonia*	4	30,76%
	Pseudomonas aeruginosa	2	15,38%
	Enterobacter cloacae	1	7,69%
	Serratia marcescens	1	7,69%
	Yeast	1	7,69%
	Total participants (respiratory site only)	**9**	69,23%
Bloodstream only	*Klebsiella pneumonia*	1	7,69%
	Total participants (bloodstream only)	**1**	**7,69%**

Both Bloodstream & Respiratory site	*Coagulase-negative staphylococcus* *Pseudomonas aeruginosa* *Coagulase-negative staphylococcus* *Klebsiella pneumonia*	**2**	**15,38%**
	Streptococcus group D *Klebsiella pneumoniae*	**1**	**7,69%**
	Total participants that cultured from both bloodstream and respiratory site	**3**	**23,07%**
	Total participants with HAI	**(9+1+3) =13**	**(69%+ 7,69%+23%) =100%**
Cultured organisms summary	Total cultured organisms from the respiratory	12	**75%**
	Total cultured organisms from the bloodstream	4	**25%**
	Total cultured organisms	**(12+4) =16**	**75%+25%=100%**

Results in Table 4.4 shows that a total of 16 organisms were cultured in 13 participants. Of the 16 cultured organisms, 12 (75%) were cultured from the respiratory site and 4 (25%) organisms were cultured from the bloodstream. The total participants with HAI from the bloodstream and respiratory site were 13, the majority of them (12 of 13 participants) 92%. cultured organisms from the respiratory site. Of the 13 participants that developed HAI, 3 (23,07%) participants cultured organism from both the respiratory site and bloodstream, and 1(7,69%) cultured only from the bloodstream, and the other 9 (69,23%) participants cultured from the respiratory site only. The most common organism cultured from the respiratory site was *Klebsiella pneumonia* which was isolated in 6 of 9 participants (66,67%%) (*6 also include the 2 participants that has cultured in the bloodstream*), *Pseudomonas aeruginosa* was isolated in 3 of 9 participants (33,33%) (*including 1 participant that has cultured organism in the bloodstream*), *Enterobacter cloacae* in 1 of 9 (11,11%) participants, *Serratia marcescens* in 1 (11,11%) participant, and lastly *Yeast* in 1 (11,11%) participant. Organisms associated with bloodstream infections were *Klebsiella Pneumoniae* (1 of 4; 25%), *Streptococcus group D* (1 of 4; 25%), and *Coagulase-negative staphylococcus* (2 of 4;50%). Sensitivity was Vancomycin and Linezolid for C*oagulase-negative staphylococcus,* Ceftriaxone, Gentamycin, and Amikacin for *Klebsiella Pneumoniae* and Vancomycin / Linezolid / Azithromycin for *Streptococcus Group D*.

4.3.6 The outcome of participants with HAI

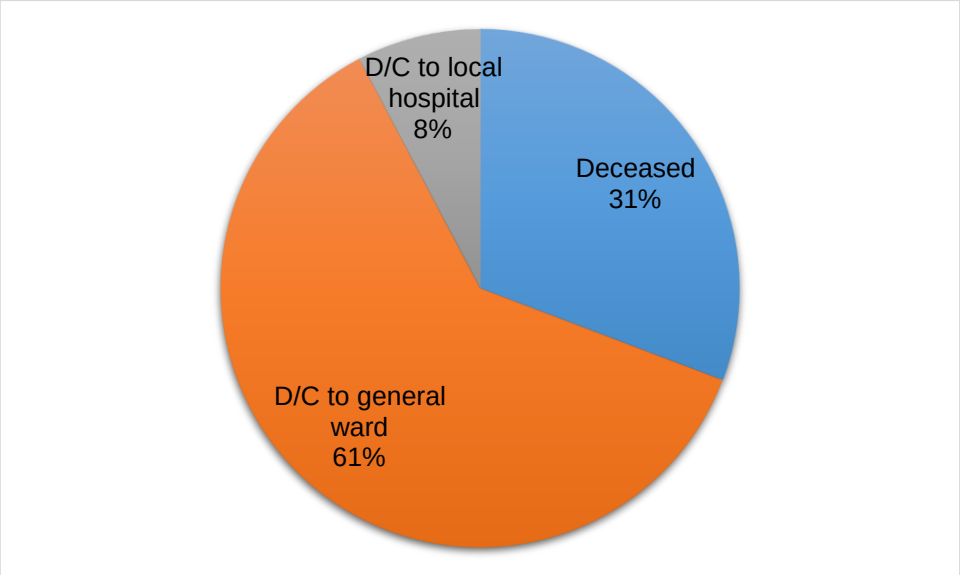


Figure 4. 10: Outcome

The outcome of participants with HAI from Figure 4.10 was 8 of 13 participants (61%) discharged to a general ward, one of 13 participants (8%) was discharged to the local hospital and 4 of 13 participants (31%) demised. There is more deceased in patients with HAI compared to 26% of the total outcome although the difference is not statistically significant (p-value= 0,50).

4.4 Comparing the average length of stay and mortality rate for patients

Table 4. 9: Comparing the average length of stay and mortality rate

Hospital stay (days)				
	With HAI		*Without HAI*	
	Deceased	Discharged	Deceased	Discharged
Mean	15,50	26,22	5,90	7,25
Standard Error	6,85	3,17	0,45	0,55
Median	9	24	6	6
Standard Deviation	13,70	9,50	2,07	4,43
Skewness	1,97	0,28	0,55	3,94
Minimum	8	16	3	4
Maximum	36	39	10	34
Count	4	9	21	64
Confidence Level (95,0%)	21,80	7,30	0,94	1,11

The average hospital stay for deceased participants who developed HAI according to Table 4.9 was 15.5 days compared to 5,90 average length of stay for deceased participants who did not develop HAI group. Participants that developed HAI and were discharged to the general ward stayed in PICU for an average of 22.66 days compared average stay of 7.25 days in the group that did not develop HAI that were discharged to the general ward.

When comparing mortality rate of participants with HAI to those without HAI shows that 85 of 98 participants (87%) were without HAI and 64 of the 85 participants (65%) were discharged to the general ward while 21 or 26% died. In the group that had HAI, 4% of the participants demised while 9% was discharged to the general ward. Thus the odds ratio in probability of death for participants who acquires HAI as a result of this study is 1:3 (33% probability) compared to 1:4 odds ratio for participants who did not acquire HAI in their hospital stay (25% probability).

4.5 Correlation analysis

Correlation analysis was applied to determine the correlation between the hospital stay and mortality rate (Outcome).

