

**RADIOLOGY IMAGING EQUIPMENT AND ACCESSORIES AS POSSIBLE FOMITES OF  
NOSOCOMIAL PATHOGENS**

**By**

**ISAAC AGYEKUM ADOMAKO (215171276)**

**Dissertation submitted in fulfilment of the requirements for the degree**

**Master of Science in Radiography**

**in the Department of Medical Imaging and Therapeutic Sciences**

**of the Faculty of Health and Wellness Sciences**

**at the Cape Peninsula University of Technology**

**Supervisor: Prof Penelope Engel-Hills**

**External supervisor: Mrs Dalene Venter**

**External supervisor: Prof Eric Sampane Donkor**

**Bellville**

**(October 2019)**

**CPUT copyright information**

The dissertation/thesis may not be published either in part (in scholarly, scientific or technical journals), or as a whole (as a monograph), unless permission has been obtained from the University.

## DECLARATION

I, Isaac Agyekum Adomako, declare that the contents of this dissertation represent my own unaided work, and that the dissertation has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed

A handwritten signature in black ink, appearing to read 'Isaac Adomako', written over a horizontal line.

Date 21/10/2019

## ABSTRACT

### **Background:**

Hospital-acquired infections (HAIs) known as nosocomial infections are a major challenge within the health-care environment. Although investment and time are continually spent on the eradication of HAIs, the problem still exists. The European Centre for Disease Prevention and Control (2015) reported that annually, 4,100,000 patients in Europe acquire additional diseases during their stay in the hospital resulting in 14,700 deaths. Nosocomial infections therefore contribute to the imbalance between resources for the management of hospitals. This is a particular challenge in developing countries like those in Sub-Saharan Africa, of which Ghana is part and, where very limited resources are available for the high volume of patient output.

Radiology is a high technology service department that provides imaging to numerous inpatients and outpatients on a continuous basis. This means that items in the radiology department may serve as possible reservoirs for the transmission of nosocomial pathogens from one individual to another. Where Radiology resides within a health-care system that is unable to give adequate attention to the spread of nosocomial infections or even to proper infection control measures, HAIs becomes a real possibility.

### **Aims**

The aim of this study was to determine whether radiology imaging equipment and accessories for general radiography are possible fomites of nosocomial pathogens. The study also aimed at investigating the effectiveness of the disinfectant chemical agents (chlorine bleach/sodium hypochlorite and methylated spirits) used for cleaning surfaces at the research site. Furthermore, the study aimed to observe the cleaning procedures and practises by radiographers in general radiography.

### **Methodology**

The design of this research included an observational and an experimental phase. The study was conducted in the radiology department of a Teaching Hospital (TH) in Ghana. Swabbing, using wet sterile swab sticks was the method for sample collection. This was done on one occasion without cleaning of the selected x-ray equipment and accessories and another occasion after cleaning with the department's preferred disinfectant chemical agents. The swab samples were then taken to the microbiology laboratory of the University of Ghana for culturing and identification. MacConkey and blood agar media were used to prepare the culture media. The prepared media were put into petri dishes and swab samples were inoculated onto the

culture plates. Culture plates were then incubated for 24 hours, at a temperature of 37°C. At the end of the incubation period, the culture plates were viewed macroscopically under a bright light, to identify any bacterial growth; according to their colony forming characteristics. Seven radiographers (n=7) were observed for a period of one month on the current cleaning procedures and practises in the radiology department. How thoroughly the equipment and accessories were cleaned (how much time spent per item) was recorded. Damp dusting (using cotton wool moistened with methylated spirits or chlorine bleach), cleaning equipment using methylated spirits or chlorine bleach after each contact with body fluid, hands washing after each patient using water and liquid soap, washing of hand randomly after patients (or in between patients) using water and liquid soap, were observed and recorded. Data was captured and analysed using the IBM SPSS Statistics Version 25.

### **Results:**

The selected radiology imaging equipment and accessories swabbed were found to be contaminated with pathogens. Organisms identified were *Staphylococcus aureus*, *Coagulase-negative staphylococci*, *Bacillus species*(spp.), *Shigella* spp., *Shigella sonnei*., *Klebsiella* spp., *Salmonella Paratyphi A*, *Salmonella Typhi*, *Providencia rettgeri*, *Enterobacter* spp. and *Citrobacter* spp. *Staphylococcus aureus* was the predominate pathogenic isolate identified. A significant number of the *Staphylococcus aureus* and CoNS isolated was methicillin-resistant. *Bacillus* spp. was the predominant non-pathogenic isolate identified in the study. Statistically there was no significant difference ( $p=0.5835$ ) between the total number of occurrences of bacterial isolates in both rooms after decontamination.

The observation phase demonstrated that no documented protocol or infection control procedures were available. It was further observed that only one of the seven radiographers washed his/her hands after each patient, but that all radiographers practised hand washing and equipment cleaning when the procedure involved body fluid from patients.

### **Conclusion:**

The research established that radiologic equipment and accessories were often exposed to pathogens and are therefore possible fomites of nosocomial pathogens. The effectiveness of the cleaning agents (methylated spirits and chlorine bleach) was not adequate. Radiographers partially practised infection control measures. Based on the findings of this study it recommended that a policy and procedure must be prepared and an awareness campaign/training of radiographers conducted. Other cleaning agents must also be

investigated in a comparative study to determine the most effective agent (but still affordable within the resource constrained environment).

## ACKNOWLEDGEMENTS

### I wish to thank:

I thank God for giving me wisdom, knowledge and strength to complete this study.

I also wish to thank the following persons for their respective contribution to this dissertation:

- My lovely wife Portia Owusu, for her unconditional love, support and encouragement.
- My children, Amankwaah, Manu, and Otubea, for their support and understanding.
- A special thank you to my supervisor, Prof Penelope Engel-Hills, for her guidance, support and encouragement.
- My co-supervisors, Mrs Dalene Venter and Prof Eric Sampane Donkor for their support and guidance.
- All the staff at the Radiology department, for their support and cooperation.
- All the staff at the Microbiology Department University of Ghana and the Chief Executive officer of the TH, for the permission to conduct the study.
- The Health and Wellness Sciences Research Ethics Committee (HW-REC) of CPUT, for giving me approval to conduct the study.
- Ms Edith Abena Appiah and Mr Amos Akumwena the biomedical scientists at the Microbiology Department, University of Ghana.
- Mr Michael Baffour-Asare whose advice was invaluable for the analysis of my data in this research.
- Dr Kofi Kyei Adesi and Mr Bernard Botwe of the School of Allied Health and Biomedical Sciences - University of Ghana for their inspiration, encouragement and guidance.

The financial assistance of the National Research Foundation towards this research is acknowledged. Opinions expressed in this thesis and the conclusions arrived at, are those of the author, and are not to be attributed to the National Research Foundation.

## **DEDICATION**

I dedicate this dissertation to my late mother, Susana Abena Amankwaah of blessed memory. May her dear soul rest in the bosom of father Abraham. Amen. My co-supervisor Mrs Dalene Venter for her commitment towards this research. In difficult times when she had even sustained injury to her foot, she readily responded to my calls and emails and never lost contact with me.

## TABLE OF CONTENTS

	Declaration	ii
	Abstract	iii
	Acknowledgements	vi
	Dedication	vii
	Table of contents	viii
	List of figures	ix
	List of tables	x
	Appendices	xi
	List of abbreviations and acronyms	xi
<b>CHAPTER ONE: ORIENTATION TO THE STUDY</b>		
1.1	Introduction	1
1.2	Statement of the problem	2
1.3	Background and rationale	3
1.4	Research questions	4
1.5	Research aims and objectives	4
1.5.1	Aims	4
1.5.2	Objectives	5
1.5.3	Significance of the research	5
1.6	Conclusion	5
<b>CHAPTER TWO: REVIEW OF LITERATURE</b>		
2.1	Introduction	6
2.2	Nosocomial or hospital-acquired infections	6
2.3	Main types of nosocomial pathogens	9
2.4	Common types of nosocomial infections	10
2.5	Pathogens found on radiology equipment and accessories	11
2.6	Modes of transmission and prevention of transfer	12
2.7	Decontamination and cleaning	14
2.8	Conclusion	16
<b>CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY</b>		
3.1	Introduction	18
3.2	Research questions	18
3.3	Research aims and objectives	18
3.3.1	Aims	18
3.3.2	Objectives	18
3.4	Study focus	19
3.5	Research design	19
3.6	Study site and sampling	21
3.6.1	Study site	21
3.6.2	Sampling	23
3.7	Data collection procedures	26
3.7.1	Observation of cleaning procedures	26
3.7.2	Swabbing procedure	27



3.8	Bacterial isolation and identification	29
3.9	Statistical analysis and presentation	30
3.10	Dissemination of results	30
3.11	Ethical considerations	31
3.12	Conclusion	33

#### CHAPTER FOUR: RESULTS

4.1	Introduction	34
4.2	Phase 1: observation	34
4.2.1	Cleaning and decontamination	35
4.2.2	Storage of cassettes and lead apron	36
4.3	Phase 2: Experimental data	37
4.3.1	Pathogens isolated pre-decontamination	43
4.3.2	Pathogens isolated post-decontamination	49
4.4	Conclusion	57

#### CHAPTER FIVE: DISCUSSION

5.1	Introduction	58
5.2	Current cleaning procedures	58
5.2.1	Storage area for equipment	61
5.3	Pathogens identified pre-decontamination	61
5.4	The effectiveness of chemical disinfectants	65
5.5	Limitations of study	67
5.6	Recommendations	68
5.7	Conclusion	69

REFERENCES	71
------------	----

#### LIST OF FIGURES

Figure 3.1:	Conceptual framework. A research study to investigate the relationships between the variables	20
Figure 3.2:	Map of Ghana showing the location of the TH	22
Figure 3.3:	Geographical location of Ghana displaying the neighbouring nations	22
Figure 3.4:	Equipment setup	25
Figure 3.5:	Control panel comprising of control buttons and exposure button (A)	25
Figure 3.6:	Flow chart of data comparisons	29
Figure 4.1:	Storage places for cassettes and lead aprons	36
Figure 4.2:	Biochemical laboratory test for <i>Klebsiella</i> spp. (A) and <i>Citrobacter</i> spp. (B)	37
Figure 4.3	Biochemical identification for <i>Enterobacter</i> spp. (C) and <i>Providencia rettgeri</i> (D)	38

Figure 4.4:	Biochemical identification for <i>Salmonella enterica</i> subsp. Typhi (E) and Paratyphi A (F)	39
Figure 4.5:	Biochemical identification for <i>Shigella</i> spp. (G)	40
Figure 4.6:	Biochemical identification of microbes A. Bacterial colony showing lactose (pink) and non-lactose (light pink) fermentations. B. <i>Klebsiella</i> spp. growing on MacConkey showing the characteristics of mucoid colonies.	40
Figure 4.7:	<i>Bacillus</i> spp. growing on blood agar	41
Figure 4.8:	Biochemical identification of microbes. A and B <i>Staphylococcus aureus</i> growing on mannitol salt agar(yellow). B, Coagulase Negative <i>Staphylococci</i> showing lactose fermentation(red)	41
Figure 4.9A:	Coagulase test to confirm <i>Staphylococcus aureus</i> (coagulase negative)	42
Figure 4.9B:	Coagulase to confirm <i>Coagulase Negative Staphylococcus</i>	42
Figure 4.10:	Bacterial growth identified from Room A pre-decontamination	44
Figure 4.11:	Bacterial growth identified from Room B pre-decontamination	45
Figure 4.12:	Bacterial growth identified from Rooms A and B pre-decontamination	46
Figure 4.13:	Number of bacterial growth identified post-decontamination with chlorine bleach (Room A) and with methylated spirits (Room B)	50
Figure 4.14:	Distribution of bacterial growth post-decontamination	53
Figure 4.15:	Number of bacterial growth identified post decontamination with chlorine bleach (Room A) and with methylated spirits (Room B)	54
Figure 4.16:	Reaction of <i>Staphylococcus aureus</i> to methicillin	56
Figure 4.17:	Reaction of CoNS to methicillin	56

## LIST OF TABLES

Table 1.1:	Frequency of HAIs 1995-2010	3
Table 2.1:	Geographical distribution of prevalence of nosocomial infections	8
Table 3.1:	Radiology items from Room A and B and number of swabs taken before and after decontamination	24
Table 3.2:	Template used for observing a radiographer's	27
Checklist 1:	application of infection control measures in June 2017	
Table 4.1:	Infection control measures practised by radiographers	35
Checklist 2:		
Table 4.2:	Number of samples and bacterial growth pre-decontamination	43
Table 4.3:	Equipment/Accessories and their respective bacterial growth from Room A pre-decontamination	47

Table 4.4:	Equipment/Accessories and their respective bacterial growth from Room B pre-decontamination	48
Table 4.5:	Number of samples and the number of bacterial growth post-decontamination	49
Table 4.6:	Bacterial growth from Room A post-cleaning with chlorine bleach	51
Table 4.7:	Bacterial growth from Room B post-cleaning with methylated spirits	52
Table 4.8:	Number of samples and bacterial growth	55
Table 4.9	Types of bacteria identified during the study	57

## APPENDICES

Appendix A.	Letter to the Research and Ethics Committee Letter: CPUT	82
Appendix B.	Approval from the Research and Ethics Committee: CPUT	83
Appendix C.	Letter to the Chief Executive Officer of the TH	84
Appendix D.	Approval from Scientific and Technical Committee (STC):TH	85
Appendix E.	Approval from Internal Review Board(IRB):TH	86
Appendix F.	Letter to the Radiographers in Charge of Examination Rooms	87
Appendix G.	Participants Informed Consent Form	88
Appendix H.	CARS checklist	89

## LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviations and Acronyms	Definition/Explanation
BSI	Bloodstream Infection
CARS	Credibility, Accuracy, Reasonableness and Support
CAUTI	Catheter-associated urinary tract infection
CLABSI	Central line associated bloodstream infection
CDC	Centres for disease control and prevention
CDI	Clostridium difficile infection
CoNS	Coagulase negative staphylococcus
CPUT	Cape Peninsula University of Technology
CT	Computed tomography
GI	Gastrointestinal
GITI	Gastrointestinal tract Infection
GLP	Good laboratory practises
HAIs	Hospital-acquired infections
HWS-REC	Research ethics committee of the Faculty of Health and Wellness Sciences
MRI	Magnetic resonance imaging
MRSA	Methicillin-resistant <i>Staphylococcus aureus</i>
MRSB	Methicillin-resistant <i>Staphylococcus haemolyticus</i>
PPE	Personal protective equipment

<b>SARS</b>	<b>Severe acute respiratory syndrome</b>
<b>Spp.</b>	<b>Species</b>
<b>SSI</b>	<b>Surgical site infection</b>
<b>TH</b>	<b>Teaching hospital</b>
<b>UTI</b>	<b>Urinary tract infection</b>
<b>VAP</b>	<b>Ventilator associated pneumonia</b>
<b>VRE</b>	<b>Vancomycin-Resistant Enterococcus</b>
<b>WHO</b>	<b>World Health Organisation</b>

## CHAPTER ONE

### ORIENTATION TO THE STUDY

#### 1.1 INTRODUCTION

Hospital-acquired infections (HAIs) also termed as nosocomial infections are a major challenge within the health-care environment. HAIs have resulted in increased illness and death, as well as an emerging antibiotic resistance which complicates patients' treatment (Hansen, Schwab, Zingg, Gasmeler & the PROHIBIT study group, 2018:1561). The European Centre for Disease Prevention and Control (2015) reported that annually, 4,100,000 patients in Europe acquire additional diseases during their stay in the hospital which result in 14,700 deaths. Infections acquired in the hospital are responsible for the majority of deaths in neonates from South-East Asia and Sub-Saharan Africa (World Health Organisation [WHO], 2004:1). Health-care services are affected by escalating financial burdens that are linked to increased patient morbidity and mortality resulting from HAIs (Donlan, 2008:134). The increasing bacterial resistance to antibiotics associated with HAIs has further contributed to patient morbidity and mortality (Van Kleef, Robotham, Deeny, Jit & Edmunds, 2013:9). Although investment and time are continually spent to eradicate HAIs, the problem still exists (Samuel *et al.*, 2010:115). According to Yawson and Hesse (2013:338), Sub-Saharan African countries of which Ghana forms a part, are financially incapacitated and nosocomial infections contribute to the imbalance of resources available for the management of hospitals. The limited funding impacts negatively on the ability to give attention to the allocation of resources for proper infection control measures. This increases the spread of nosocomial diseases that lead to an additional financial burden on these countries.