Table 4. 10: Correlation analysis (Hypothesis 4 and hypothesis 1)

Variables	Descriptions	Mortality rate (Outcome)	
		Correlation	P-value
Patients details	Hospital stay	36%	0,0001
	Diagnosis	23%	0,0370
Risk factors	Surgery in last 24 hours	-35%	0,0010
	Antibiotics given	-25%	0,0210
Condition of interest	Patient on antimicrobials	-25%	0,0210
Antimicrobial use	First antimicrobials	40%	0,0000
	Diagnosis	22%	0,0420
	Second antimicrobials	39%	0,0000

Results in Table 4.10 shows that there is a correlation between hospital stay and mortality rate (r=36%; p-value<0.0001). Factors correlating to mortality rate are diagnosis with 23% correlation significant at a p-value of 0,0370; Risk factors such as Surgery in last 24 hours with a negative correlation of -35% significant at a p-value of 0,0010; Antibiotics are given with a negative correlation of -25% significant at a p-value of 0,0210; Condition of interest such as Patient on antimicrobials with a negative correlation of -25% and significant at a p-value of 0,0210; and Antimicrobial use such as First antimicrobials with a correlation of 40% significant at a p-value of 0,0000; Diagnosis with a correlation of 22% and significant at a p-value of 0,0420 while Second antimicrobials had a correlation of 39% and significant at a p-value of 0,0000 to mortality rate.

4.6 Chi-square results

4.6.1 Chi-square results between a hospital stay and Risk factors, Condition of interest, Antimicrobials use, and Type of Nosocomial Infection

Table 4. 11: Chi-square results between a hospital stay and Risk factors, Condition of interest, and Type of Nosocomial Infection and mortality rate

	Description	Chi-Square	Degrees of freedom	p-value
Risk factors	Surgery since admission	27,649	7	0,0003
	Surgery in last 24 hours	9,074	7	0,2474
	Central vascular catheter	21,195	7	0,0035
	Peripheral vascular catheter	17,106	7	0,0167
	Urethral catheter	20,013	7	0,0055
	Intubation	2,5615	7	0,9224
	Antibiotics given	4,4902	7	0,7219
	Underlying disease	140,14	9	0,0034
Condition of interest	Patient acquired Nosocomial infection or HAI	12,795	7	0,0773
	Date of HAI diagnosis	174,14	9	0,0000
Type of Nosocomial Infection	Urinary catheter	114,13	1	0,0000
	Relevant device in situ before onset	100,72	1	0,0000
	Invasive device	17,222	7	0,0160
	Relevant device in situ before onset	12,382	7	0,0887
	Cultured organism 1	73,092	4	0,0021
	Sensitivity	102,42	3	0,0000
	Ventilator	14,952	7	0,0366
	Relevant device in situ before onset	16,367	7	0,0220
	Cultured organism 2	28,276	1	0,0131
	Sensitivity	146,36	6	0,0000
Details	Mortality rate (outcome)	163,42	133	0.0376

Table 4.11 shows the results between hospital stay and Risk factors, condition of interest, and type of Nosocomial infection. Results shows that there is an association between hospital stay and the following risk factors: surgery since admission (Chi-square = 27,649; p-value= 0,0003); central vascular catheter (Chi- square =21,195; p-value= 0,0035); peripheral vascular catheter (Chi-square = 17,106; p-value= 0,0167); urethral catheter (Chi-square = 20,013; p-value= 0,0055) and underlying disease (Chi-square = 140,14; pvalue 0,0034) due to Chi-Squares that has p values of less than 0.05. The results show

that there is no association between hospital stay and the following risk factors: surgery in last 24 hours; intubation and antibiotics given with a p-value of greater 0.05

Related to the condition of interest, the results show that there is a strong association between hospital stay and date of HAI diagnosis (Chi-square = 174,14; p-value= 0,0000). Since Chi-square value contains p-values that are less than 0.05. However, there is no association between a hospital stay and the following condition of interest: patient on antimicrobials and patient acquired Nosocomial infection or HAI since the p-value was greater than 0.05.

Hospital stay is associated to the type of Nosocomial infection and its sensitivity. The following are associated to Hospital stay: urinary catheter (Chi-square =114,13; p-value <0,0001) and relevant device in situ before onset (Chi-square = 100,72; p-value= 0,0000)

Blood stream invasive device (Chi-square = 17,222; p-value= 0,0160); Blood stream cultured organism 1 (Chi-square = 73,092; p-value= 0,0021); sensitivity (Chi-square = 102,42; p-value= 0,0001); Pneumonia ventilator (Chi-square = 14,952; p-value= 0,0366); Pneumonia Relevant device in situ before onset (Chi-square = 16,367; p-value= 0,0220); Pneumonia cultured organism 2 (Chi-square = 28,276; p-value= 0,0131) and Pneumonia sensitivity (Chi-square = 146,36; p-value=0,0000).

Results further shows an association between hospital stay and mortality rate (outcome) (Chi-square = 163,42 and p-value= 0.0376 since the p-value is less than 0.05

4.6.2 Chi-square results between Mortality rate and Risk factors, Condition of interest, Antimicrobials use, and Type of Nosocomial Infection

Table 4. 12: Chi-square results between mortality rate (outcome) and Risk factors, Condition of interest, Antimicrobials use, and Type of Nosocomial Infection

		Chi-Square	Degrees of freedom	pvalue
Risk factors	Surgery since admission	18,2447	6	0,0057
	Surgery in last 24 hours	1,91958	6	0,9269
	Central vascular catheter	4,50373	6	0,6088
	Peripheral vascular catheter	20,9999	6	0,0018
	Urethral catheter	8,44511	6	0,2073
	Intubation	5,65726	6	0,4627
	Antibiotics given	2,05241	6	0,9148
	Underlying disease	174,899	84	0,0000
Condition of interest	Patient acquired Nosocomial infection or HAI	55,193	6	0,0000
	Date of HAI diagnosis	400,188	78	0,0000
Type of Nosocomial Infection	Urinary catheter	64,8237	12	0,0000
	Relevant device in situ before onset	43,1698	12	0,0000
	Invasive device	46,5965	6	0,0000
	Relevant device in situ before onset	37,6868	6	0,0000
	Cultured organism 1	261,017	36	0,0000
	Sensitivity	256,073	30	0,0000
	Ventilator	52,0926	6	0,0000
	Relevant device in situ before onset	55,3579	6	0,0000
	Cultured organism 2	36,7742	12	0,0002
	Sensitivity	251,959	54	0,0000

In Table 4.12, results show that there is an association between mortality rate and the following risk factors: surgery since admission (Chi-square = 18,2447; p-value= 0,0057); Peripheral vascular catheter (Chi-square = 20,9999; p-value= 0,0018); underlying diseases (Chi- Square = 174,89; p-value= 0,0000) since these Chi-square contains p values that are less than 0.05. However, the results depict that surgery in last 24 hours; central vascular catheter; urethral catheter; intubation and antibiotics given do not have any association to mortality rate since p-values indicated in Table 4.15 are greater than

0.05.