In the last two decades, Ghana has identified nosocomial infections as a chronic problem, which has affected the quality of care and cost to patients, health-care facilities, and the national budget. The reasons given include that health-care professionals do not comply with guidelines on disinfection, practises inadequate washing of hands, cleaning of hospital equipment and items, and other aseptic procedures due to inadequate information and understanding of infection prevention and control procedures (Ghana Ministry of Health, 2015:2). In addition to this, Allegranzi and Pittet (2008:228) noted that the developing countries suffer greater effects of HAIs because of a lack of sufficient surveillance programmes required to curb the repercussions of these infections. According to Saint, Krein and Stock (2015:2), although many publications address the identification and description of the

various types of infections and prescribed methods for prevention, health-care personnel pay little attention to the use of preventative measures for nosocomial infections. This scenario is common in developing countries like Ghana where very limited resources are available for the high volume of patient output (Tagoe, Baidoo, Dadzie, Tengey & Agede, 2011:22). According to Raka and Osmani (2012:65), a further challenge in most developing countries is the lack of adequate data and monitoring systems for HAIs such that the problem cannot be evaluated effectively.

This study evaluated the radiology equipment and accessories as potential fomites of nosocomial pathogens (microorganisms which can cause a disease), the effectiveness of two disinfectant chemicals, namely methylated spirits and chlorine bleach (sodium hypochlorite), as well as the current cleaning procedures and practises in a radiology department of a teaching hospital (TH) in Ghana.

## **1.2 Statement of the problem**

According to literature, many patients die due to nosocomial infections (Abreu, Tavares, Borges, Mergulhão & Simões, 2013:2718). It is found that 33% of nosocomial infections and as much as 92% of human life losses from hospital infections are preventable (Tagoe *et al.*, 2011:23). In spite of the dangers and monetary burden related to HAIs, Tagoe *et al.* (2011:23) observed that the Ghanaian government and hospital supervisors have not made the adequate commitment to end the menace of HAIs. According to WHO (2011), developing, low and middle-income countries have higher prevalence rates of hospital-acquired infections than high-income regions worldwide (Table 1.1). According to literature hospital staff are not committed to reduce HAIs (Saint, Krein & Stock, 2015:3). A study by Saint, Krein and Stock (2015:3) found that the total percentage staff commitment to stop the three commonest device-related infections, namely central line-associated bloodstream infection (CLABSI), ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infection (CAUTI) was between 6% and 27% for CAUTI, between 37% and 71% for CLABSI and between 45% and 55% for VAP.

**Table 1.1: Frequency of HAIs, 1995-2010 (WHO, 2011a:13-17)**

High-income countries	Percentage of HAIs	Low & middle-income countries	Percentage of HAIs
Germany	3.6%	Latvia	5.70%
Korea	3.7%	Ghana	6.7%
United States of America	4.5%	Lebanon	6.80%
Norway	5.1%	Thailand	7.30%
France	6.7%	Lithuania	9.20%
The United Kingdom	9.0%	Turkey	13.40%
Spain	8.1%	Cuba	7.3%
Cyprus	7.9%	Malaysia	13.90%
Italy	8.3%	Brazil	14.00%
Finland	9.1%	Tanzania	14.80%
Greece	9.3%	Morocco	17.80%
Scotland	9.5%	Tunisia	17.90%
Switzerland	10.1%	Mali	18.70%
Canada	11.6%	Albania	19.10%

### 1.3 Background and Rationale

Radiology is a service department within a hospital environment and therefore receives patients from various units such as wards, trauma, and outpatient clinics. The presence of in and outpatients from across the hospital increases the chance of the spread of nosocomial infections. It is noted that not all patients are at risk and that those with strong and uncompromised immune systems are not susceptible to nosocomial infections (Fox & Harvey, 2007:307; Horton & Parker, 2002:124).

The commonest type of HAIs occurring in low and middle-income countries is infection acquired at surgical sites (WHO, 2011a:3). Pre-and post-surgery patients frequently require a series of radiographic procedures and their encounter with the radiology department could result in contamination of the radiology equipment and accessories they come in contact with. According to Ochie and Ohagwu (2009:33), some radiographers fail to apply steps to control contamination of radiology equipment and accessories because there is no strict departmental monitoring of infection control practises. This can lead to cross-contamination from one patient to another.

It is noted that many developing countries, suffer a greater burden of the effects of nosocomial infections due to the lack of financial resources to acquire adequate data on controlling the impact of HAIs (Allegranzi & Pittet, 2008:22). According to Boyle and Strudwick (2010:298), the United Kingdom National Health Service spends one million pounds sterling annually on HAIs.

A study conducted in America by Chang, Sethi, Stiefel, Cadnum and Donskey (2010:608) revealed that 18% of inpatients colonised with methicillin-resistant *Staphylococcus aureus* (MRSA) polluted their surroundings with MRSA within 25 hours of admission. Another finding from a radiology facility in England by Fox and Harvey (2008:308) demonstrated that *Staphylococcus aureus*, *Escherichia coli*, *Staphylococcus epidermidis* and *Enterobacter aerogenes* were found on x-ray cassettes. The authors concluded that these pathogens have the potential for cross-infection within the radiology department. It is therefore imperative that the hospital environment, of which the radiology department forms part, consistently adopt measures to control infections. This is to guarantee the protection of health-care workers and patients against contracting any HAIs during any hospital attendance (Boyle & Strudwick, 2010:298). According to Saint, Krein and Stock (2015:2), 20 to 70 percent of all nosocomial infections are avoidable.

It was anticipated that this study could identify the types and numbers of nosocomial pathogens present on radiology equipment and accessories at the research site. In addition, there would be knowledge gained on the more effective disinfectant chemical agent to help reduce nosocomial pathogens.

#### **1.4 Research questions**

The research questions were;

- Are radiology equipment and accessories fomites of nosocomial pathogens?
- Is there a difference in the effectiveness of the two disinfectant chemical agents routinely used at the study site?
- Do radiographers apply cleaning procedures and practices in the radiology department?

#### **1.5 Research aims and objectives**

##### **1.5.1 Aims**

This study aimed to determine the extent to which radiology imaging equipment and accessories are possible fomites of nosocomial pathogens. The study also aimed at investigating the effectiveness of the disinfectant chemical agents (Sodium hypochlorite and methylated spirits) used for cleaning surfaces at the research site. Furthermore, the study aimed to observe the cleaning procedures and practices by radiographers in general radiography. These findings will be used to propose recommendations for improving infection control measures at the research site.



### **1.5.2 Objectives**

The objectives of this study were to:

- Observe current cleaning procedures and practices in a radiology department.
- Determine types and number of nosocomial pathogens present on selected radiology equipment and accessories before decontamination.
- Ascertain the presence of nosocomial pathogens following decontamination of selected radiology equipment and accessories with one of two preferred departmental disinfectant chemical agents.
- Compare the effectiveness of the two cleaning agents.

### **1.5.3 Significance of the research**

Literature searches revealed that no study of this kind has been done at the study site. Identifying the types and number of nosocomial pathogens in this department could contribute to the reduction in nosocomial infections by raising awareness of radiographers on how to reduce cross-contamination as well as the importance thereof. The identification of the more effective disinfectant chemical agent could facilitate the purchase of an appropriate chemical agent. The need exists for more studies on infection control to guide radiographers throughout their practises. The application of established infection control policies helps protect patients and health-care professionals (Ehrlich & Daly, 2009:140). This study anticipated that the outcome might influence the application of policies on infection control by health-care practitioners and might assist hospital administrators in the reduction of nosocomial infections. The development and implementation of infection control measures or policies at the proposed research site could be improved through this research.

## **1.6 Conclusion**

This chapter introduced the study, presented the statement of the problem, explained the background and rationale of the study, stated the research questions, the aims and the objectives and the significance of the research.

Nosocomial or hospital-acquired infections, main types of nosocomial pathogens, common types of nosocomial infections, pathogens found on radiology equipment and accessories, modes of transmission and prevention of transfer, decontamination and cleaning will be discussed under literature review in the next chapter.

## CHAPTER TWO

### REVIEW OF LITERATURE

#### 2.1 Introduction

Reviewing literature entails identifying, recording and transmitting information on quantitative and qualitative data to highlight what is already known and unknown on a particular topic of research interest (Onwuegbuzie & Frels, 2016:3).

This chapter discusses the following: The burden of nosocomial or hospital-acquired infections, the types of microorganisms and infections found in the hospital, microorganisms found on radiology equipment and accessories, modes of transmission of infection, and decontamination of radiology equipment and accessories. The selection and evaluation criteria used to find the resources for this literature review were adapted from the CARS (Credibility, Accuracy, Reasonableness and Support) checklist (McGraw-Hill Higher Education, 2003:1) (Appendix H). Only peer-reviewed medical research journal articles were included. The results presented by authors were applicable to this study.

#### 2.2 Nosocomial or hospital-acquired infections

The World Health Organisation (WHO, 2002a:1) defines a nosocomial infection as “an infection occurring in a patient in a hospital or other health-care facility in whom the infection was not present or incubating at the time of admission. This includes infections acquired in the hospital but appearing after discharge and also occupational infections amongst staff of the facility”.

Humans frequently encounter different types of microorganisms (microbes) and serve as hosts for microbes such as bacteria, viruses, fungi and protozoa (Turgeon, 2012:459-460). These microbes increase while in their host. Infection occurs when the immune system of the host reacts by activating different mechanisms to control the microbe invasion. These microbes which can cause infectious diseases are now called pathogens (Muehlenbein, 2015:417). The nature of the pathogens' resistance to antimicrobial agents, the inherent virulence and the number present on objects can influence whether infections to patients will occur or not (Muehlenbein, 2015:417).

Nosocomial cross-infection gained scientific attention during the mid-18th century and from that era until the commencement of the study of bacteria a considerable number of the most acclaimed commitments began in Scotland (Forder, 2007:1161). Later in 1858 to the end of the nineteenth century, the research of Florence Nightingale, and

disclosures of Pasteur, Koch and Lister advertised the case for medical clinic change (Forder, 2007:1161). This transformation and discoveries in the health-care environment were highly appraised to end nosocomial cross-infection. However, Forder (2007:1161) noted that the conquest to eradicate nosocomial cross-infection decreased when it was appreciated that infections did not only occur in obstetric and surgical patients, but also in medical patients.

Hospital-acquired infections are a major challenge within the health-care environment. This is because although investment and time are continually spent on the eradication of HAIs, the problem still exists (Samuel *et al.*, 2010:102; Tugwell & Maddison, 2010:115). Regardless of the intense effort and attempts to curb the transfer of nosocomial infection, the Centers for Disease Control and Prevention (CDC) (2017:6) noted that one out of 25 hospitalised patients in the United States of America can be affected by a nosocomial infection daily. However, research has established that the burden of nosocomial infections can still be reduced by more than 70 percent if health-care professionals are aware of the effects of infections and take definite preventive steps (CDC, 2017:6). Nosocomial infection is the fourth principal cause of disease and poses a major challenge in health-care (Guggenbichler, Assadian, Boeswald & Kramer, 2011:1).

MRSA is the major pathogen accountable for infections in the hospital and health-care facilities. Its occurrence has gradually grown to being a global pandemic. Although there are a series of measures to control its transmission, countless incidence of MRSA has led to high mortality rates in various parts of the world (Alvarez, Labarca & Salles, 2010:109). *Clostridium difficile* which causes the majority of nosocomial diarrhoea was evaluated to cost the United States of America three billion dollars annually (McGlone *et al.*, 2012:4). The European Centre for Disease Prevention and Control (2015) reported that annually, 4,100,000 patients in Europe contract additional diseases during their stay in the hospital resulting in 14,700 deaths. The United States of America in the year 2002 recorded 1.7 million incidences of infections acquired in the hospital contributing to 98,987 deaths (Klevens *et al.*, 2007:160). A report by the WHO (2004:1) indicated that infections acquired in hospitals are responsible for 75% of the cause of death in hospital-born babies in South-East Asia and Sub-Saharan Africa. Although much is known about the microorganisms that cause nosocomial infections, it was revealed that the traditional solutions (cleaning, scrubbing, disinfecting, sterilising and other procedural control) have not eliminated the problem (Kowalski, 2012:1). This has led to the loss of lives and patients having to stay in the

hospital for longer which increases the health-care burden (patient numbers and cost). According to Boyle and Strudwick (2010:298), the United Kingdom National Health Service spends one million pounds sterling annually on hospital-acquired infections.

The burden of nosocomial infections is widely distributed among African countries. Most countries, particularly within the Sub-Saharan African region encounter the highest prevalence of nosocomial infections ranging from 2.5%-14% (Nejad, Allegranzi, Syed & Ellis, 2011:757). The prevalence rate of nosocomial infections in Ghana and Mali is 6.7% and 9.6-18.7% respectively (Mbim, Mbotto & Agbo, 2016:3). The Democratic Republic of Congo and Burundi recorded prevalence rates of 1.7% and 10.4% respectively (Chu, Maine & Trelles, 2014:1169). The individual distribution of nosocomial infections in Sub-Saharan countries are outlined in Table 2.1.

**Table 2.1 Geographical distribution of prevalence of nosocomial infections (Mbim, Mbotto & Agbo, 2016:4)**

The prevalence rate of nosocomial infections			
	1-10%	11-20%	21% and above
Sub-Saharan Countries	Burkina Faso	Botswanan	Sierra Leone
	Ghana	Mozambique	Ivory Coast
	Benin	Ethiopia	Nigeria
	Cameroon	Liberia	Chad
	Gabon	Guinea	Sudan
	Congo DRC	Gambia	Uganda
	Kenya	Senegal	Zambia
	Rwanda		Zimbabwe
	Burundi		South Africa
	Tanzania		
	Malawi		
	Madagascar		
	Namibia		
	Mali		

Nosocomial infections contribute to the imbalance between resources for the management of patients. This is common in developing countries like Ghana where very limited resources are available for the high volume of patient output (Tagoe *et al.*, 2011:22). Of late, Ghana has identified nosocomial infections as a chronic problem, which has affected the quality of care and cost to patients, health-care facilities and government. Many patients die due to nosocomial infections and it is considered that one out of ten hospitalised patients, at any specified period would be affected by not less than one health-care-associated infection in Ghana (WHO, 2011b). Angola has the highest nosocomial prevalence of MRSA in Africa (Conceição, Coelho, Santos, de Lencastre & Aires-de-Sousa, 2016:22). A prevalence survey of nosocomial infections in a tertiary-care hospital in Accra, Ghana revealed that out of the 907 patients on

admission (24 hours after admission), 61 (6.7%) had hospital-acquired infections (Newman, 2009:302). However, hospitals within high-income countries have managed to prevent infection through resourceful surveillance programmes, improved practical steps for infection prevention and constant training (Doll, Hewlett & Bearman, 2016:8). On the contrary, some of the higher-income countries still have similar prevalence rates of HAIs than those of the lower-income countries (Table 1.1).

A hospital encounters a varied proportion of individuals including the paediatric, geriatric and immuno-suppressed. Many of these individuals are susceptible hosts for nosocomial pathogens and are more prone to HAIs (Wolfe, 2018:8). Nosocomial pathogens and by extension the resulting infectious diseases can complicate and prolong hospital stays.

Currently, such nosocomial infections are the foremost frequent complications affecting hospitalised patients. HAIs, particularly the ones involving resistant microorganisms, represent one of the difficult complications to contemporary medicine (Cox, Burahee, Lucier, Fernando & Mugambi, 2016:494). While antibiotics can treat most nosocomial infections, the strains that are antibiotic resistant, such as methicillin-resistant *Staphylococcus aureus* (MRSA) present serious health-care complications (Orellana *et al.*, 2016:184). Zhang and Burbridge (2011:1155) noted that in the United States MRSA accounts for 49.9 to 63% of inpatient *Staphylococcus aureus* infections.

Numerous inpatients and outpatients visit radiology departments each day. This allows for several items in the diagnostic radiology department to serve as reservoirs and transmitters of nosocomial pathogens from one individual to another.

### **2.3 Main types of nosocomial pathogens**

Bacteria, viruses and fungal parasites are the pathogens responsible for HAIs. These HAIs are typically associated with gram-positive bacteria like methicillin-resistant *Staphylococcus aureus*, *Coagulase Negative staphylococci* and *Glycopeptide resistant Enterococci* species and gram-negative bacteria like *Escherichia coli*, *Haemophilus influenza*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* (Foley, Chen, Simjee & Zervos, 2011:4). The number of these nosocomial pathogens varies depending on different patient populations, medical facilities and even difference in the health-care surroundings (Khan, Baig & Mehboob, 2017:479). Bacteria are the most common pathogens responsible for more than 50% of nosocomial infections. *Staphylococcus aureus*, *Citrobacter* species (spp), *Coliform* spp. *Coagulase Negative Staphylococci*, *Enterococcus* spp., *Escherichia coli*, *Enterobacteriaceae*,

*Pseudomonas* spp., *Acinetobacter* spp., *Candida* spp., *Klebsiella* spp., *Streptococci*, *Providencia rettgeri*, *Salmonella* Paratyphi A, *Salmonella* Typhi, and *Shigella* spp. are examples of bacteria associated with nosocomial infections (New York State: Department of Health, 2014:30).

Viruses are responsible for 5% of all nosocomial infections (Khan, Baig & Mehboob, 2017:479). Hepatitis A, B and C viruses, influenza, human immunodeficiency virus, rotavirus, and herpes-simplex virus I and II are responsible for some of the viral nosocomial infections (CDC, 2016). Fungal parasites behave as opportunistic pathogens causing nosocomial infections in immune-compromised individuals (Aitken & Jeffries, 2001:529). *Aspergillus* spp., *Candida albicans* and *Cryptococcus neoformans* are types of nosocomial fungal parasites (Sydnor & Perl, 2011:153; Duce & Nicolle, 2002:7). A study by Weber and Rutala (2013:31-35) revealed that contaminated environmental surfaces in hospitals significantly contribute to the transmission of numerous major health-care-associated pathogens, including MRSA, Vancomycin-resistant (VRE) species, *Clostridium difficile*, *Acinetobacter* species and *Norovirus*.

## **2.4 Common types of nosocomial infections**

In Europe it was estimated that 3.2 million patients acquire HAIs in acute care hospitals annually. The most common types of HAIs are surgical site infections (SSIs), urinary tract infections (UTIs), pneumonia, bloodstream infections (BSIs) and gastrointestinal tract infections (GITIs), with *clostridium difficile* infections (CDIs) accounting for a high proportion presently (European Centre for Disease Prevention and Control, 2013).

UTIs are the most common healthcare-associated group of bacterial infections affecting both in and out patients in Africa (Suwangool, 2012:102; Ozumba, 2005:108). Numerous studies conducted in Ghana and Nigeria recorded the prevalence rates of UTI as 31.6% at the Ghana Police Hospital Laboratory, 50.4% at Cape Coast, Ghana and 86.6% at Benin City, Nigeria (Lutterodt, Afriyie, Asare, Amponsah, Abutiare & Darko, 2014:310; Boye, *et al.*, 2012:76).

SSIs are the second most common type of nosocomial infections affecting 2%–5% of patients who underwent surgery. These infections are mainly caused by MRSA resulting in extended hospital stays and a threat of death (Anderson, 2011:137). A retrospective study conducted in a tertiary hospital in Ghana identified that 39% of patients who underwent surgery acquired surgical site wound infection (Apanga, Adda, Issahaku, Amofa, Mawufemor & Bugr, 2014:207).

The most common types of nosocomial infections, especially in the intensive care units, include central line associated bloodstream infections, catheter-associated urinary tract infections, surgical site infections and ventilator-associated pneumonia (Sydnor & Perl, 2011:150). Central line-associated bloodstream infection (CLABSI) is a deadly nosocomial infection. CLABSI causes 12%–25% nosocomial deaths in the United States of America (CDC, 2011:448). Ventilator-associated pneumonia (VAP) is nosocomial pneumonia found in 9–27% of patients on mechanically assisted ventilators. It normally emerges within two days after tracheal intubation (Hunter, 2012:40). According to Steven and Koenig (2006:637), 86% of nosocomial pneumonia is associated with ventilation. It is the major nosocomial infection that prolongs patients' stay at the intensive care unit and causes 9% of deaths (Melsen, Rovers, Koeman & Bonten, 2011:40).

## **2.5 Pathogens found on radiology equipment and accessories**

A radiology department provides a service to patients from various units within the hospital such as wards, trauma, and orthopaedic units and clinics such as paediatric, geriatric and chest units. It is documented that the radiology department facilitates the transferral of various health-care associated pathogens including *Vancomycin*-resistant *enterococci* (VRE), *Clostridium difficile*, *Acinetobacter* species, MRSA and *Norovirus* (Dancer, 2014:665-690). Tohidnia, Dezfolimanesh and Almasi (2012:273) confirmed the presence of a significant number of *Coagulase Negative Staphylococcus*, *Escherichia coli* and *Pseudomonas aeruginosa* on radiology equipment and accessories. This contributes to the spread of nosocomial infections.

Numerous studies have confirmed that equipment and accessories within the radiology department are potential fomites for nosocomial pathogens. A study by Fox and Harvey (2007:310) conducted in the radiology department of a hospital in England revealed that *Staphylococcus aureus*, *Coagulase Negative Staphylococcus*, *Micrococci*, *Diphtheroids* and species of *Bacillus* were present on x-ray cassettes, as well as *Escherichia coli*, *Staphylococcus epidermis*, and *Enterobacter aerogenes*. The authors concluded that these pathogens have the potential for cross infection within the radiology department. Dancer, Stewart, Coulombe and Viridi (2012:236) noted that *Staphylococci*, *Coliform* bacteria, and moulds are capable of contaminating the surfaces of diagnostic radiology equipment such as erect Buckys and x-ray tables.

According to Kim *et al.* (2012:206), x-ray cassettes are easily contaminated with MRSA and methicillin-resistant *Staphylococcus haemolyticus* (MRSH). The authors noted that contaminated lead aprons and x-ray cassettes might serve as fomites of

methicillin-resistant *Staphylococci*. Similarly, Eze, Chiegwu and Okeji (2013:1407) indicated that cassettes were contaminated with *Coagulase Negative Staphylococci*; *Staphylococcus aureus* and MRSA. Results from a study by Tugwell and Maddison (2010:119) confirmed that anatomical markers used in radiography serve as fomites for nosocomial pathogens and contaminated with *Staphylococcus* and *Bacillus* species.

In and outpatients sharing the same space can contribute to an increased chance of the transfer of nosocomial infections. According to Ochie and Ohagwu (2009:33) some radiographers fail to apply infection control measures on radiology equipment and accessories because there is no strict departmental monitoring of infection control practises.

## **2.6 Modes of transmission and prevention of transfer**

According to Mirza, *et al.* (2015:1232) clients and health-care workers are exposed to pathogenic organisms. Environmental contamination may occur when the infected patients visit the radiology department. This may happen in patients' waiting areas, in examination rooms, on the surface of equipment, and accessories. Eisenberg (2004:228) noted that radiographers who have acquired transmissible infections should not perform radiographic procedures such as biopsies, angiography, and other interventional procedures to avoid the spread of nosocomial infections. Pathogens responsible for HAIs are frequently spread by cross-contamination. The principal sources are infectious patients, patients with illnesses, and the hands of service providers. Be that as it may, numerous studies point to conceivable environmental sources in the support and spread of pathogens that increases the probability for hospitalised patients to contract HAIs (Viana, Santos & Oliveira, 2016:465-469).

The dangers of developing HAIs cannot be overruled when full knowledge on the mode of transmission is not realised. Modes of transmission are the mechanisms that infectious organisms adopt to ensure that the cycle of infection is not broken (Shanson, 2014:504). According to Mirza *et al.* (2015:1232), direct and indirect contact, are the main modes of infection transfer within the radiology department. Infections can be transmitted through direct modes where pathogens spread directly from one human host to another and indirect modes that require a transitional host or agent to enable the spread of pathogens between human hosts (Merrill, 2013:10-11). Radiology equipment and accessories may serve as fomites that can harbour infectious organisms and are capable of being an indirect mode of infection transmission (Ochie & Ohagwu, 2009:33). Indirect transmission occurs when intermediate objects such as



x-ray cassettes and radiographic anatomical markers carry infectious or contaminated agents from a source to a susceptible host (Abubakar, Stagg, Cohen & Rodrigues, 2016:11).

According to Tugwell and Maddison (2010:116) among the most well-known items handled in the radiology department are the anatomical markers. They are utilised with each patient and are kept in the radiographers' pockets, when not used. The authors noticed that radiographers ignore the capability of these accessories to turn into fomites for cross-contamination, therefore they never or infrequently clean them. The lead apron when contaminated by radiographers or when hung up for a long time without routine decontamination also transmits infectious organisms (Chingarande & Chidakwa, 2014:21). Campeau and Fleitz (2010:85) referred to the hands of the radiographer as a limited tool used regularly for positioning of the patient, preparing the examination room, and handling of cassettes, anatomical markers and lead aprons. They expose their hands to infectious organisms, which may contaminate imaging equipment and accessories. The most significant and effective method to prevent infection within the health-care setting including the radiology department is the appropriate application of hand hygiene by radiographers. Hand hygiene is applied when the hands are washed with soap and water before and after contact with patients, visitors or their environment, before invasive or aseptic procedures and after contact with body fluids (Ontario Agency for Health Protection and Promotion, 2014:9). Alcohol-based hand disinfectants are agents that when used within 15 to 30 seconds to kill transient organisms on the hands may have an additional antimicrobial effect on resident microflora. Hand disinfectants such as hexachlorophene, iodophors, and chlorhexidine are more effective than alcohol-based agents due to prolonged residual activity with repeated use. These agents can terminate both the existing transient bacteria and *Staphylococcus aureus* which contaminate the hands (Todd, Michaels, Holah, Smith, Greig & Bartleson, 2010:2129). Hussein, Mavalankar, Sharma and D'Ambruso (2011:3) noted that alcohol-based antiseptics are more convenient than the use of soap and water and readily available at places with limited access to potable water.

Certain practises such as covering the x-ray cassettes with disposable plastic bags and placing anatomical markers on cassettes instead of on patients help prevent transmission of infection through direct contact (Zhang & Burbridge, 2011:1157).

Hospitals must adopt standard precaution practices to curb infections. These standard precaution practises are the basic requirements for the control of infection areas prone

to infection transmission and are designed for the protection of both patients and health-care professionals. Standard precautions entail hand washing, use of appropriate personal protective equipment (PPE) such as gloves to protect the hands, gowns or aprons to protect the skin, goggles to protect the eyes, and face shields to protect the entire face, use of aseptic techniques to eliminate patient contact to microorganisms, immunisation of health-care workers, regular environmental cleaning and proper handling of sharps, blood spills, linen and waste to maintain a safe working area (Timilshina, Ansari & Dayal, 2011:8).

## **2.7 Decontamination and cleaning**

Ineffective cleaning of hospital surfaces, rooms, instruments and accessories has resulted in the existence of a considerable number of HAIs. The fast-adaptive nature of microorganisms to multi-drug resistance has resulted in a situation where a majority of compounds intended to prevent or destroy the infectious agents have failed to serve this purpose (Abreu *et al.*, 2013:2718). According to Campeau and Fleitz (2010:85) infections can be controlled by asepsis, disinfection and surgical asepsis.

The purpose of asepsis is to decrease the rate of multiplication, growth and the spread of microorganisms. These could be achieved through appropriate washing of hands and radiology equipment and accessories (White, Ducan & Baumle, 2014:451-452).

The aim of disinfection (decontamination) is to eliminate or terminate microorganisms from hospital equipment by using antimicrobials (McDonnell & Sheard, 2012:8). This keeps them from achieving adequate amounts in defenceless destinations which generally could prompt microorganism transmission to patients or health-care workers (Solon & Killeen, 2015:527). Hospital equipment and accessories that are potential fomites requires appropriate decontamination to avoid the danger of transmission. Inadequate decontamination of diagnostic radiology equipment and accessories may facilitate pathogens transmission (Walker, 2014:3). The radiology department, equipment, and accessories (x-ray table, cassettes, lead aprons, erect Buckys and anatomical markers) must therefore be decontaminated to eliminate microorganisms (Campeau & Fleitz, 2010:87).

According to Nagaraja (2011:4) sterilisation or surgical asepsis is the utilisation of physical or compound techniques to terminate all microbial survival, including viruses, bacteria, and fungi. Lerouge and Simmons (2012:3) refer to sterilisation as the act of destroying all forms of pathogens. This means disinfection does not have the same

level of decontamination as sterilisation and does not necessarily make all forms of microbes inactive.

Recently, in many hospitals, alcohol-based gels have been introduced for hand asepsis because of their superior antimicrobial efficacy and fast action, ease of use, and good skin tolerance level (Suchomel, Kundi, Pittet, Weinlich & Rotter, 2012:328-331). The World Health Organisation recommended the use of alcohol-based hand rubs for both hygienic and pre-surgical hand treatments to decrease the spread of pathogens through the hands of health-care workers and to lessen the menace of HAIs (WHO, 2009a). Hospitals use many different chemical agents to eliminate or reduce the effects of microorganisms.

Originally, intended as a bleaching agent, hypochlorite solutions and bleaching powders (chlorine formed from the sodium hypochlorite compound) were useful disinfecting agents (Walker, 2014:35). Iodine in an alcoholic solution (tincture) was also widely used as an antiseptic. It later became less popular because of its stinging and staining side effects (Walker, 2014:35). However, povidone-iodine (a form of iodophor) remains one of the most commonly used antiseptics which is active against gram-positive and gram-negative organisms, yeast, fungi and protozoa (Schachner & Hansen, 2011:214).

X-ray cassettes, anatomical markers and lead aprons can be disinfected with lemon-based disinfectants, alcohol-based chemicals (70% ethanol) and diluted bleach (Kim *et al.*, 2012:20; Ehrlich & Coakes, 2013:85; Chingarande & Chidakwa, 2014:21). Hospec (Alcohol, Ethoxylated, Sulphates, Sodium salts) a general-purpose neutral liquid detergent significantly removed *Coagulase Negative staphylococci*, *Staphylococcus aureus*, *Bacillus*, *Diphtheroids* and certain fungal spores from radiological equipment and accessories (Boyle & Strudwick 2010:297-303). Furthermore, cleaning with a detergent and water eliminated a substantial number of microorganisms. According to Silva, Martins, Medici-Filho, Moraes, Castilho and Jorge (2004:15-21) disinfection of instruments and equipment with alcoholic chlorhexidine solution (70% ethyl alcohol with 5% chlorhexidine) was effective in removing nosocomial pathogens. Ochie and Ohagwu (2009:31-35) suggested the use of chemical disinfectant agents such as chloroxylenol, dichloroxylenol, sodium hypochlorite and methylated spirits. The authors noted that the most effective chemical disinfectant agent was sodium hypochlorite and that it has been a preferred choice due to its fast microbiocidal activity, cost-effectiveness and efficacy (Rutala &

Weber,1997:607). However, it was also found that sodium hypochlorite can form carcinogenic compounds and that some pathogens have become resistant to it.