When it comes to the condition of interest, the results show that there is an association between mortality rate and the following condition of interest: patient acquired Nosocomial infection or HAI (Chi-square = 55,193; p-value= 0,0000); and the date of HAI diagnosis (Chi-square = 400,188; p-value= 0,0000) since the Chi-square values contains p values that are less than 0.05

4.6.3 Chi-square results between microorganisms and its sensitivity

Table 4. 13: Chi-square results between the microorganisms and its sensitivity

		Sensitivity	**Chi-Square**	**degrees of freedom**	**P-value**
Bloodstream sensitivity	**Cultured Organism 1** (*Coagulase negative staphylococcus; Klebsiella pneumonia and Streptococcus group D*)	Vancomycin/Linezolid; Vancomycin/Linezolid; Azithromycin/Vancomycin	39,0000	1	0,00109
Pneumonia sensitivity	**Cultured Organism 1** (*Enterobacter cloacae. ; Pseudomonas aeruginosa; Serratia marcescens; Pseudomonas aeruginosa; Klebsiella pneumonia*)	Carbapenems, I- to Amikacin; Tazobactam/Amikacin; Colistin; Meropenem/Ciprofloxacillin; Tazobactam/IMIPENEM Tazobactam/Amikacin Amikacin/Carbapenems Carbapenems/Ciprofloxacillin	72,22	6	0,19961
	Cultured Organism 2 (*Enterobacter cloacae*)	Carbapenems, I- to Amikacin	16,54	1	0,55454

Results in Table 4.13 shows that there is a significant association between sensitivity (i.e., Vancomycin/Linezolid; Ceftriaxone/Gentamycin/amikacin; Vancomycin/Linezolid; Azithromycin/Vancomycin) and Bloodstream cultured organism 1 (i.e., *Coagulasenegative staphylococcus; Klebsiella pneumonia and Streptococcus group D*). The Chisquare value of 39,0000; and p-value of 0,00109 less than 0,05 implies that there is enough evidence to conclude that bloodstream and sensitivity does have an association. However other types of sensitivity were not associated with the microorganisms due to a p-value greater than 0.05.

4.7 Conclusion

This chapter presented the results of the analysis and interpretation. The demography of participants was presented. Participants with HAI and cultured *organisms* were presented. The results further identified the correlational and associated variables to the hospital stay, mortality rate, and the risk factors. The next chapter discusses the results and provides recommendations and conclusions of the study.

CHAPTER 5: DISCUSSION RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

This chapter discusses the results and provides the recommendations of the study. The chapter will also conclude the study and indicate its limitations and areas for further study.

5.2 Discussion of results

This study was conducted to determine the prevalence of nosocomial infections in the paediatric intensive care unit of Pietersburg hospital and to identify the most common site of nosocomial infections. The researcher also aimed at identifying microorganisms and the antimicrobial activity associated with these infections and comparing the average length of stay and mortality rate between patients with nosocomial infections and those without nosocomial infections.

5.2.1 Prevalence of nosocomial infections

The results of the study show that the prevalence of nosocomial infections in children admitted from 1st January 2017 – 31st December 2017 at Pietersburg hospital was 13.27% which can be presented as 13 per 98 participants (Figure 4.6). In this study (Armour, Patrick, et al. (2018), the data showed a lower frequency of hospital-acquired infections compared to HAI rates of 20.4 and 15.3 per 100 admissions in 2013 and 2014 respectively from a study done in Grey's hospital paediatric intensive care unit by Armour, Patrick, et al. (2018). A further higher increased rate of HAI of 16.8% was reported by Sodhi, Satpathy, et al. (2016) which was conducted in a Paediatric intensive care unit in India. However, the higher rate (20,4% and 15,3% of HAI respectively in the paediatric ward by the two authors (Armour, Patrick, et al. (2018) and Sodhi, Satpathy, et al. (2016)) are comparable to this study findings. Contrary to the findings of this study, lower HAI rates of 4.7% were reported by Haque and Bano,(2009) study which was conducted in a paediatric ICU in Pakistan. A further decline of HAI rates from the findings of this study was reported by Cevik et al., (2016) who reported a hospital infection rate of 6.1% over a six years study period. However, the difference might be because this index study was

conducted for a year and the 6.1% rate by Cevik et al., (2016) was conducted for six years and shows that the rate of HAI in Pietersburg hospital is high. According to WHO (2012), the incidence of NI in countries with limited or low and medium-income varies from 4.488.9%. In Europe, the incidence ranges from 1% in general paediatric wards to 23.6% in Paediatric Intensive Care units in line with the findings of this study (Kouchak, and Askarian, 2012).

5.2.2 Prevalence of nosocomial infections by demographic information of participants

In this section, the NI rate is discussed per gender, age, and patients' diagnosis in line with the study results.

**Gender*

In this study, both males (5 of 13) and female (8 of 13) participants had an equal rate of acquiring HAI with a ratio of 1: 1.5 (Table 4.5).

Gender had no association to HAI implying that gender did not play a role in acquiring HAI, this finding was similar to a study by Cevik, et al., (2016) where (30) 42% of the patients that developed Device Associated Healthcare-Associated Infections (DA-HAI) were females and (42) 58% were males, thus a ratio of 1:1.4. A study conducted in Paediatric Intensive care of a developing country reported 50 males and 31 female's s incidence, thus a ratio of 1: 1.6 Patel, Engelbrecht, et al., (2016). These results are in line with the literature by Cevik, et al., (2016) and Patel, Engelbrecht, et al., (2016).
The lack of association between gender and development of HAI is since both sexes were exposed to a similar environment with almost similar risk factors and that the rate of participants with NI was lower and not enough data with varying factors was available for the results to be conclusive.

**Age*

In this study majority of patients that developed HAI were below 24 months of age (69%) (Table 4.5). This study is in line with the findings by Kasmi et al., (2016) study conducted in Albania which reported that age group between 1 month to 12 months are the most affected by HAI, the mean age of the participants with HAI in this index study were 25

months with a minimum age of 1 month and a maximum of 112 months (9 years) and in line with this study findings.

**Hospital stay*

The results in this index study show that participants with HAI, the hospital stay was a mean of 23 days. The Hospital stay for participants with HAI ranged between a minimum of 8 days to 39 days compared to an average of 6,025 days a minimum range of 2 days and maximum days of 33 for those without HAI at (Table 4.6). The length of stay of patients with NI in ICU was higher than that without the infection according to (Kouchak, and Askarian, 2012) in line with what this study found. Castagnola, Gargiullo, et al. (2018) also found in their study that the duration of admission in the PICU was 57 days in patients with infection vs. 37 days in patients without infection although the difference was not statistically significant.

**Underlying condition*

The underlying conditions in participants who developed HAI were HIV in 4 of 13 (31%) participants followed by congenital heart disease in 2 0f 13 (15%) participants while only 1 of 13 participants (8%) had Tuberculous Meningitis and cerebral palsy (Figure 4.9).
Patients with no underlying conditions accounted for 38% of the total. In Shahunja, Ahmed, et al., (2016), some predisposing infections or comorbid conditions were UTIs and the presence of any congenital anomalies (e.g., cleft lips, cleft palates, Down's syndrome, congenital heart diseases) provoked the development of NI. Pre-existing infection was a significant risk factor for NI. Similar to a multicentre cohort study, in which 45% of NIs occurred in patients with pre-existing infection. Thus the findings of the index study are in line with the literature in that underlying conditions contribute significantly to the development of NI.