Studies have shown that quaternary ammonium (quat), iodine, alcohol, aldehyde, organic acid, peroxide, and halogenated compounds have demonstrated activity against a wide variety of microorganisms (Boothe, 2012:429).

There are however some important factors to consider regarding the cleaning of radiology equipment and accessories. Radiology equipment has irregular surfaces and body parts. Furthermore, the non-uniform nature of the equipment and accessories can make them cumbersome to disinfect (Mollura, Palmore, Folio & Bluemke, 2015:541). The electrical parts of equipment must also be protected against moisture. Disinfectants must be harmless, simple to utilise and powerful against various types of pathogenic microorganisms and ought to have no form of toxicity (Hirai, 1991:195). Formaldehyde vapour used for disinfecting laboratory safety cabinets and the rooms of patients with transmissible infections in the past was proven to be toxic and unsafe for sterilising room surfaces (Kowalski, 2012:135).

Regardless of tests' proof proposing that a reasonable utilisation of disinfectants is recommended, their use and application methods are however questionable. However, appropriate cleaning is prescribed by every single universal rule, as a precaution for anticipating diseases and extensive proof exists concerning the advantages of emergency clinic tidiness towards lessening HAIs. In reality, the inability to guarantee appropriate cleaning or disinfection may prompt the spread of pathogens from patient-to-patient.

## **2.8 Conclusion**

According to the literature reviewed the radiology department facilitates the transferral of various health-care associated pathogens (Dancer, 2014:665-690). Ideally radiology equipment and accessories should be pathogen-free because the presence of any number of pathogens is sufficient to cause a significant threat to immunosuppressed patients and overworked health-care workers. It has been proven that the most significant and effective method to prevent infection within the radiology department is the appropriate application of hand hygiene by radiographers. According to WHO (2011), developing, low and middle-income countries have higher prevalence rates of HAIs than high-income regions worldwide. However, some of the higher-income countries still have similar prevalence rates of HAIs than those of the

lower-income countries. The findings of this research study will therefore be used to propose recommendations for improving infection control measures at the site.

The next chapter discusses the methodology used in this study. The population, sampling techniques, data collection, and statistical analysis are highlighted. The chapter ends with a discussion of issues relating to the ethical considerations for the study.

## CHAPTER THREE

### RESEARCH DESIGN AND METHODOLOGY

#### 3.1 Introduction

This chapter describes the research focus, research design and methodology used in the study. The population, sampling techniques, data collection and statistical analysis are highlighted. The chapter ends with a discussion of issues related to the ethical considerations of the study.

#### 3.2 Research questions

The research questions were:

- Are radiology equipment and accessories fomites of nosocomial pathogens?
- Is there a difference in the effectiveness of the two disinfectant chemical agents routinely used at the study site?
- Do radiographers apply cleaning procedures and practices in the radiology department?

#### 3.3 Research aims and objectives

##### 3.3.1 Aims

The study aimed to determine whether radiology equipment and accessories for general radiography are possible fomites of nosocomial pathogens. The study also investigated the effectiveness of the disinfectant chemical agents (sodium hypochlorite and methylated spirits) used for cleaning surfaces at the research site. Additionally, the study aimed to observe the cleaning procedures and practises by radiographers in general radiography.

##### 3.3.2 Objectives

The objectives of this study were to:

- Observe the current cleaning procedures and practices in a radiology department.
- Determine the types and number of nosocomial pathogens present on selected radiology equipment and accessories before decontamination.
- Ascertain the presence of nosocomial pathogens following decontamination of selected radiology equipment and accessories with one of two preferred departmental disinfectant chemical agents.
- Compare the effectiveness of the two cleaning agents.

### **3.4 Study focus**

This research focused on the identification of the two groups of bacteria namely the gram-negative and gram-positive. The reasons for focusing on these groups of bacteria are that the gram-negative bacteria are responsible for 30% of HAIs while gram-positive bacteria cause approximately 50% of bacterial infections which are not easily treated because of their resistance to antibacterial agents (Peleg & Hooper, 2010:1-2; Corey, 2009:254; Sakorafas & Tsiotou, 2005:28). The outer surfaces of the selected items were swabbed. The reason for swabbing the outer surfaces of items was that they might serve as fomites for transmission of pathogens based on their frequent contact with patients and radiographers (Tagoe *et al.*, 2011:23). Examination rooms for computed tomography (CT), magnetic resonance Imaging (MRI) ultrasound and interventional procedures such as angiography were excluded from this study. This was decided because this study aimed to determine whether radiology equipment and accessories for general radiography are possible fomites of nosocomial pathogens. Furthermore, the effectiveness of the two disinfectants were compared therefore similar general radiography rooms, using the same type of equipment and accessories, were selected.

### **3.5 Research design**

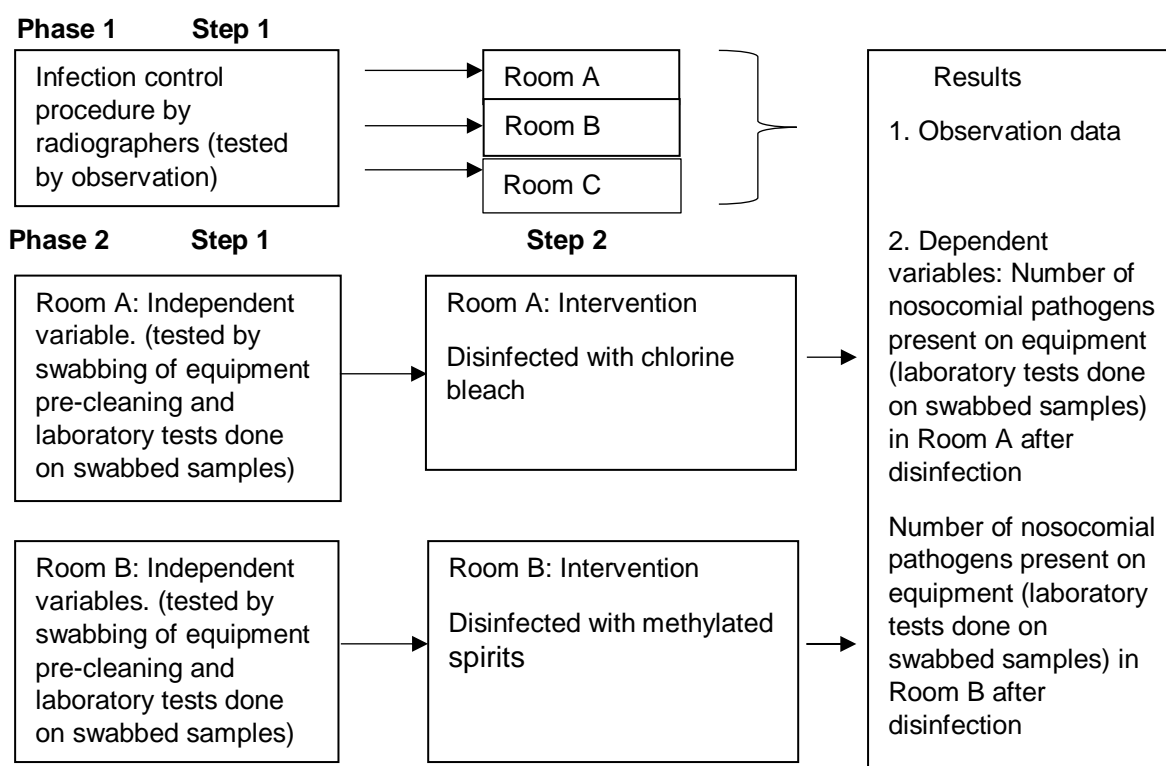
A quantitative inquiry with a prospective observational and experimental approach, based on the positivist paradigm as guide, was deemed an appropriate design to achieve the objectives of this study. The researcher conducted the study within the positivist paradigm (Plooy- Cilliers, 2014:24). The positivist paradigm directed that the results for this study can only be obtained through observation and experiment. Ontologically, the researcher conducted the study objectively and independent of external influence. Epistemologically, only observable phenomena through the experimental process undertaken during the study provided credible data. Axiologically, the researcher was independent of the data and strived to uphold the integrity of the data.

The study was conducted prospectively in a clinical radiology department at a TH in Accra, Ghana. The research project included an observational study of practices designed to investigate infection control measures by radiographers and an in vitro (laboratory) experimental design. The observational phase would give possible descriptions of how radiographers practised infection control measures during work. The experimental phase would help identify the number and type of pathogens present on the equipment and accessories (before and after cleaning). The findings of the

observational phase and experimental phase could lead to suggestions for improving infection control measures in the department/study site. The equipment and accessories were swabbed, followed by laboratory tests done pre-cleaning, as well as post-cleaning. Numerical data were obtained in this study for the experimental and observational phases. Quantitative research establishes the difference between variables using an appropriate instrument. The numerical data obtained were quantified and analysed using descriptive and comparative inferential methods (Creswell, 2014:4).

In the experimental component, quantitative data were generated through the measuring of possible bacterial activity on the selected radiology equipment and accessories.

The conceptual framework shown in figure 3.1 is a diagrammatic representation of the flow of activities during the data collection.



**Figure 3.1: Conceptual framework. A research study to investigate the relationships between the variables.**

The independent variables referred to nosocomial pathogens identified on the selected items pre-cleaning the selected items. This presents the true state of the items before the introduction of an intervention that is cleaning with methylated spirits or chlorine bleach. Nosocomial pathogens identified were dependent on the effectiveness of the disinfectant used to clean the items. Nosocomial pathogens



identified pre and post-cleaning the items were independent and dependent variables respectively considered for this study.

### **3.6 Study site and sampling**

#### **3.6.1 Study site**

The site for the study was the radiology department of TH in Ghana. The hospital has approximately 2,000 beds with a daily attendance of 1,500 out-patients and 250 new admissions. According to general knowledge in the health sector, it is one of the largest hospitals in Africa and a leading referral centre for Ghana (Figure 3.2). The radiology department has eight general examination rooms for conventional radiography, computed tomography (CT), magnetic resonance imaging (MRI), mammography, fluoroscopy and ultrasound units. Furthermore, the hospital serves as a referral hospital for the neighbouring countries (Figure 3.3) Cote d'Ivoire, Burkina Faso and Togo due to its reputable national centre for radiotherapy and nuclear medicine and the advanced radiology imaging centre. Many of the patients attending the hospital are referred to the radiology department for diagnostic procedures. This department performs approximately 227,500 conventional and interventional radiographic procedures annually (Teaching hospital, 2016). The staff consists of twenty-five radiographers in addition to radiologists and other clinical and non-clinical staff in the department.

A research population is an entire element or group with a common set of characteristics of interest, selected for a scientific inquiry (Hair-Jr., Celsi, Money, Samouel & Page, 2011:165). The population consists of the radiology equipment and accessories of the eight (N=8) conventional general radiology rooms and 25 (N=25) radiographers.



Figure 3.2: Map of Ghana showing the location the TH (Easy Tract Ghana, 2019).



Figure 3.3: Geographical location of Ghana displaying the neighbouring nations: Cote d'Ivoire (left), Burkina Faso (top), Togo (right) with Ghana in the centre (Easy Tract Ghana, 2019)

### 3.6.2 *Sampling*

Sampling is an act of selecting objects/subjects that are representative of the population of interest for observation and analysis (Bhattacharjee, 2012:65). The sample considered was the selected radiology equipment and accessories (Table 3.1, Figure 3.4 and 3.5) from two out of the eight ( $n=2/8$ ) general radiology rooms (Room 5 and Room 6) which were named Room A and B respectively for the purpose of this study. Purposive sampling is a non-probability sampling where a researcher deliberately selects a particular group that is available and presents the information to satisfy the objectives and aim of the study in order to answer the research questions (Pascoe, 2014:142). A purposive sampling method was used in this study to select two examination rooms from the eight examination rooms in the radiology department for the experimental phase. Only three of the department's eight general radiology rooms were functioning of which two examination rooms were selected because of the high turnover of patients being examined there. It was anticipated that cross-contamination is most likely to occur in them. These two main general examination rooms were used for outpatients, ward patients, accident and emergency cases. Furthermore, these two rooms possessing identical equipment and accessories were also selected for comparing the effectiveness of the two detergents. The radiology equipment and accessories selected and swabbed from each room are listed in Table 3.1.

In addition, seven out of 25 ( $n=7/25$ ) radiographers from three rooms (including Room A and B) used for conventional general radiography were conveniently selected and were observed for their routine hand washing and cleaning procedures of radiology equipment and accessories. These radiographers were selected because they were working at the only functioning general radiology rooms during the study's data collection period. Radiographers working at an extra general radiology room C were added to increase the sample size for the observational phase as a large sample size gives a more accurate estimate of the effect size and an easier assessment of the representativeness of the sample and the generalisation of the study results (Roessner, 2014:1003).

**Table 3.1: Radiology items from Rooms A and B and number of swabs taken before and after decontamination**

Equipment/ Accessories	Number of swabs Room A (before decontamination)	Number of swabs Room B (before decontamination)	Number of swabs Room A (after using chlorine bleach)	Number of swabs Room B (after using methylated spirits)
Exposure button	2	2	2	2
Horizontal Bucky surface*	4	4	4	4
Cassette 35cm x43cm	3	3	3	3
24cm x 30cm	3	3	3	3
Control button	2	2	2	2
Door handles	2	2	2	2
Erect Bucky surface	3	3	3	3
Erect Bucky handle	2	2	2	2
Lead apron	3	3	3	3
Tube head handles	2	2	2	2
Tube head collimators	2	2	2	2
Horizontal Bucky handle	2	2	2	2
Horizontal Bucky knobs	2	2	2	2
Total swabs	32	32	32	32
Total	128			

\*Horizontal Bucky surface refers to the surface of the table top

Simple random sampling was employed to select two x-ray cassettes from each of the two selected examination rooms. Considering the small number of cassettes in the department, cassette identity numbers were written on paper slips and were concealed in a box. The intended cassettes for the study were drawn from the box (Pascoe, 2014:138). This gave an unbiased and equal chance to every diagnostic radiology cassette for possible selection into the study (Berg & Latin, 2004:70). The door handles, although not part of the radiology equipment and accessories, were also swabbed. This was because they are touched by patients, radiographers and others, and could be fomites of nosocomial pathogens. A total of 128 (n=128) swabs were taken over four weeks (Table 3.1). Thirty-two swabs were taken from each room in the morning just before the equipment and accessories were used (pre-decontamination). Thirty-two (n=32) swabs were again taken per room after cleaning with one chemical disinfectant agent (post-decontamination).

Chlorine bleach (sodium hypochlorite) or methylated spirits was used in a particular room. The chlorine dilution was 1:10. This solution was prepared by adding one

volume of the chlorine bleach (1 litre) to nine volumes of clean water (9 litres). Methylated spirits 95/5, or denatured alcohol, is a mixture of ethyl (95%) and methyl alcohols (5%). The names of the chemical agents were written on paper slips containing names and concealed in a box. Staff from Room A were asked to pick from the box. The name of the chemical agent picked was then assigned to that specific room and the other cleaning agent was assigned to Room B.



**Figure 3.4: Equipment setup. A= Horizontal Bucky surface (table top surface), B= Tube head handles, C= Erect Bucky handle, D=Tube head collimators, E= Horizontal Bucky handle, F= Erect Bucky surface, G= Horizontal Bucky knobs.**



**Figure 3.5: Control panel comprising of control buttons and exposure button (A)**

### **3.7 Data collection procedures**

Data collection is the use of appropriate research tools/instruments to gather information for meaningful analyses and interpretation (Hancock & Algozzine, 2017:9). Data for phase 1 of the study were collected by observing how radiographers routinely practiced hand washing, clean radiology equipment and accessories. Data for phase 2 (step 1 and step 2) were collected by swabbing of equipment and accessories before and after cleaning, followed by laboratory testing for pathogens (Figure 3.1).

#### **3.7.1 *Observation of cleaning procedures***

Observation of the routine cleaning procedures of the radiology equipment and accessories preceded the swabbing procedure. Ensuring discreet observation, the researcher being a radiographer at the site of the study, continued with routine work in the department. The study was explained to the radiographers and they were taken through the informed consent with the understanding that they would not know precisely when they would be observed. This minimised the Hawthorne effect and maintains the value of the observational data (Chiesa & Hobbs, 2008:67).

Seven radiographers were observed for one month. A checklist compiled by the researcher was used per radiographer (Table 3.2). On certain days, more than one radiographer was observed. How thoroughly the equipment and accessories were cleaned (how much time spent per item) was recorded. Damp dusting (using cotton wool moistened with methylated spirits or chlorine bleach), cleaning equipment using methylated spirits or chlorine bleach after each contact with body fluid, washing hands after each patient using water and liquid soap, washing hands randomly after patients (or in between patients) using water and liquid soap were observed and recorded.

**Table 3.2 Checklist 1: Template used for observing a radiographer’s application of infection control measures in June 2017**

Radiographer 1						
Day	Date	Damp dusting using cotton wool moistened with methylated spirits or chlorine bleach	Cleaning equipment using methylated spirits or chlorine bleach after each contact with body fluid	Washing hands after each patient using water and liquid soap	Washing hands randomly after patients (or in between patients) using water and liquid soap	Time per item
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

According to literature radiographers do not clean equipment properly and practise inadequate hand washing (Ghana Ministry of health, 2015:2). The effectiveness of chemical disinfectants can depend upon both the antimicrobial activity of the disinfectant and appropriate application, including adequacy of cleaning. An entire clinical hand washing procedure takes 40-60 sec (WHO, 2009b:3). Enough contact time of a detergent with a surface is necessary to inactivate organisms and to ensure effective disinfection. It ranges from 60 seconds to 10 minutes depending on the type of detergent used. The minimum contact time for chlorine bleach is 10 minutes (Leas, Sullivan, Han, Pegues, Kaczmarek & Umscheid, 2015:1). According to CDC (2018) a wide variety of gram-negative and gram-positive bacteria are killed after 10 seconds of contact with methylated spirits (60-90% ethyl alcohol).

**3.7.2 Swabbing procedure**

With the aid of swab sticks, swabbing was conducted before decontamination on the selected radiology equipment and accessories (Table 3.1). To avoid the Hawthorne effect according to Chiesa and Hobbs (2008:67), the day of the first swabbing was not disclosed to the staff at the radiology department. Swabbing after decontamination with the two types of disinfectant chemical agents (chlorine bleach -32 swabs and methylated spirits -32 swabs) was done to assess the effectiveness of the decontamination procedures at the study site.

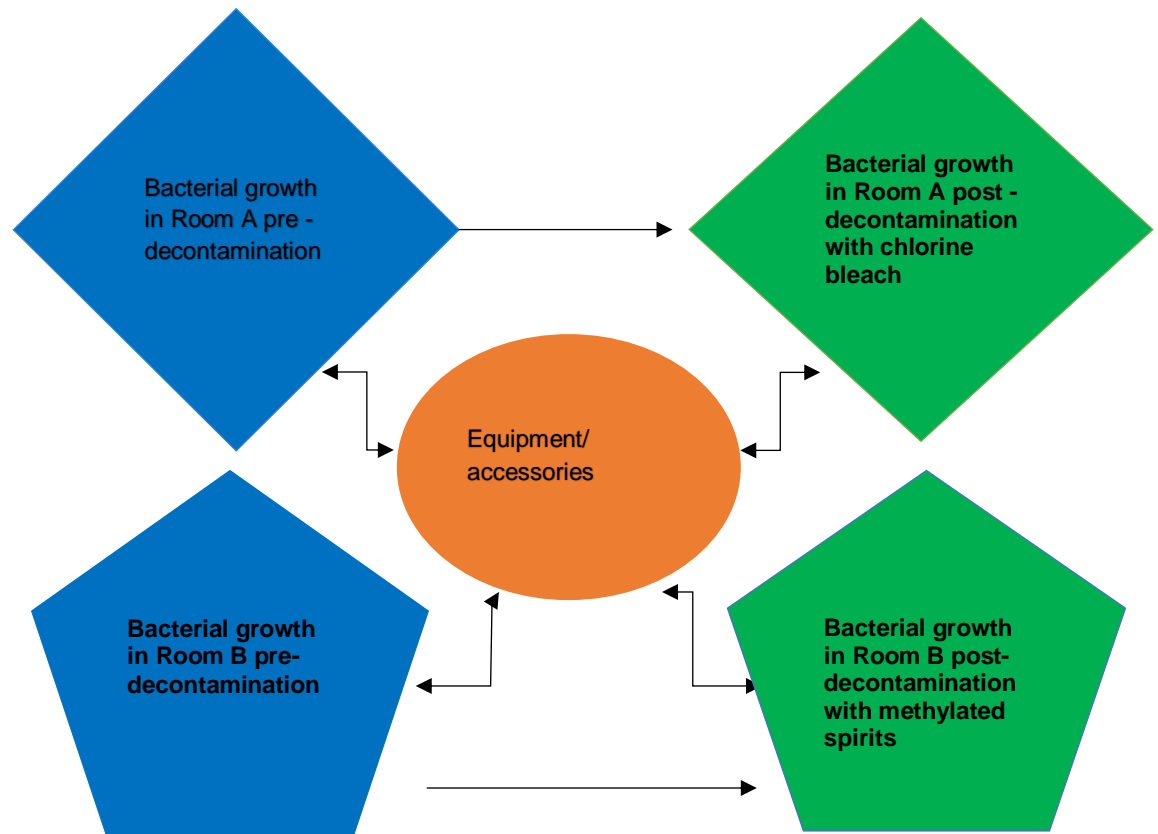
Both swabbing before and after decontamination were done at eight o'clock before the start of the morning shift and directly after the night shift. This was decided on because literature evidence suggests that radiographers' workload is higher during the night shift. They thus have less time to clean the equipment and accessories (Fox & Harvey, 2007:308). The previous was only important for the pre-decontamination step (step 1). This early morning swabbing also prevented a delay in patients scheduled for radiographic examinations during the day. It avoided disturbing the patient flow, as well as the work of the staff and other health-care professionals in the radiology department. The first days for swabbing pre-decontamination were 10<sup>th</sup> July 2017 and 17<sup>th</sup> July 2017 for Room A and Room B respectively. Subsequently, post-decontamination swabbing took place respectively on 24<sup>th</sup> July 2017 in Room A and 28<sup>th</sup> July 2017 in Room B. The difference in swabbing dates for the two rooms, as well as the period of time in between the first and second swabbing process were because all the equipment at the study site, except those of Room A and Room B were under repair. These two rooms, therefore, experienced a high workload at that time which prevented prompt access (for research purposes) to them. Room B, however, had a higher workload due to its location (ground floor) which explains the later swabbing dates than Room A. It is important to note that under normal working circumstances the decontamination process as well as the second swabbing process would have occurred directly after the first swabbing process.

The swabbing was done by the researcher under the supervision of two biomedical scientists from the Microbiology Department of the University of Ghana. During the swabbing processes, the researcher and the biomedical scientists wore sterile hand gloves. These gloves were changed in between swabbing each selected potential fomite to reduce the potential of cross-infection between the swabbed items and from the hands to the swab. The sample areas were swabbed horizontally, vertically and diagonally for each chosen field. The surface materials of the equipment and accessories between the two rooms were the same. Swabs were taken from the entire surface (area) of the items identified.

The swabbed samples taken from each selected item were placed in bijoux bottles containing peptone broth. The bijoux bottles were accurately marked with the codes for the type of the equipment or accessory and the name of the individual room. For instance, a cassette in Room A was coded CRA17.1 (where C= Cassette, RA = Room 5, 17= the size of the cassette; 35cm x 43cm, 1 = 1<sup>st</sup> sample taken). The code for the x-ray tube handle in Room B was HTRB.46 (where HT=Handle of Tube, RB= Room 6, 46 = 46<sup>th</sup> sample taken).



These swabbed samples were immediately stored in a cleaned ice packed container and transported to the department (laboratory) of Microbiology at the University of Ghana for colony isolation, morphological and bacteriological analysis of bacteria.



**Figure 3.6: Flow chart of data comparisons**

Comparisons were made between the total isolated bacteria found in Room A and Room B before decontamination with the total isolated bacteria after decontamination with chlorine bleach (selected for Room A) and methylated spirits (selected for Room B) Figure 3.6. Isolated bacteria found in both rooms pre-and-post decontamination were traced to the equipment and accessories on which they were identified.

### **3.8 Bacterial isolation and identification**

Swab samples placed in peptone broth were packed into the brain heart infusion (a nutrient rich medium) and incubated in the peptone water overnight at 37°C to encourage bacterial growth. Growth in peptone water was observed and then streaked to cover the surface of a plate on top of MacConkey and Blood agars (gelatinous substances) and incubated for 18 – 24 hours for colony isolation and morphological identification (Chingaranda & Chidakwa, 2014:21; Tagoe *et al.*, 2011:24). A standard technique was employed for isolation of organisms (Da Silva *et al.*, 2013:24). After

incubation, the plates were read with the help of experienced Microbiology staff and a quantitative assessment was obtained of the colonies' morphology.

A laboratory report was generated of each swab sample and transfer of all data onto the data collection sheets were performed by the biomedical scientists and the researcher respectively. The isolated colonies were identified by the morphological characteristics, gram stain and biochemical reactions. Isolates were identified and classified based on the three basic shapes of bacteria namely: spherical (coccus), rod like (bacillus), or curved (Vibro, spirillum or spirochete) (Rogers, 2011:8).

Subsequently, the biochemical reactions performed were done employing the motility test, catalase generation, the oxidase test, indole, citrate usage, urease action, hydrogen sulphide generation, gelatine hydrolysis, starch hydrolysis and carbohydrates tests.

Methicillin sensitivity tests were performed to determine which of *Staphylococcus aureus* and CoNS identified were resistant or sensitive to methicillin.

### **3.9 Statistical analysis and presentation**

Data obtained from the results after swabbing and culturing were summarised as total numbers (column percentages) for categorical variables in order to compare the number and types of nosocomial pathogens. Baseline comparisons where appropriate were made using a chi-square ( $X^2$ ) test. This was selected to test the significance of association between two variables and to help determine the significance of population variance (Kothari, 2004:233). Statistical significance was determined as  $p < 0.05$ . All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) Statistics, version 25 (IBM, 2017). The Excel 2016 program was also used to plot graphical presentations of data. A comprehensive descriptive and comparative statistical analysis was used for the observations made on radiographers' practices of departmental infection control. This involves the use of observation and survey tools to gather data and analyse them using frequencies, percentages, averages, or other statistical analyses to determine relationships (Nassaji, 2015:129)

The observed phenomena were described and compared with best practices approved by the WHO. Representations in a form of tables, pie and bar charts were applied to illustrate the findings.

### **3.10 Dissemination of results**

Copies of the results of this study will be made available to the library of the Cape Peninsula University of Technology and the infection control department at the

research site. The latter will facilitate the possible adjustment to existing infection control policies and practises in the radiology department if necessary. The work will be published in the Ghana Journal of Allied Health Sciences and other appropriate journals.

### **3.11 Ethical considerations**

Research ethics is the researcher's guide to uphold ethical standards in a study. Ethics in Research is intended to maintain human dignity and to promote justice, equality, truth and trust (South African Medical Research Council, 2015:14).

This study was clinical research in an active environment that involved laboratory investigations on radiology equipment and accessories and observation of infection control practises by radiographers. Ethical considerations were mainly concerned with the radiographers, the site and radiology equipment and accessories selected. It is highly unethical to collect data haphazardly; and collecting data in a rush or with a lack of attention could lead to systematic errors (Morrison, 2016:358). These challenges were overcome by being careful, giving attention to detail and ensuring accuracy at all times. This was achieved through limiting the cleaning time when using chlorine bleach to not less than 10 minutes, through the careful handling of swabs using gloves and through the double checking of documented data and codes. Experienced microbiologists assisted throughout the experimental phase. The circumstances and technique, used during the swabbing process and laboratory tests before and after decontamination, were identical (e.g. the same standardised incubation period and temperature were used for bacterial growth before and after decontamination). Data and results were also carefully transferred from collection sheets to avoid transposition errors.

To assure the quality and integrity of the research, this study adhered to Good Laboratory Practises (GLP) standards recommended by WHO (2002b:37). These standards include requirements for adequate equipment and accessories handling and proper documentation of research results and record keeping.

Scientifically qualified biomedical scientists (a minimum of Bachelor's in Biomedical Science, and more than five years working experience) from the Microbiology department of the University of Ghana, conducted the culturing and microscopic testing as posited by the Nuremberg Code (1947). Items from each examination room were coded differently from the usual identification by the department. The researcher endeavoured to keep the codes to individual items strictly confidential. The data

obtained could not be linked to specific rooms as the two rooms were referred to as Room A or Room B.

Before conducting the research, a letter (Appendix A) and the research proposal were submitted to the Research Ethics Committee of the Faculty of Health and Wellness Sciences (HWS-REC), at the Cape Peninsula University of Technology for protocol review and ethics approval. The research proposal obtained approval (Appendix B) from the HWS-REC.

The Belmont report (1979) identifies respect for subjects as one of the basic ethical principles. The study site, the radiographers and the radiology equipment and accessories were the subjects for the study. The researcher sought and obtained approval (Appendix D and E) from the Scientific and Technical Committee and the Institutional Review Board of the TH. A letter (Appendix C) was submitted to the Chief Executive Officer of the TH, to seek permission to carry out the study. This permission was valid for access to the radiology department including radiology equipment and accessories for the intended research. For confidentiality, the researcher assured hospital authorities and observed participants (radiographers) that no name or identity would appear at any stage of the data collection in the final written report or any publications. The hospital's name will be removed from the final dissertation for confidentiality purposes.

The researcher upheld the respect for persons, beneficence and justice as the three core ethical principles that must be applied to research studies involving humans (Belmont report, 1979). Letters (Appendix F) were sent to the staff within the selected rooms of the diagnostic radiology department to request their cooperation during data collection and other related activities in the department. Written informed consent (Appendix G) was sought from radiographers before the observation of how they practised infection control at work. There was no form of coercion by the researcher. The head of the department, the unit managers and the infection control officer of the hospital, were immediately informed of any dangerous organisms found, during and after the research. Proper decontamination measures were also immediately applied.

Results and data from the microbiology department were stored on an external hard disc drive protected with a coded password. Hard copies of data were kept safe and locked in a cupboard to prevent damage or information loss and unauthorised access to information. The researcher ensured the integrity of the data by making conscious efforts that the data were not falsified, modified or omitted.

### **3.12 Conclusion**

This chapter outlined the study focus, research design and provided a detailed description of the research methodology. Furthermore, ethical considerations related to this study were highlighted.

Chapter four follows next and will present the results of the study.

## CHAPTER FOUR

### RESULTS

#### 4.1 Introduction

This study was undertaken to observe the cleaning procedures by radiographers in general radiography and determined whether radiology equipment and accessories for general radiography serve as possible fomites of nosocomial pathogens. The study also investigated the effectiveness of disinfectant chemicals (chlorine bleach and methylated spirits). These are the two agents used to clean radiology equipment and accessories at the study site.