**Patient's diagnosis*

In the index study, the majority of patients that acquired HAI were admitted for a respiratory condition (77%) mainly Pneumonia and Bronchiolitis (Figure 4.8). Some studies indicated that in South Africa, patients are most commonly in PICU for the management of infection mainly pneumonia and gastroenteritis like Dramowski, Cotton, and Whitelaw, (2017) who reported HAI prevalence of 14.3%, with a predominance of

gastrointestinal and respiratory tract infections from Chris Hani Baragwanath hospital whereas in developed countries the major reason is care after surgical procedure, (Morrow et al.,2009). In Castagnola, et al. (2018), in their study of the epidemiology of infectious complications during extracorporeal membrane oxygenation in children, heart disease was amongst diagnosed. In this index study, results further show a significant correlation between mortality rate and diagnosis (23%; p-value=0,0370) (Table 4.12).

**Potential risk factors for developing HAI*

Potential risk factors for developing HAI are Endotracheal intubation and mechanical ventilation; central venous catheter; peripheral vascular catheter; urethral catheter and surgery since admission (Table 4.7). However, it is important to note Shahunja, Ahmed, et al., (2016) study which found that 45% of NIs occurred in patients with pre-existing infection. Thus according to Castagnola, Gargiullo, et al. (2018), the infection was suspected and antibiotic treatment was initiated. Results of our study show there is a significant association between a hospital stay and risk factors, condition of interest, antimicrobials use, type of nosocomial infection, and Underlying disease (Chi-square = 140,14; p-value 0,0034) due to Chi Squares that have p values of less than 0.05. The results show that there is no association between a hospital stay and the following risk factors: surgery in the last 24 hours; intubation and antibiotics given with a p-value of greater 0.05

**Endotracheal intubation and mechanical ventilation*

In this index study, 90.8% of patients were intubated and endotracheal intubation seemed to be a significant risk factor as all 13 patients that developed HAI were intubated and on a mechanical ventilator (Table 4.7). Red Cross War Memorial, Cape Town, South Africa reported that approximately 1400 children are admitted annually to their paediatric intensive care unit and many of these children (~1000) require intubation and mechanical ventilation, which places them at risk of developing VAP, (Kunzmann et al., 2016). Also, Iyad, Baoqir, Khursheed, and Shahnaz, (2007) found underlying conditions that were most closely related to NI acquisition to be prolonged hospital stays, prematurity, and exposure to high-risk device procedures.

**Central venous catheter*

In this index study, one patient who acquired HAI had a central venous catheter, some literature has reported an association between the duration of catheterization and HAI, (Tacconelli et al., 2000). In this index study, the duration of catheterization was not calculated. Yogaraj et al., (2006) reported a bloodstream infection rate of 13.8 per 1000 central venous catheter days. Porto et al., (2011) reported the use of central venous catheters as a significant risk factor associated with a study done in a paediatric intensive care unit of a developing country. This index study results shows that there is an association between hospital stay and the following risk factors: surgery since admission (Chi-square = 27,649; p-value= 0,0003); (Table 4.7)

**Peripheral vascular catheter*

In this index study, 10 of 13 patients (76,92%) that developed HAI had a peripheral vascular catheter. There are no previous studies that documented the association between the peripheral vascular catheter and the development of HAI. A significant association was also found between hospital stay and Peripheral vascular catheter (Chisquare = 17,106; p-value= 0,0167); Table 4.11.

**The urethral catheter (UC)*

Berreca et al., (2010) reported asymptomatic (UTI in 9 patients and 6/9 UTIs presented in children with urethral catheters, the incidence rate for NI in children with UC 2.7 per 100 patient days but the rate of incidence of UTI in patients without UC was not significantly greater than in patients without UC (3.6% vs 1.1%, p=0.14); Kasmi et al., (2016) reported catheter-associated UTI in older than 12 years old children with an incidence rate and Device associated rate (DAR) higher than the other age groups. From this index study, the urinary catheter did not indicate Cultured organisms. Also, in this study, none of the participants older than 12 years had HAI. In this index study hospital stay had an association with Urethral catheter (Chi-square = 20,013; p-value= 0,0055) Table 4.11.

**Surgery since admission*

In this index study 3 of 13 (23,07%) participants that acquired HAI had surgery since admission compared to 10 (76,69%) that did not have. None of the 13 participants that

acquired HAI had surgery in the last 24hrs of admission to PICU. Saiman, Ludington, Pfaller, Jarvis, Rangel, Wiblin, Dawson, et al., (2000) reported surgery, risk factors, including gestational age less than 32 weeks, Apgar score of less than 5; shock, disseminated intravascular coagulopathy, prior use of intralipid, parenteral nutrition, central venous catheters, H2 blockers, intubation or length of stay >7 days before candidaemia. Catheters, steroids, and GI tract colonization were not independent risk factors, but GI tract colonisation preceded candidaemia in 15 of 35 (43%) case-patients. There is a significant negative correlation between mortality rate and Surgery in last 24 hours (r=-35%; p-value=0,0010) and Antibiotics given (r=-25%; p-value=0,0210) in line with the literature. Results shows that there is an association between hospital stay and the following risk factors: Surgery since admission (Chi-square = 27,649; p-value= 0,0003); Table 4.11

5.2.3 Types of nosocomial infections

In this study ventilator-associated pneumonia was found to be the most common type of HAI, 92% (n=12) had VAP, 15% (n=2) had bloodstream infection and one (1) patient had both VAP and bloodstream infection. No patient had a positive urine culture. Kasmi, et al., (2016) reported similar findings with the respiratory site being the most common site of NI, in a study that was conducted in PICU in Albania. Another study by Anwarul and Surraiya (2009) reported bloodstream infection from the central venous catheter and ventilator-associated pneumonia as the main sites of infections in patients with nosocomial infections. Other studies reported bloodstream infections as the common site of HAI, Berreca, et al., (2010) reported incidence rate as follows, 20% for BSI,8.6 for VAP, and 3.6% for UTI. Cevik, et al., (2016) also identified bloodstream infections as the most common site of HAI with 81 infections related to a bloodstream infection, 57 infections related to VAP, and 14 urinary catheter-related infections. Juliana, et al., (2011) reported pneumonia as the second most common infection of NI at (30.2%) with an incidence rate of 11.4 per 1000 patients a day and 17.8 per 1000 ventilation days.

Urinary tract infection was the least type of HAI in this study probably because the urine samples were not collected for culture in most of the patients with suspected HAI. One patient amongst those that developed HAI had a negative urine culture. This index study results show that Hospital stay is associated with the Type of Nosocomial Infection and

its sensitivity. The following are associated to hospital stay: urinary catheter (Chi-square =114,13; p value=,0000) relevant device in situ before onset (Chi-square = 100,72; pvalue = 0,0000), Table 4.11.