This research involved a two-phase approach using an observational study followed by an experimental component. The observational aspect was carried out to establish whether regular infection control measures (hand washing practice, cleaning of equipment and accessories) were undertaken by radiographers of radiology equipment and accessories at the study site. The experimental phase of the study involved swabbing selected radiology equipment and accessories and conducting laboratory culturing pre and post decontamination of those items. A total of 128 (n=128) swabs were taken over four weeks. In the morning, just before the equipment and accessories were used (pre-decontamination), 32 (n=32) swabs were taken from each Room (A and B). Thirty-two swabs (n=32) were again taken per room after cleaning with one of the two chemical disinfectant agents.

This chapter presents the results of the observational and experimental phases of the study. For phase 1, the findings report on a descriptive analysis of how radiographers practise infection control measures. Phase 2 findings were derived from the laboratory cultures of the swabs taken pre and post decontamination of the selected radiology equipment and accessories.

A comparative analysis was made from results obtained from the laboratory cultures. For statistical analysis the laboratory cultures were categorised into those isolates identified pre and post decontamination with methylated spirits or chlorine bleach.

#### 4.2 Phase 1: Observational data

This section is based on the first objective namely to observe the current cleaning procedures and practices in the radiology department. It therefore presents

the observational results gathered regarding radiographers' practise of hand washing and cleaning of equipment and accessories. Seven (n=7) radiographers working in the three functional general examination rooms (A, B and C) were observed for one month in total. These radiographers were each observed for 10 days regarding their application of infection control measures. The number of times equipment and accessories were cleaned (e.g. daily damp dusting, after contact with body fluid) was recorded. The number of times the radiographer washed his/her hands was observed and recorded. The time spent per item was also recorded.

#### 4.2.1 *Cleaning and decontamination*

It was observed that the department had no documented infection control measures on how to clean and decontaminate equipment and accessories. There were no scheduled dates to clean the equipment and accessories. What was observed, however, was that all the radiographers cleaned accessories and equipment in between patient procedures when these items came into contact with blood or other body fluid. The results in Table 4.1 are the average scores of cleaning time per item for each radiographer documented over the ten-day period.

**Table 4.1: Checklist 2: Infection control measures practised by radiographer**

	<b>Damp dusting of equipment and accessories</b>	<b>Washing of hands after each patient</b>	<b>Cleaning equipment/accessories after contact with body fluid</b>	<b>Average cleaning time (minutes) per item</b>
Radiographer 1	✓	x	✓	2.60
Radiographer 2	✓	x	✓	1.96
Radiographer 3	✓	x	✓	2.63
Radiographer 4	x	x	✓	2.14
Radiographer 5	✓	✓	✓	2.54
Radiographer 6	x	x	✓	2.38
Radiographer 7	x	x	✓	2.44

**Note x = radiographer did not apply infection control measures, ✓ = radiographer did apply infection control measures.**

From the observational data (Table 4.1) it was noted that four radiographers practised damp dusting of equipment and accessories when it was evident that these items were soiled with dust, while three did not practise damp dusting at any time during the observational period. It was observed that six radiographers did not wash their hands

after each patient whereas one radiographer did wash his/her hands after completing each patient's procedure. Furthermore, all the radiographers cleaned equipment/ accessories after contact with body fluid.

#### 4.2.2 **Storage of cassettes and lead aprons**

Additional information was obtained during the observational phase regarding practices in the radiology department which could play a role in the contamination of accessories. It was observed that the rooms did not have a cassette hatch to keep x-ray cassettes and instead the cassettes were kept on the floor (Fig 4.1). There were no hangers or railings for storing of lead aprons, leaving them to be placed on tables, tops of cupboards or other convenient surfaces. This handling method of the lead aprons, as well as their heavy nature, meant that they frequently fell off these places on to the floor (Fig. 4.1).



**Figure 4.1 Storage places for cassettes and lead aprons**

**A. Cassettes kept on the bare floor**

**B. Lead apron hung on a cupboard**

**C. Lead apron and lead skirt hung on X-ray generator**



### 4.3 Phase 2: Experimental data

Biochemical tests were done to identify the characterisation of the types of bacterial growth. Figures 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8 and 4.9 present the biochemical tests done for the characterisation of pathogens identified on equipment and accessories. This is presented based on the research objectives to;

- Determine types and number of nosocomial pathogens present on selected radiology equipment and accessories before decontamination.
- Ascertain the presence of nosocomial pathogens following decontamination of selected radiology equipment and accessories with one of two preferred departmental disinfectant chemical agents.
- Compare the effectiveness of the two cleaning agents.

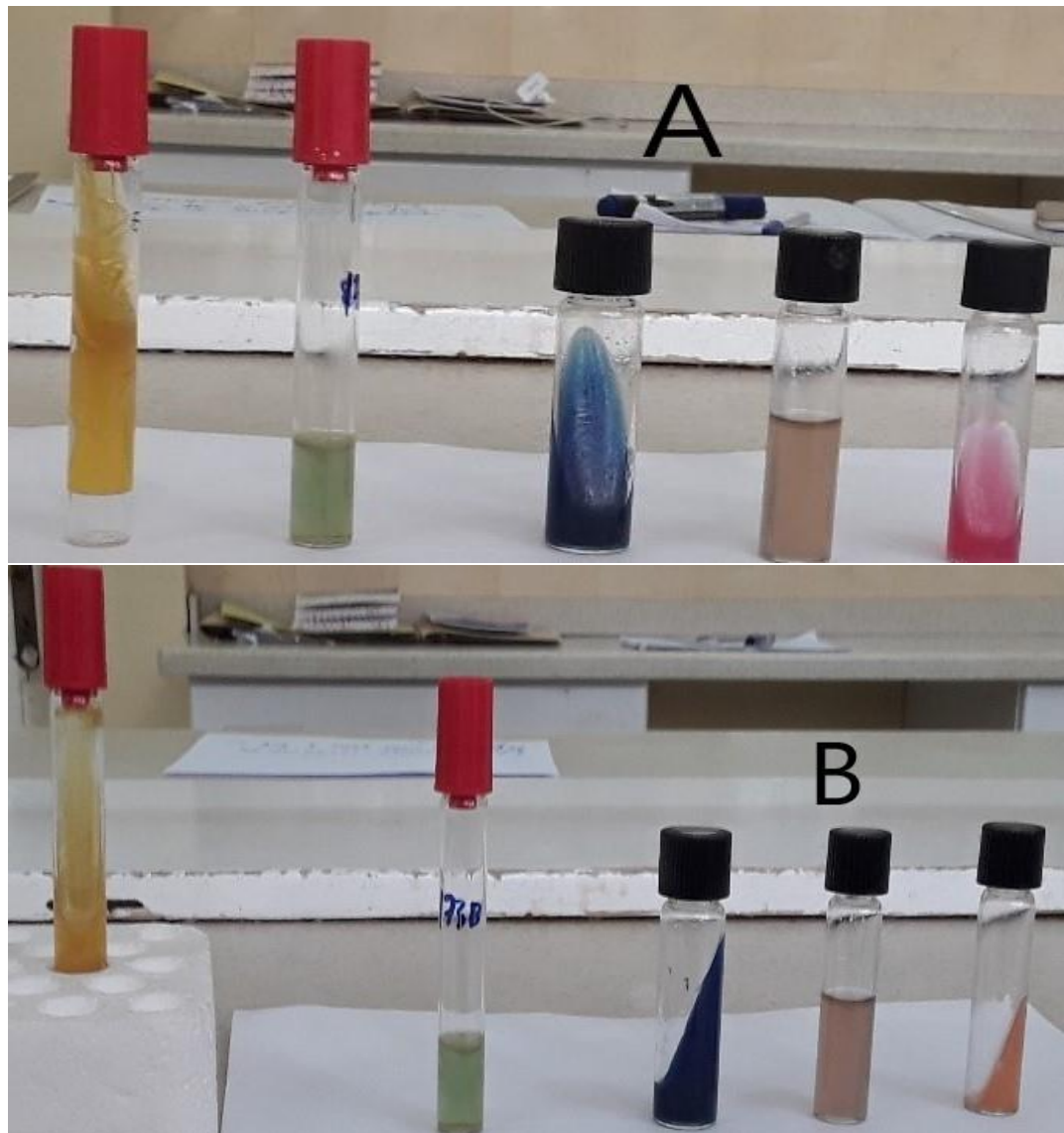


Figure 4.2. Biochemical laboratory test for *Klebsiella* spp. (A) and *Citrobacter* spp. (B)

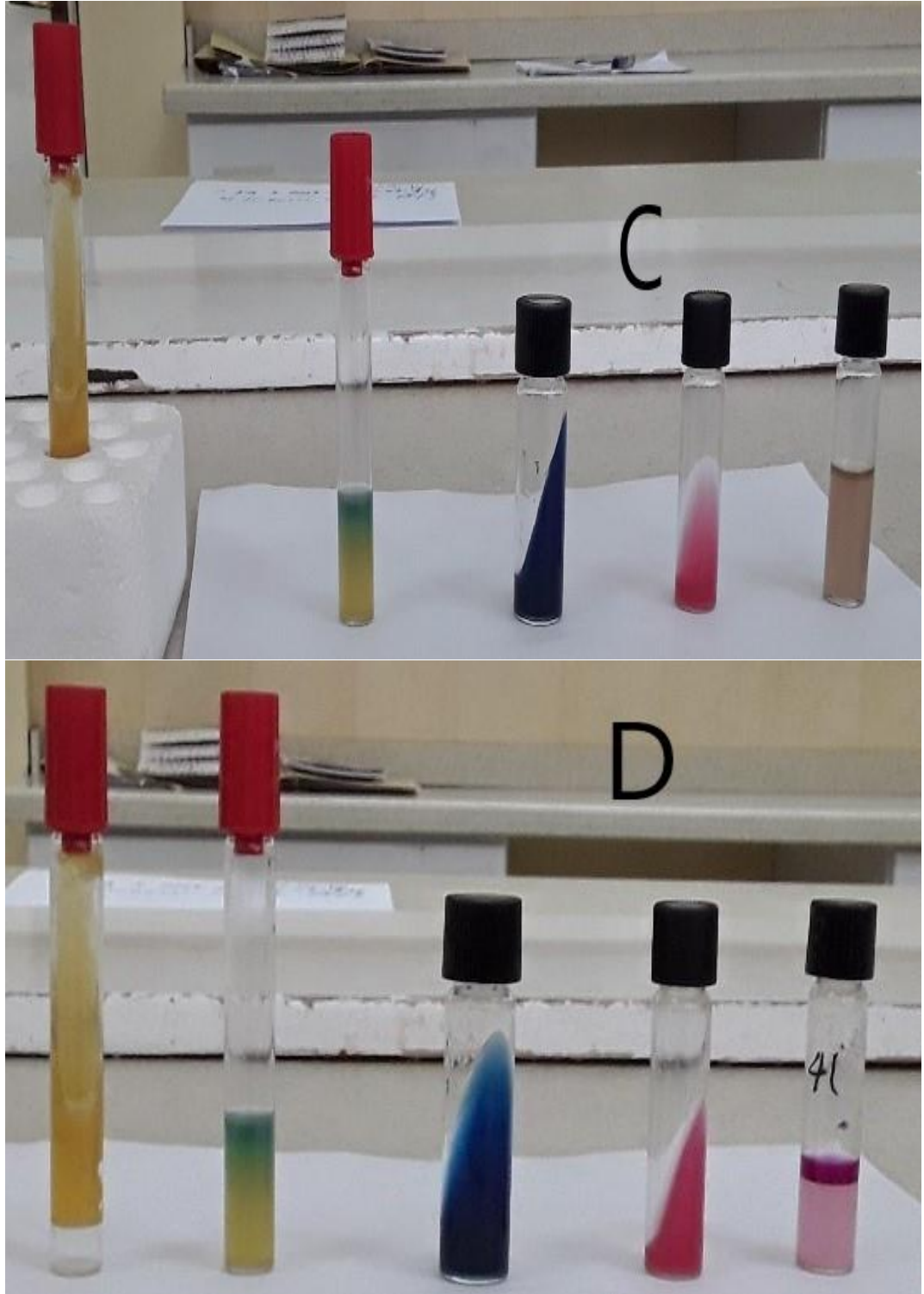


Figure 4.3. Biochemical identification of *Enterobacter* spp. (C) and *Providencia rettgeri* (D)

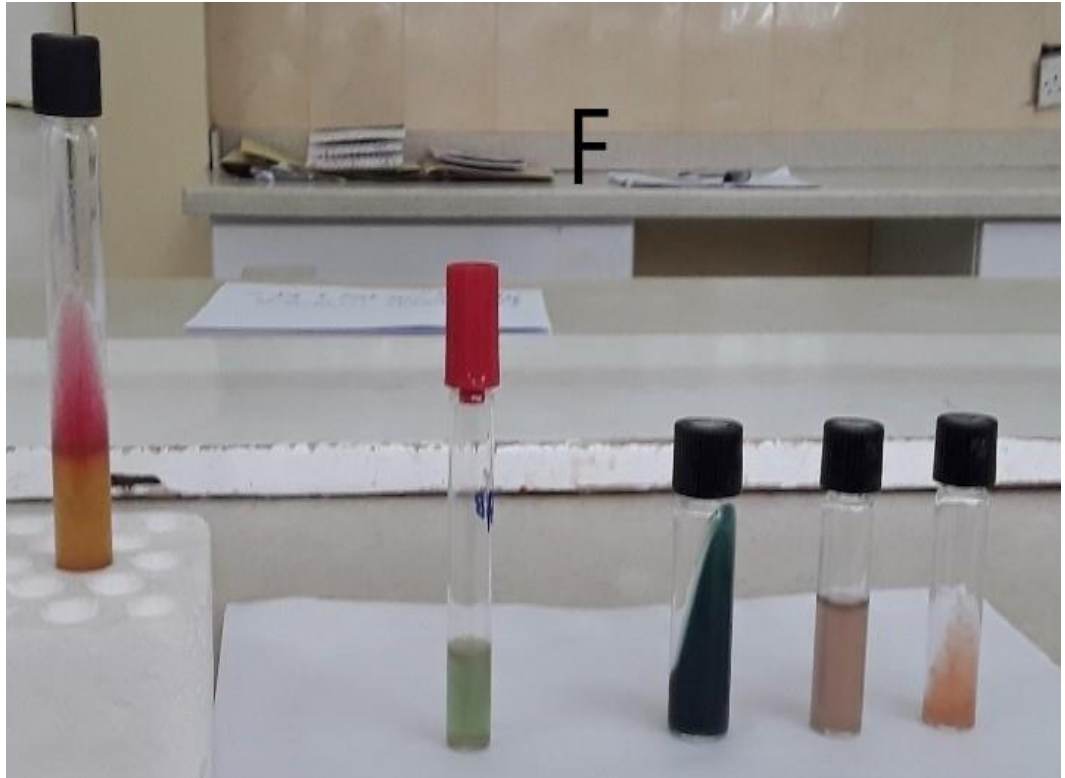
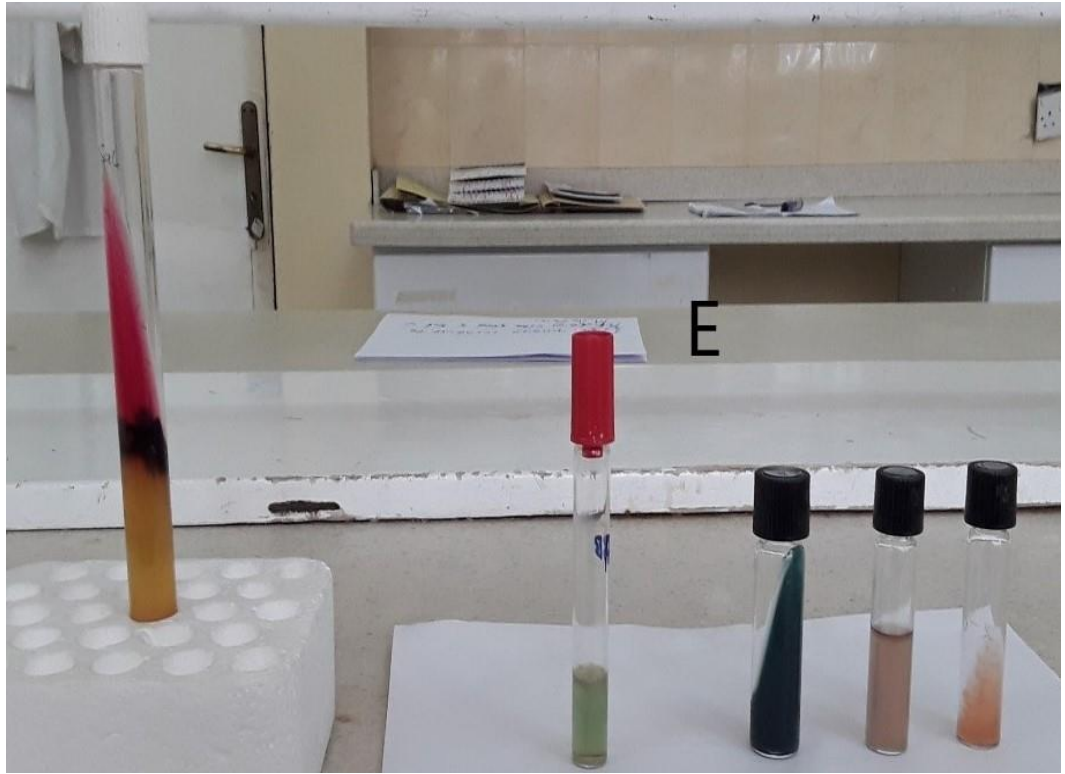


Figure 4.4 Biochemical identification for *Salmonella enterica* subsp. Typhi (E) and Paratyphi A (F)



Figure 4.5 Biochemical identification for *Shigella* spp. (G).