Blood stream Invasive device (Chi-square = 17,222; p-value =0,0160); Blood stream cultured organism 1 (Chi-square = 73,092; p-value = 0,0021); Sensitivity (Chi-square = 102,42; p-value= 0,0000); Pneumonia ventilator (Chi-square = 14,952; p-value = 0,0366); Pneumonia relevant device in situ before onset (Chi-square = 16,367; p-value = 0,0220); Pneumonia cultured organism 2 (Chi-square = 28,276; p-value = 0,0131) and Pneumonia sensitivity (Chi-square = 146,36; p-value =0,0000) Table 4.13.

5.2.4 Organisms causing nosocomial infection

In the index study, the most common pathogen identified from the respiratory site was *Klebsiella pneumonia* which was isolated in six patients 13 or 46,15% participants, *Pseudomonas aeruginosa* in 3 (23,07%) participants, Enterobacter cloacae in two (1;7,69%) patient, *Serrata marcescens* in one (1) patient, and yeast in one (1;7.69%) participant (Table 4.8). Three to seven percent of the hospital-acquired infections bacterial infections are related to *Klebsiella pneum*onia, which is the eighth significant pathogen in the healthcare setting, *Klebsiella pneumonia* in a hospital setting can be transmitted by person to person contact and especially when the health care professional does not wash or clean hands after checking a contaminated patient, respiratory machines, catheters or exposed wounds can be the source of its transmission, (Hassan et al., 2015). In a study by Hlophe and McKerrow (2014), there was an incidence for *Klebsiella pneumonia* HAI of 10/1000 admissions with a range of 28.8/1000 patients per annum. The pathogens isolated were also similar to isolations from a study by Juliana Porto (2012) where they isolated pseudomonas aeruginosa (1.5%) and *staphylococcus aureus* (3.2%). In Marra et al., (2006), *Klebsiella pneumonia* ranked among the top ten pathogens causing bloodstream infections.

In this study, the most commonly identified pathogen cultured from the bloodstream was *Coagulase Negative staphylococcus* (2 of 4) followed by *Streptococcus Group D* (1 of 4) and *Klebsiella Pneumoniae* (1 of 4) (Table 4.8). A review article by Hassan et al., (2015) described *Coagulase negative staph aureus* as the most common isolated pathogen in

blood-borne infections. In this index study, results have shown that there are cultured organisms from both the bloodstream and respiratory site i.e. *Coagulase-negative staphylococcus* in the bloodstream and *Pseudomonas aeruginosa* in the respiratory site; *Coagulase-negative staphylococcus* from the bloodstream and *Klebsiella pneumonia* in the respiratory site and *Streptococcus group D* in the bloodstream and *Klebsiella pneumonia* in the respiratory site as presented in Table 4.8 and in line with the literature Hassan et al., (2015).

5.2.5 Microorganism sensitivity

For this study, cultured organisms' sensitivity was Vancomycin and Linezolid for *coagulase-negative staphylococcus*, Ceftriaxone, Gentamycin, and Amikacin for *Klebsiella Pneumoniae* and Vancomycin/Linezolid/Azithromycin for *Streptococcus Group D*. The index study results show that there is a strong association between the Bloodstream type of Nosocomial infection sensitivity and cultured organism 1 which was *CNS; Klebsiella pneumonia* and *Streptococcus D*; (Chi-square = 39,0000; p-value= 0,00109 less than 0.05 although the latter cannot be said about cultured *organisms* 2. However other types of sensitivity are not associated with the microorganisms due to pvalue greater than 0.05. (Table 4.13)

5.2.6 Mortality Rate and Length of stay

The length of stay in PICU was longer in patients with HAI as compared to those without HAI as it is reported in a similar study by Berreca, et al., (2010) with a range of 2-60 days in patients with NI vs 5-268 days in patients without HAI and another study by Neeta P observed a mean duration ICU stay of 17.2 days in patients with HAI vs 7 days in patients without HAI. Results in this index study show that there is a correlation between hospital stay and mortality rate of 36% with a p-value of 0,0001. (Table 4.9)

During the period of the study, 74% of the participants were discharged to the general ward and 26% demised. Four percent (4%) of the participants that demised had HAI and 22% of them did not have HAI. Thus there is a ratio of 1 in 3 patient's odds of the possibility of death in patients with HAI compared to 1 in 4 in patients without HAI. The higher mortality rate in patients with HAI was reported in other similar studies in Paediatric ICU

in Albania May 2011- December 2012 with rates between 36.7% vs 15% Kasmi, et al., (2016). Results further shows an association between hospital stay and mortality rate (outcome) (Chi-square = 163,42 and p-value= 0.0376 since the p-value is less than 0.05.

5.3 Recommendations of the study

The following are the recommendations of the study:

- Proper handwashing as adherence to basic measures of infection control and prevention
- Ongoing training of health care professionals about adherence to basic measures of infection control and prevention to ensure that the basic measures are adhered to without fail since a direct association with HAI was depicted.
- The use of surveillance programs to devise a strategy comprising of infection control practices according to the Centre for Disease Control and Prevention guidelines.

  The study found a strong association between a hospital stay and HAI and that the longer the hospital stay the greater the hospital burden. To improve the level of HAI within Pietersburg hospital, this study recommends the introduction of the bundle concept which was introduced by the Institute for Health care Improvement as an intervention to reduce HAIs (introduced in 2001 and by the Institute for Health care Improvement (IHI)). A bundle is a set of evidence-based interventions that when implemented together result in improved patient outcomes. Bundles are targeting central line-associated bloodstream infections, catheter-associated urinary tract infections, ventilator-associated pneumonia, surgical site infections, and antibiotic stewardship. In South Africa, the concept was introduced in 2009 with the Best Care Always campaign. Multiple studies have shown a significant reduction in infection rates where compliance is achieved.

5.4 Conclusion of the study

In this retrospective descriptive study, the study found that the prevalence of nosocomial infections in patients admitted to Pietersburg Hospital from January 2017 to 31st December 2017 was 13.8% in line with other similar studies. Pneumonia was the most common type of HAI, followed by bloodstream infections, and endotracheal intubation

and mechanical ventilation were significant risk factors. *Klebsiella pneumonia* was the most identified pathogen from the respiratory site followed by *Pseudomonas aeruginosa* and from the bloodstream infection, *Coagulase-negative staphylococcus* was the most identified organism followed by *Klebsiella pneumonia* and *Streptococcus Group D*.

In this study, the development of HAI was associated with increased length of hospital stay and increased chance of mortality. The prolonged hospital stay would be associated with an increased cost of care and an ongoing risk of acquiring further HAI.

This chapter discussed the findings of the study and presented recommendations and conclusion of the study.