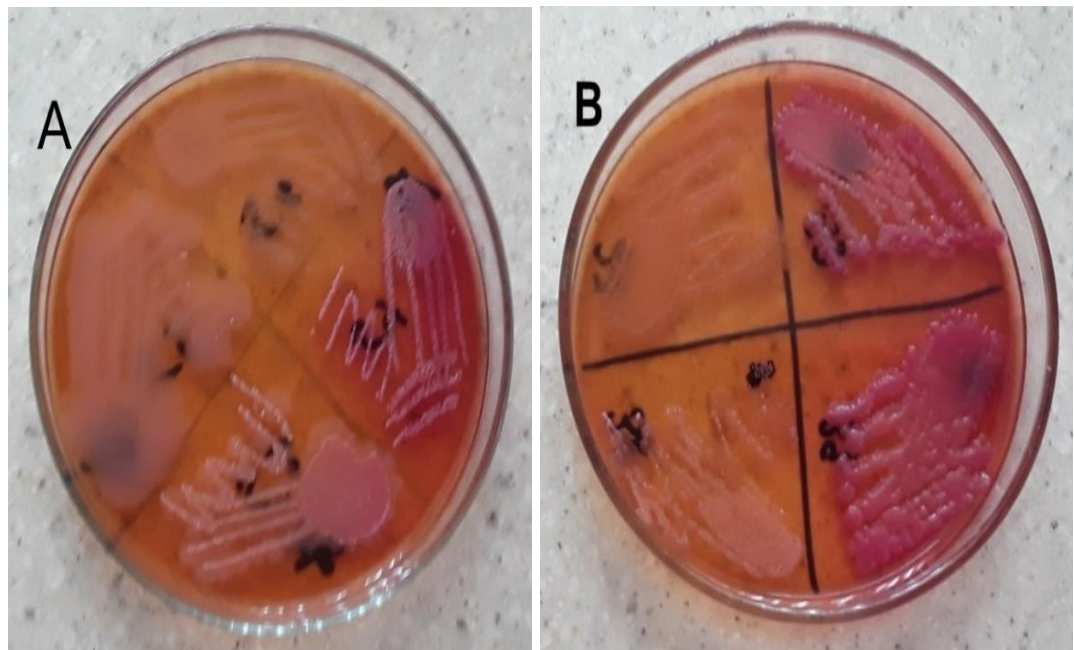


Figure 4.6 Biochemical identification of microbes. A. Bacterial colony showing lactose (pink) and non-lactose (light pink) fermentations. B. *Klebsiella* spp. growing on MacConkey showing the characteristics of mucoid colonies.





Figure 4.7 *Bacillus* spp. growing on blood agar

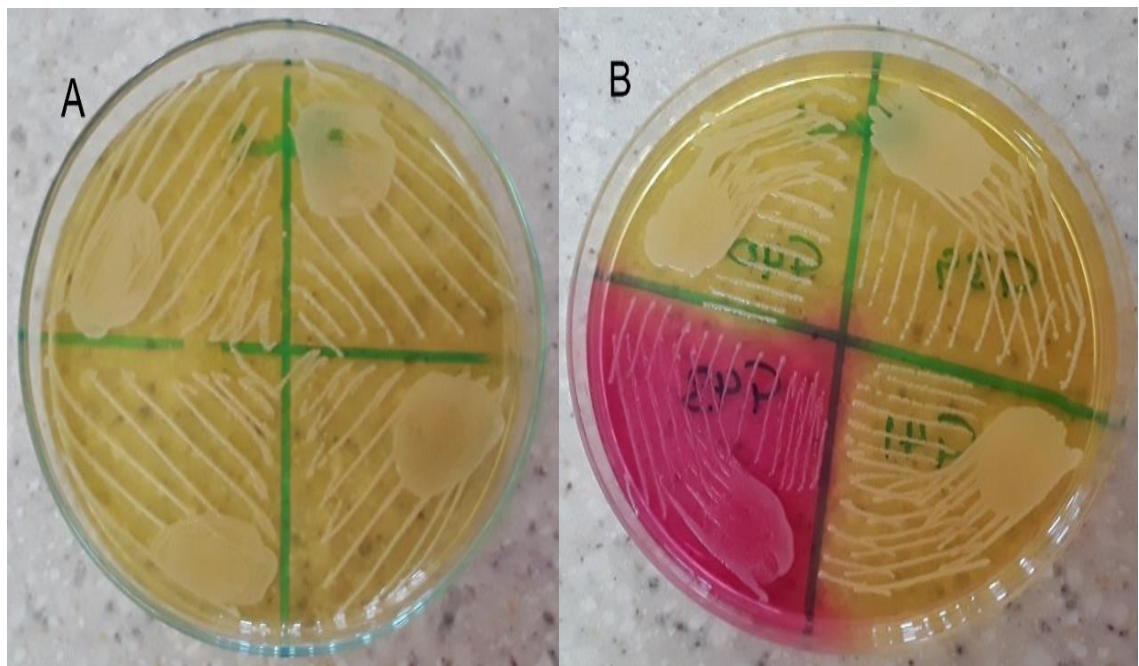


Figure 4.8 Biochemical identification of microbes. A and B, *Staphylococcus aureus* growing on mannitol salt agar (yellow). B, *Coagulase Negative Staphylococci* showing lactose fermentation (red).

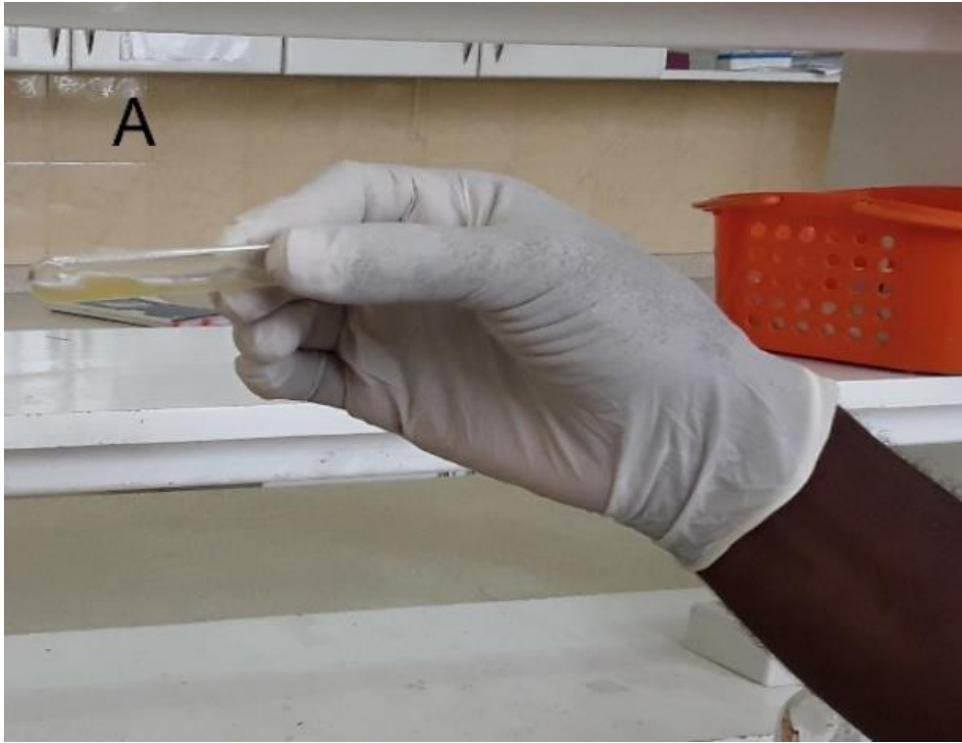


Figure 4.9 A: Coagulase test to confirm *Staphylococcus aureus* (coagulase positive)

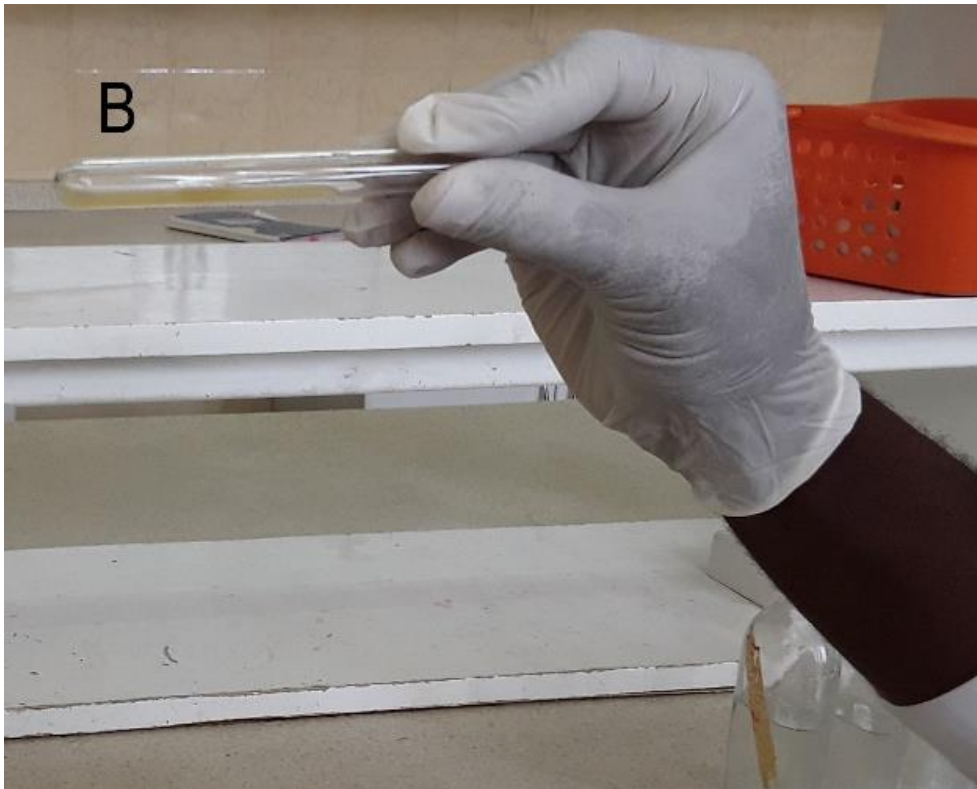


Figure 4.9 B: Coagulase test to confirm *Coagulase Negative Staphylococci*

#### 4.3.1 *Pathogens isolated pre-decontamination*

This section is based on the following objective:

To determine the types and number of nosocomial pathogens present on selected radiology equipment and accessories before decontamination. It therefore highlights the tabular and graphical presentation of data obtained from the culturing of swab samples before the radiology equipment and accessories were decontaminated. The number of samples and bacterial growth pre-decontamination that were identified from each of the selected rooms and items are outlined in this section.

**Table 4.2: Number of samples and bacterial growth pre-decontamination**

Equipment/accessories	Number of samples per item	Number of bacterial growth per item	
		Room A	Room B
Exposure button	2	2	3
Horizontal Bucky surface	4	4	4
Cassettes	3	4	3
35cm x 43cm	3	4	3
24cm x 30cm			
Control buttons	2	2	2
Door handles	2	2	3
Erect Bucky surface	3	3	4
Erect Bucky handle	2	2	2
Lead apron	3	3	3
Tube head handles	2	2	3
Tube head collimators	2	2	3
Horizontal Bucky handle	2	2	2
Horizontal Bucky knobs	2	2	3
Total	32	34	38

Table 4.2 shows that the two samples taken in Room A from the exposure button, the control buttons, the door handles, the tube head handles, the tube head collimators, the horizontal Bucky handle, the erect Bucky handle and the horizontal Bucky knobs recorded two bacterial growths each. The lead apron and the erect Bucky surface had three bacterial isolates each. Bacterial isolates (four each) were detected on the two cassettes (35cm x 43cm and 24cm x 30cm) for three samples taken from each. The horizontal Bucky surface recorded four bacterial isolates for four samples taken. Samples taken from Room B, from the horizontal Bucky surface and the erect Bucky surface recorded four isolated bacteria for each of the four and three samples taken respectively. There were two bacterial growths each for the control buttons, the erect Bucky handle and the

horizontal Bucky handle. Six bacterial isolates were found on the two x-ray cassettes for the six samples taken.