5.5 Limitation of the study

The main limitation of this index study is that it was a retrospective study of identifying nosocomial infection between 1st January 2017 to 31 December 2017 which prevented the researcher from collecting information on a broader range of variables that may have been potential additional risks and cases.

In a retrospective study, the response rate is expected to be higher since this is under the researcher's control however in this study, only a 72% response rate was achieved due to the inclusion criteria not met. The rate of nosocomial infection may have changed although not significant based on study findings.

Missing records - Provision of patient records and relevant notes would have increased the sample size and precision of results

Types of nosocomial infections studied- the National Healthcare Safety Network with the Centre for Disease Control classified Nosocomial infections into 13 types. In this study, the focus was on only three types.

The omission of urine samples collection - urine samples were not collected in most of the patients with suspected HAI, therefore much cannot be said about hospital-acquired urinary tract infections.

5.6 Further study

This was a retrospective study for a period of a year between January to December. Further work can include following up years after and assess if the rate of HAI had improved over time.

Another work for further study can involve Prospective study where cases are captured as they come to assess the results in real-time in improving managing HAI in a hospital setting. A Prospective study can provide an opportunity to look into more other variables such as bed occupancy within the PICU which this study did not address due to limited information and related literature.

The introduction of the bundle concept introduced by the institute for health care improvement as an intervention to reduce HAIs. A full study in this regard can confirm the level of intervention this concept has on HAI.

REFERENCES

Abdel-Wahab, F., Ghoneim, M., Khashaba, M. EL-Gilany, A, H., Hady, A.D. 2013. Nosocomial infection surveillance in an Egyptian neonatal intensive care unit. *The Journal of Hospital Infection* 83(3):193-5.

Armour, A.L., Patrick, M.E., Reddy, Z., Sibanda, W., Naidoo, L. and Spicer, K.B. 2018. Healthcare-associated infection in the Grey's Hospital paediatric intensive care unit: does an Infection Control Programme work? *Southern African Journal of Infectious Diseases*, pp.1-5.

Asembergiene, J., Gurskis, V.M., Kevalas, R., Valinteleze, R. 2009. Nosocomial infections in paediatric intensive care units in Lithuania. *Medicina* 45(1):29-36.

Bamberg, W., Heinrichs, G., Nyberg, C. and Parker, R. 2015. A tutorial guide for prevention of hospital acquired infections. https://www.preventionofhai.org/assets/pdf/phai_tutorial_guide_v0180414a.pdf. (Accessed 31 October 2020)

Barrasa-Villar, J.I., Aibar-Remón, C., Prieto-Andrés, P., Mareca-Doñate, R. and MolinerLahoz, J. 2017. Impact on morbidity, mortality, and length of stay of hospital-acquired infections by resistant microorganisms. *Clinical Infectious Diseases*, *65*(4), pp.644-652.

Becerra, M., Tantalean, J., Suarez, V., Alvarado, M., Candela, J. Urcia, F.C. 2010 Epidemiologic surveillance of nosocomial infections in a paediatric intensive care unit of a developing country. *BMC Paediatrics10 (66):*1*.*

Bochennek, K., Hassler, A., Perner, C., Gilfert, J., Schöning, S., Klingebiel, T., Reinhardt, D., Creutzig, U. and Lehrnbecher, T. 2016. Infectious complications in children with acute myeloid leukemia: decreased mortality in multicenter trial AML-BFM 2004. *Blood cancer journal*, *6*(1), pp. e382-e382.

Brink, A., Feldman, C., Duse, A., Golapan, D., Grolman, D., Mer , M.et al. 2006.Guideline for the management of nosocomial infections in South Africa.*South African Medical Journal96(7pt2):642-52.*

Caniza, M.A., Odio, C., Mukkada, S., Gonzalez, M., Ceppi, F., Chaisavaneeyakorn, S., Apiwattanakul, N., Howard, S.C., Conter, V. and Bonilla, M. 2015. Infectious complications in children with acute lymphoblastic leukemia treated in low-middle-income countries. *Expert review of hematology*, *8*(5), pp.627-645.

Castagnola, E., Gargiullo, L., Loy, A., Tatarelli, P., Caviglia, I., Bandettini, R., Grasso, C., Lampugnani, E., Pezzato, S., Tuo, P. and Moscatelli, A. 2018. Epidemiology of infectious complications during extracorporeal membrane oxygenation in children: a single-center experience in 46 runs. *The Pediatric infectious disease journal*, *37*(7), pp.624-626.

Cohen, L., Manion, L. & Morrison, K. 2011. Research Methods in Education.

Committee on Pediatric Workforce. 2015. Definition of a Pediatrician. *Pediatrics*, 135(4), pp.780-781.

Creswell, J. & Creswell, J. 2017. Research design: Qualitative, quantitative, and mixed methods approaches.

Dramowski, A., Cotton, M.F. and Whitelaw, A. 2017. A framework for preventing healthcare-associated infection in neonates and children in South Africa. South African Medical Journal, 107(3), pp.192-195.

Ducel, J., Fabry, J ., Nicolle, L. 2002. *Prevention of hospital-acquired infections*, A practical guide 2nd edition: *WHO/CDS/EPH/2002.(12)1.*

Farideh, K., Mehrdad, A. 2012.Nosocomial infections. *The Definition Criteria.Iranian Journal of Medical Sciences* 37(2):72-73.

Folgori, L., Bernaschi, P., Piga, S., Carletti, M., Cunha, F.P., Lara, P.H.R .et al. 2016. Healthcare-Associated Infections in Pediatric and Neonatal Intensive Care Units. Impact of Underlying Risk Factors and Antimicrobial Resistance on 30-Day Case-Fatality in Italy and Brazil. *Infection Control & Hospital Epidemiology* :1-8

Gliem, J.A and Gliem, R.R. 2003. Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert- type scales, Midwest Research to practise conference in adult, continuing and community education.

Haque, A. and Bano, S. 2009. Clinical profile and outcome in a paediatric intensive care unit in Pakistan. *Journal of the College of Physicians and Surgeons Pakistan*, *19*(8), p.534.

Hassan, A., Aftab, A., Riffat, M .2015. Nosocomial infections and their control strategies. *Asian Pacific Journal of Tropical Medicine* 5(7):505-509

Hernandez, M.D.P., Martin, P. and Simkins, J. 2015. Infectious complications after liver transplantation. Gastroenterology & hepatology, 11(11), p.741.

Khan, H.A., Baig, F.K. and Mehboob, R. 2017. Nosocomial infections: Epidemiology, prevention, control and surveillance. Asian Pacific Journal of Tropical Biomedicine, 7(5), pp.478-482.

Hill, R., Paulus, S., Dey, P., Hurley, M.A. and Carter, B. 2016. Is undernutrition prognostic of infection complications in children undergoing surgery? A systematic review. *Journal of Hospital Infection*, *93*(1), pp.12-21.

Hooker, E. and Shiel Jr, W.C. 2018. Medical Author. https://www.medicinenet.com/prevalence/definition.htm (Accessed 31 October 2020)

Hossein, M., Alireza, N. 2009.Epidemiology of nosocomial infections in a paediatric intensive care unit.*Iranian Journal of Infectious Diseases*4(2):83-86.

Iyad, N., Baqir, S., Naqvi, S., Khusheed, H., Shahnaz, G.2007.Incidence rate and distribution of paediatric nosocomial infections. *Pakistan Journal of Pharmacology* 24(1):53-59.

Juliana, P., Orlando, CM., Aglai, A., Claudette, F., Paulo, P., Rosineide ,MR. 2011.Nosocomial infections in a paediatric intensive care unit of a developed country.*Revista da Sociedade Brasileira de Medicina Tropical 45(4):475-479.*

Kouchak, F. and Askarian, M. 2012. Nosocomial infections: the definition criteria. *Iranian journal of medical sciences*, *37*(2), p.72.

Kulaylat, A.N., Engbrecht, B.W., Rocourt, D.V., Rinaldi, J.M., Santos, M.C., Cilley, R.E., Hollenbeak, C.S. and Dillon, P.W. 2016. Measuring surgical site infections in children:

comparing clinical, electronic, and administrative data. *Journal of the American College of Surgeons*, *222*(5), pp.823-830.

Lavrakas, P.J .2008. Encyclopedia of Survey Research Methods.

Lodha, R.,Natchu,U,.Nanda,M,.Kabra,S. 2001.Nosocomial infections in paediatric intensive care units.*Indian journal of paediatrics 68(11):1063-70.*

Magill, S.S., O'Leary, E., Janelle, S.J., Thompson, D.L., Dumyati, G., Nadle, J., Wilson, L.E., Kainer, M.A., Lynfield, R., Greissman, S. and Ray, S.M. 2018. Changes in the prevalence of health care-associated infections in US hospitals. *New England Journal of Medicine*, *379*(18), pp.1732-1744.

Mahajan, V., Tiwari, M., Arya, A., Tiwari, A., Chawla, D. and Saini, S.S. 2016. Clinical predictors of hospital admission in acute lower respiratory tract infection in 2 months to 2year-old children. *Respirology*, *21*(2), pp.350-356.

Mahmoud, L.A.N. 2012., *Hospital-acquired infection: Molecular study and infection control guidelines* (Doctoral dissertation, Mansoura University).

Mani, C.S. 2018. Acute pneumonia and its complications. *Principles and practice of pediatric infectious diseases*, p.238.

Mireya, U., Marti, P., Marisa , S., Latorre, C. Palomeque, A. 2003.Prospective incidence study of nosocomial infections in a paediatric Intensive Care Unit.P*aediatric infectious disease journal 22(6):2003.*

Mitt, P., Metsvaht, T., Adamson, V., Telling, K., Naaber, P. et al. 2014. Five-year prospective surveillance of nosocomial bloodstream infections in an Estonian paediatric intensive care unit. *Journal of Hospital Infection 86*(2):95-99.

Monegro, A.F., Muppidi, V. and Regunath, H. 2020. Hospital-acquired infections. StatPearls [Internet].

Moolchandani, K., Sastry, A. S., Deepashree, R., Sistla, S., Harish, B. N., & Mandal, J. 2017. Antimicrobial resistance surveillance among intensive care units of a tertiary care hospital in Southern India. *Journal of clinical and diagnostic research: JCDR*, *11*(2), DC01.

Mythri, H. and Kashinath, K. 2014.Nosocomial infections in intensive care unit of a tertiary health centre. *Ann Med Health Sci Res*,4(5):738-41

Nguyen, P.H.L. 2018. *Defining the Aetiology and Antimicrobial Susceptibility Patterns of the Predominant Bacteria Associated with Bloodstream Infections at the Hospital for Tropical Diseases in Ho Chi Minh City, Vietnam* (Doctoral dissertation, The Open University).

Nicholas, J., B. 2016." Bacteremia": http://emedicine.medscape.com/article/961169overview (Accesed13may2017). An observational cohort study. *Journal of critical care* 32:152-158.

Oladokun, R., Muloiwa, R., Hsiao, N.Y., Valley-Omar, Z., Nuttall, J. and Eley, B. 2016. Clinical characterisation and phylogeny of respiratory syncytial virus infection in hospitalised children at Red Cross War Memorial Children's Hospital, Cape Town. BMC infectious diseases, 16(1), p.236.

Olivier, C., Kunneke, H., O'Connell, N., Von Delft, E., Wates, M. and Dramowski, A. 2018. Healthcare-associated infections in paediatric and neonatal wards: A point prevalence survey at four South African hospitals. South African Medical Journal, 108(5), pp.418422.

Oxford South African School Dictionary. 2010.Sv" context", 3rd edition. Southern Africa, Oxford University press.

Ozkan, H., Cetinkaya, M., Koksal, N., Celebi, S. and Hacımustafaoglu, M. 2014. Cultureproven neonatal sepsis in preterm infants in a neonatal intensive care unit over 7 years.
Coagulase-negative Staphylococcus as the predominant pathogen. Pediatrics *International* 56(1): 60-66.

Pagano, R.R. 2012. *Understanding statistics in the behavioural sciences* (Vol. 1). Cengage Learning.

Parajuli, N. P., Acharya, S. P., Mishra, S. K., Parajuli, K., Rijal, B. P., & Pokhrel, B. M. 2017. High burden of antimicrobial resistance among gram-negative bacteria causing

healthcare-associated infections in a critical care unit of Nepal. Antimicrobial Resistance & Infection Control, 6(1), 1-9.

Patel,B.,Engelbecht,H.,Mc Donald, H., Morris, V., Smythe , W. 2016. A multifaceted hospital-wide intervention increases hand hygiene compliance. *South African Medical Journal* 106(4):335-341.

Pérez, D.V., Jordan, I., Esteban, E., García-Soler, P., Murga, V., et al. 2014.Prognostic factors in pediatric sepsis study, from the Spanish Society of Pediatric Intensive Care. *The Pediatric infectious disease journal 33*(2): 152-157.

Peronnet, E., Nguyen, K., Cerrato, E., Guhadasan, R., Venet, F. et al. 2016. Evaluation of MRNA Biomarkers to Identify Risk of Hospital Acquired Infections in Children Admitted to Paediatric Intensive Care Unit. *Plos one 11*(3): e0152388.

Porto, J.P., Mantese, O.C., Arantes, A., Freitas, C., Gontijo Filho, et al. 2012. Nosocomial infections in a pediatric intensive care unit of a developing country.NHSN surveillance. *Revista da Sociedade Brasileira de Medicina Tropical 45*(4):475-479

Revelas, A. 2012. Healthcare –associated infections. A public health problem.*Nigerian Medical Journal* 53(2):59-64.

Richards, M., Edwards, J., Culver, D., Gaynes, R.1999.Nosocomial infections in paediatric intensive care units in the United States *Paediatrics103(4).*

Robert,S & Porter,MD. 2009.*The Merck Manual*:2nd home edition, White house station: Merck Research Laboratories.

Saiman, L., Ludington, E., Pfaller, M., Rangel-Frausto, S., Wiblin, R.T.et al. 2000. Risk factors for candidemia in neonatal intensive care unit patients. *The Pediatric infectious disease journal 19*(4):319-324

Saptharishi, L.G., Jayashree, M., Singhi, S. 2016. Development and validation of the "Pediatric Risk of Nosocomial Sepsis (PRiNS)" score for health care-associated infections in a medical pediatric intensive care unit of a developing economy—a prospective

Shahida, S.M., Islam, A., Dey, B., Islam, F., Venkatesh, K. and Goodman, A. 2016. Hospital-acquired infections in low and middle-income countries: root cause analysis and the development of infection control practices in Bangladesh. *Open Journal of Obstetrics and Gynecology*.

Shahunja, K.M., Ahmed, T., Faruque, A.S.G., Shahid, A.S.M.S.B., Das, S.K., Shahrin, L., Hossain, M.I., Islam, M.M. and Chisti, M.J. 2016. Experience with nosocomial infection in children under 5 treated in an urban diarrheal treatment centre in Bangladesh. *Global pediatric health*, *3*, p.2333794X16634267.

Sodhi, J., Satpathy, S., Sharma, D.K., Lodha, R., Kapil, A., Wadhwa, N. and Gupta, S.K. 2016. Healthcare-associated infections in Paediatric Intensive Care Unit of a tertiary care hospital in India: Hospital stay & extra costs. *The Indian journal of medical research*, *143*(4), p.502.

Solutions, S. 2018. Using chi-square statistic in research. *Hämtat från Statistics Solutions: https://www. statisticssolutions. com/using-chi-squarestatistic-inresearch/den*, *29*(04), p.2018.

Solutions, S., 2017. Correlation. Hämtat från Statistics Solutions: https://www. statisticssolutions. com/using-chi-squarestatistic-in-research/den, 29(04), p.2017

Spicer, K.B., Green, J. and Dhada, B. 2018. Hospital-acquired infections in paediatric medical wards at a tertiary hospital in KwaZulu-Natal, South Africa. Paediatrics and international child health, 38(1), pp.53-59.

Stevens, J., Herberg, J.A. and Levin, M. 2016. Infectious diseases and the kidney in children. *Pediatric Nephrology*, p.1609.

Stockwell, J.A. 2007.Nosocomial infections in the pediatric intensive care unit affecting the impact on safety and outcome*. Paediatric Critical care medicine* 8(2 Suppl): S21-37.

Teresa, C., Andrus, M., Dudeck, M. 2008.CDC/NHSN surveillance definition of healthcare-associated infections and criteria for specific types of infections in the acute care setting.*AJIC major articles36(5):314-323.*

Trochim, William M. K. 2006. "Descriptive statistics". *Research Methods Knowledge*

Base. Retrieved 19 August 2020

Ugalde, O.C., Hidalgo, R.F., Rosenthal, V.D., Hernandez, I.C., Gutierrez, G.M. et al. 2016. Device-associated infection rates, bacterial resistance, length of stay, and mortality in intensive care units of Costa Rica, findings of the International Nosocomial Infection Control Consortium (INICC). *Canadian Journal of Infection Control3*(1):28-34.

van Elst, H. 2013. Foundations of descriptive and inferential statistics. arXiv preprint arXiv:1302.2525.

ANNEXURE A: DATA COLLECTION SHEET

Data collection sheet

Case no:			

1. Patient Details

	Fill in the information
Gender	☐ Male ☐ Female
Age in years and months	☐☐☐
Date of admission	
Date of discharge	
Number of days in ICU	
Diagnosis	
Outcome	

2. Risk factors

Surgery since admission	☐ No ☐ Yes If yes, surgical procedure_____

Surgery in the last 24 hours	☐ No ☐ Yes
Central vascular catheter	☐ No ☐ Yes
Peripheral vascular catheter	☐ No ☐ Yes
Urethral catheter	☐ No ☐ Yes
Intubation	☐ No ☐ Yes
Antibiotics are given	☐ No ☐ Yes
Underlying disease	☐ None ☐ Non-fatal disease ☐ Life limiting prognosis ☐ Not known

3. Condition of interest

Patient on antimicrobials	☐ No ☐ Yes

The patient acquired Nosocomial infection or HAI	____ ____ No Yes
Date of HAI diagnosis	

4. Antimicrobials use

First antimicrobials	Generic name _____
Route	☐ Parenteral ☐ Oral ☐
Reason	
Indication	
Diagnosis	
Duration	
Second antimicrobials	Generic name _____
Route	☐ Parenteral ☐ Oral ☐
Reason	
Indication	
Diagnosis	
Duration	

5. Type of Nosocomial Infection (NI) or (Hospital-acquired infection data (HAI)

NI 1: Urinary	

Urinary catheter	___ ___ No Yes
Relevant device in situ before the onset	☐ No ☐ Yes
Origin of infection	___ ___ ___ Current Other acute Other

	☐	hospital	☐	hospital	☐ origin
Date of NI onset	☐☐☐☐☐☐☐☐				
Cultured organism 1	___ _____				
Cultured organism 2	___ _____				
Cultured organism 3	___ _____				
Sensitivity					
NI 2: Bloodstream					
Invasive device	☐ No ☐ Yes If y s specify				
Relevant device in situ before the onset	☐ No ☐ Yes				
Origin of infection	☐ Current hospital		☐ Other acute hospital		☐ Other origin
Date of NI onset	___ _____				

Cultured organism 1	___ _____
Cultured organism 2	___ _____
Cultured organism 3	___ _____
Sensitivity	
NI 3: Pneumonia	
Ventilator	☐ No ☐ Yes
Relevant device in situ before the onset	☐ No ☐ Yes
Origin of infection	
	☐ Current hospital ☐ Other ac ıte hospital ☐ Other origin
Date of NI onset	☐☐☐☐☐☐☐☐
Cultured organism 1	_____ ___
Cultured organism 2	_____ ___
Cultured organism 3	_____ ___
Sensitivity	

ANNEXURE B: ETHICS CLEARANCE

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 3935, Fax: (015) 268 2306, Email: anastasia.ngobe@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING:	**27 November 2018**
PROJECT NUMBER:	**TREC/237/2018: PG**
PROJECT:	
Title:	Prevalence of Nosocomial Infection in Paediatric Intensive Care Unit at Pietersburg Hospital in Limpopo Province, South Africa.
Researcher:	TM Makhwanya
Supervisor:	Prof SM Risenga
Co-Supervisor/s:	N/A
School:	Medicine
Degree:	Master of Medicine in Paediatrics and Child Health

PROF TAB MASHEGO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: REC-0310111-031

Note:
i) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.**
ii) **The budget for the research will be considered separately from the protocol.**
PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES.

Finding solutions for Africa