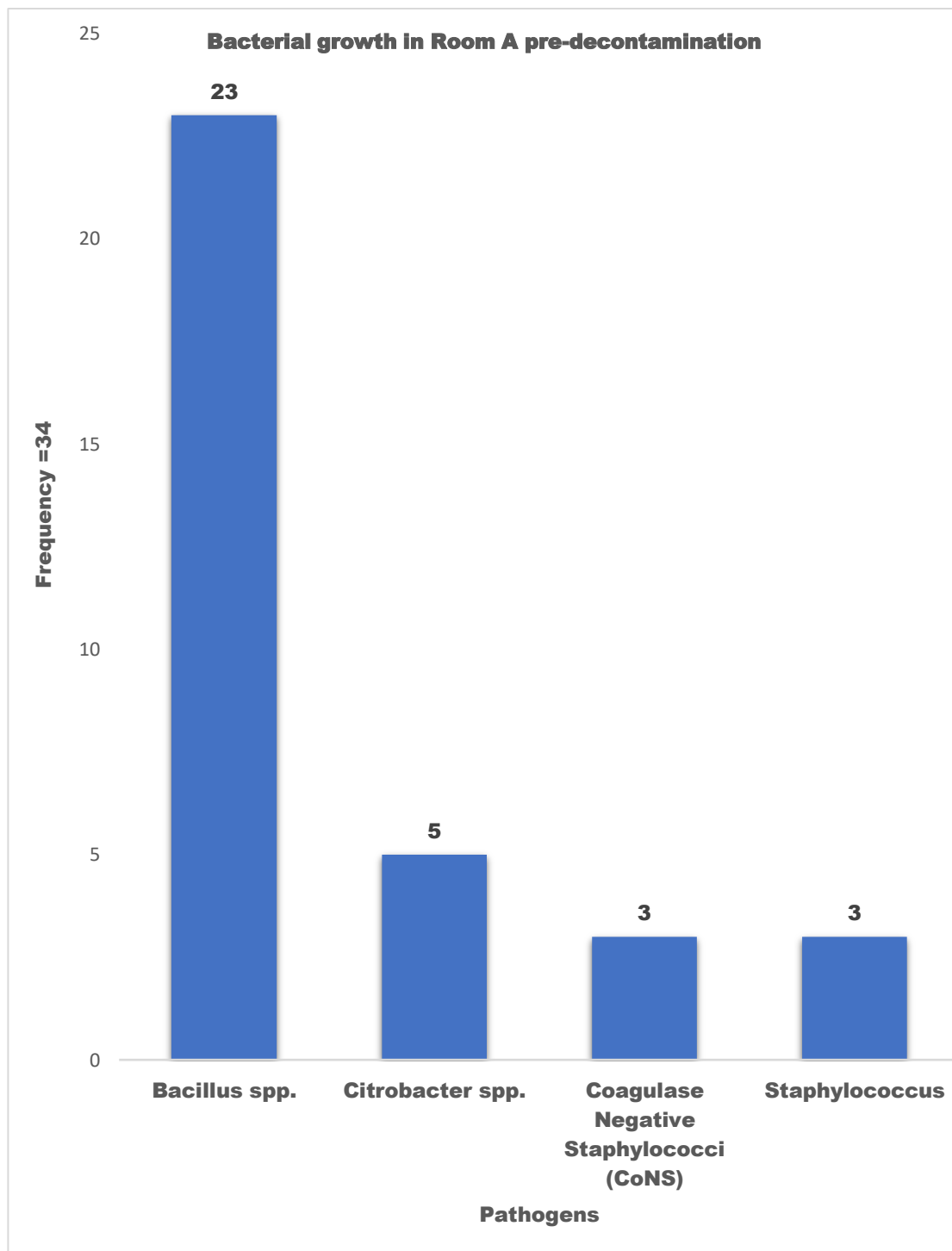
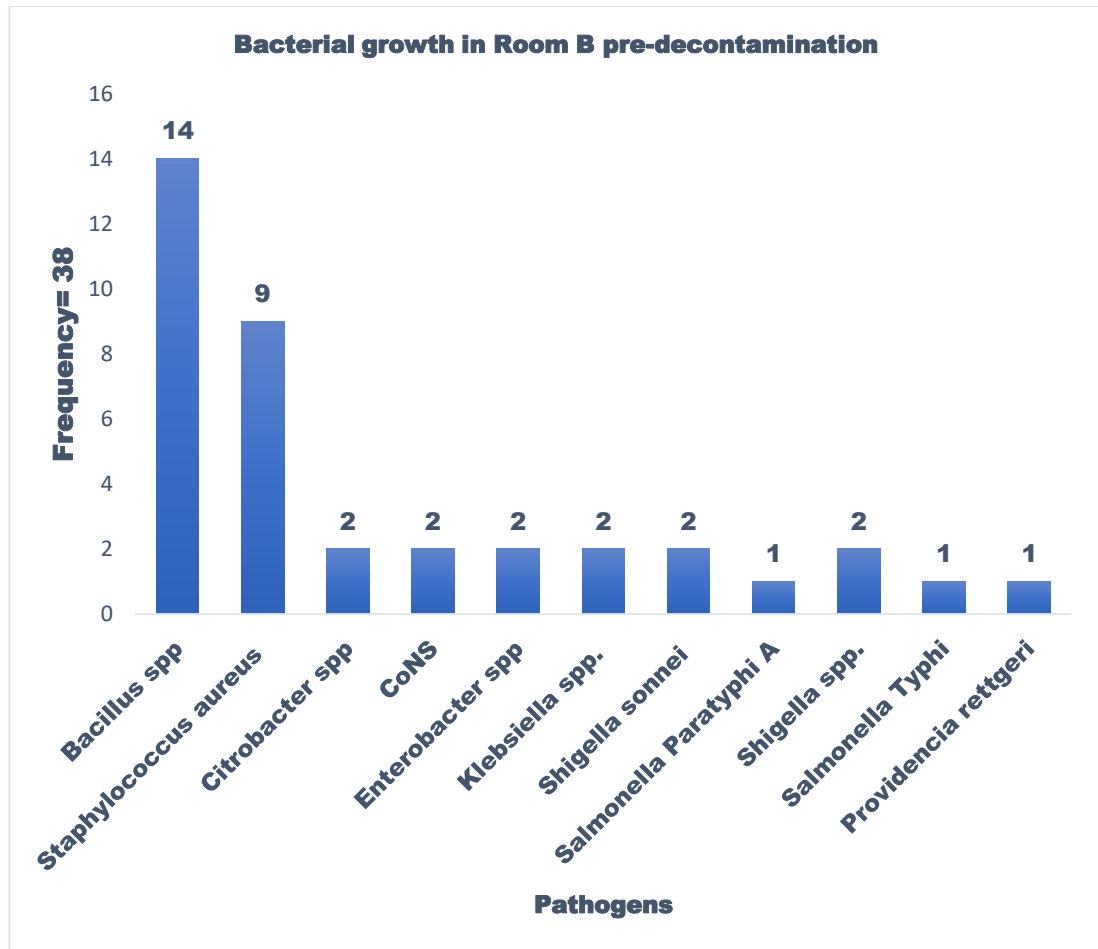


Figure 4.10 Bacterial growth identified from Room A pre-decontamination

Figure 4.10 shows that four types of bacteria were isolated from the 32 samples taken pre-decontamination of equipment/accessories from Room A. The majority (22) of the isolates were *Bacillus* spp., five bacteria were isolated as *Citrobacter* spp. There were three bacterial isolates each recorded for *Coagulase Negative Staphylococci* (CoNS)



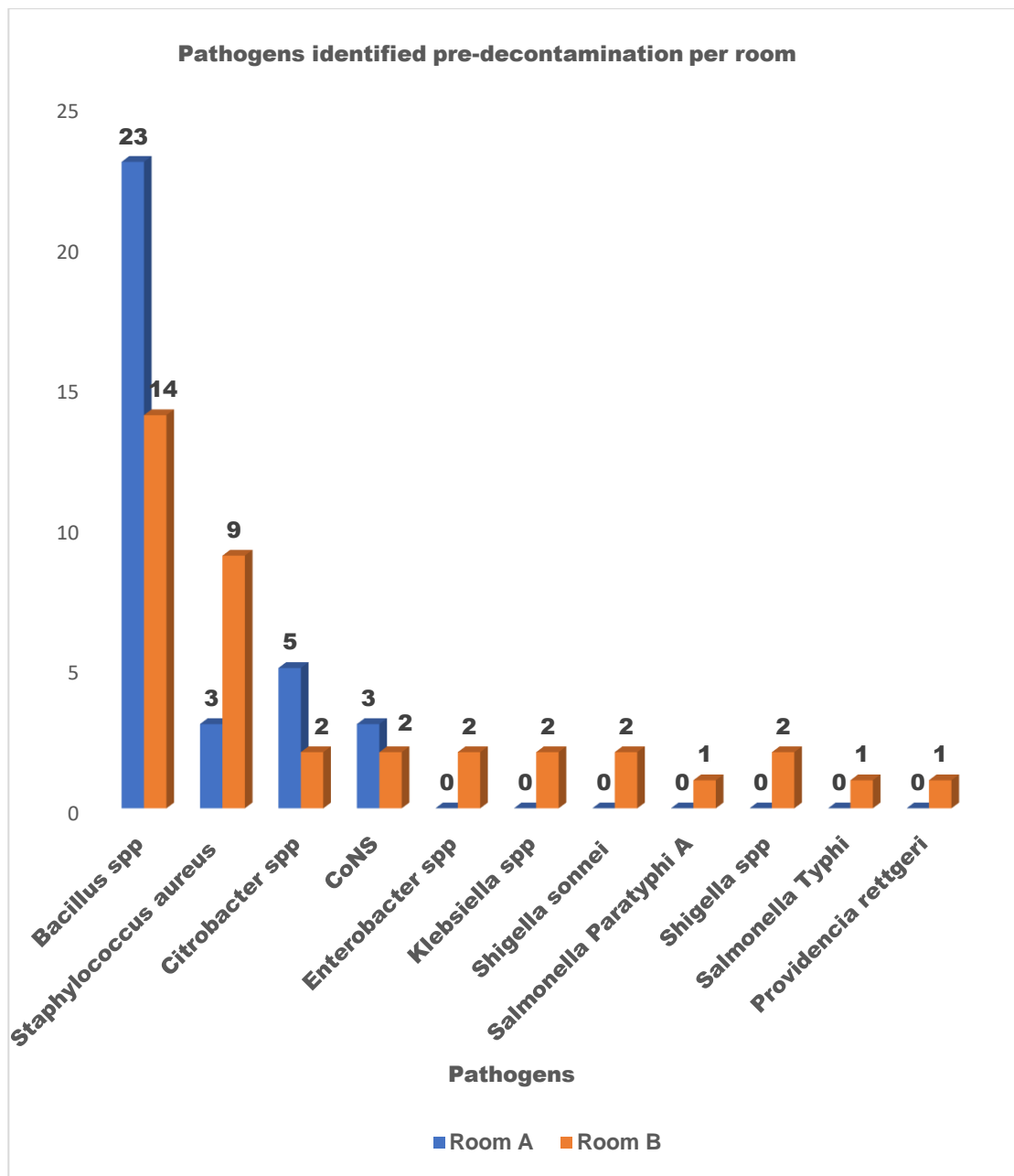
and *Staphylococcus aureus*. There was no finding for *Enterobacter* spp., *Providencia rettgeri*, *Salmonella* Paratyphi A., *Klebsiella* spp., *Salmonella* Typhi, *Shigella* spp. and *Shigella sonnei* which were found in Room B.



**Figure 4.11 Bacterial growth identified from Room B pre-decontamination**

Figure 4.11 shows that eleven types of bacteria were isolated from the 32 samples taken pre-decontamination of equipment/accessories from Room B. The frequency of occurrence of these bacteria isolated was 38. The majority (14) of the isolates were identified as *Bacillus* spp. Nine bacterial isolates were *Staphylococcus aureus*. *Citrobacter* spp., CoNS, *Enterobacter* spp., *Klebsiella* spp. *Shigella sonnei* and *Shigella* spp. had two (2) isolates of bacteria each. There was one bacterial isolate for each of the following: *Providencia rettgeri*, *Salmonella* Paratyphi A and *Salmonella* Typhi.

There was also a significant difference ( $p=0.0007$ ) in occurrence of types of isolates before decontamination in Room A and Room B (Figure 4.12).



**Figure 4.12 Bacterial growth identified from Rooms A and B pre-decontamination**

The outcome was that four out of eleven pathogens were identified in Room A whereas all 11 pathogens were identified in Room B.

Only one type of isolate identified during the study out of 11 was non-pathogenic namely Bacillus. There was therefore a significant difference in number ( $p=0.0267$ ) between pathogenic and non-pathogenic isolates identified before decontamination in both rooms.

**Table 4.3: Equipment/Accessories and their respective bacterial growth from Room A pre-decontamination**

Equipment / Accessories	Bacterial growth per item				Total
	<i>Bacillus</i> spp.	<i>Staphylococcus aureus</i>	<i>Citrobacter</i> spp.	<i>Coagulase Negative Staphylococci</i>	
Exposure button	-	-	1	1	2
Horizontal Bucky surface	2	-	2	-	4
Cassettes					
35cm x 43cm	3	-	1	-	4
24cm x 30cm	3	-	1	-	4
Control buttons	2	-	-	-	2
Door handles	1	1	-	-	2
Erect Bucky surface	2	1	-	-	3
Erect Bucky handle	2	-	-	-	2
Lead apron	2	1	-	-	3
Tube head handles	2	-	-	-	2
Tube head collimators	2	-	-	-	2
Horizontal Bucky handle	-	-	-	2	2
Horizontal Bucky knobs	2	-	-	-	2
Total	23	3	5	3	34

Table 4.3 illustrates the total number (34) and types of bacteria identified on individual equipment and accessories pre-decontamination from Room A. The exposure button recorded one bacterial growth of *Citrobacter* spp., as well as a *Coagulase Negative Staphylococci*. Additionally, the horizontal Bucky handle had two bacterial growths of *Coagulase Negative Staphylococci*. Furthermore, the lead apron had two and one bacterial growths for *Bacillus* spp., and *Staphylococcus aureus* respectively. The control buttons recorded two bacterial growths for *Bacillus* spp., but none for *Staphylococcus*, *Citrobacter* spp., and *Coagulase Negative Staphylococci*. *Bacillus* spp. was found on most of the items while other isolates were only identified on certain items. However, all the items were found to be contaminated by bacterial growths.

**Table 4.4: Equipment/Accessories and their respective bacterial growth from Room B pre-decontamination**

Equipment / Accessories	Bacterial growth per item											Total
	A	B	C	D	E	F	G	H	I	J	K	
Exposure button	1	1	-	-	1	-	-	-	-	-	-	3
Horizontal Bucky surface	1	2	-	-	-	-	-	-	-	-	1	4
Cassettes 35cm x 43cm	3	-	-	-	-	-	-	-	-	-	-	3
24cm x 30cm	2	-	-	-	-	-	-	-	-	1	-	3
Control buttons	1	1	-	-	-	-	-	-	-	-	-	2
Door handles	-	1	-	-	-	-	1	-	1	-	-	3
Erect Bucky surface	1	-	1	-	1	1	-	-	-	-	-	4
Erect Bucky handle	1	-	-	1	-	-	-	-	-	-	-	2
Lead apron	2	1	-	-	-	-	-	-	-	-	-	3
Tube head handles	-	1	1	-	-	1	-	-	-	-	-	3
Tube head collimators	1	1	-	-	-	-	-	-	1	-	-	3
Horizontal Bucky handle	1	-	-	-	-	-	1	-	-	-	-	2
Horizontal Bucky knobs	-	1	-	1	-	-	-	1	-	-	-	3
<b>Total</b>	<b>14</b>	<b>9</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>38</b>

Note: A=*Bacillus* spp.  
 B= *Staphylococcus aureus*  
 C=*Citrobacter* spp.  
 D=CoNS  
 E=*Enterobacter* spp.  
 F= *Klebsiella* spp.  
 G= *Shigella sonnei*  
 H= *Salmonella* Paratyphi A  
 I= *Shigella* spp.  
 J= *Salmonella* Typhi  
 K= *Providencia rettgeri*

Table 4.4 illustrates the total number (38) and types of bacteria identified on individual equipment and accessories pre-decontamination in Room B. The cassettes (24cm x 30cm and 35cm x 43cm) recorded one bacterial growth for *Salmonella* Typhi, as well as five for *Bacillus* spp. Additionally, the horizontal Bucky handle had one bacterial growth for each of the following: *Bacillus* spp. and *Shigella sonnei*. Furthermore, the door handles had one bacterial growth for each of the following: *Staphylococcus aureus*, *Shigella sonnei* and *Shigella* spp. The tube head collimators recorded one bacterial

growth for each of the following: *Bacillus* spp., *Staphylococcus aureus* and *Shigella* spp. but none for *Citrobacter* spp., CoNS, *Providencia rettgeri* and the others. All items were contaminated but with different type of bacterial growths. *Bacillus* spp. and *Staphylococcus aureus* were mostly present on the equipment and accessories.

#### 4.3.2 Pathogens isolated post-decontamination

This section is based on the following objectives:

- To determine the types and number of nosocomial pathogens present on selected radiology equipment and accessories after decontamination
- To compare the effectiveness of the two detergents.

The number of samples and the number of bacterial growth post-decontamination of the selected radiology equipment and accessories are now presented.

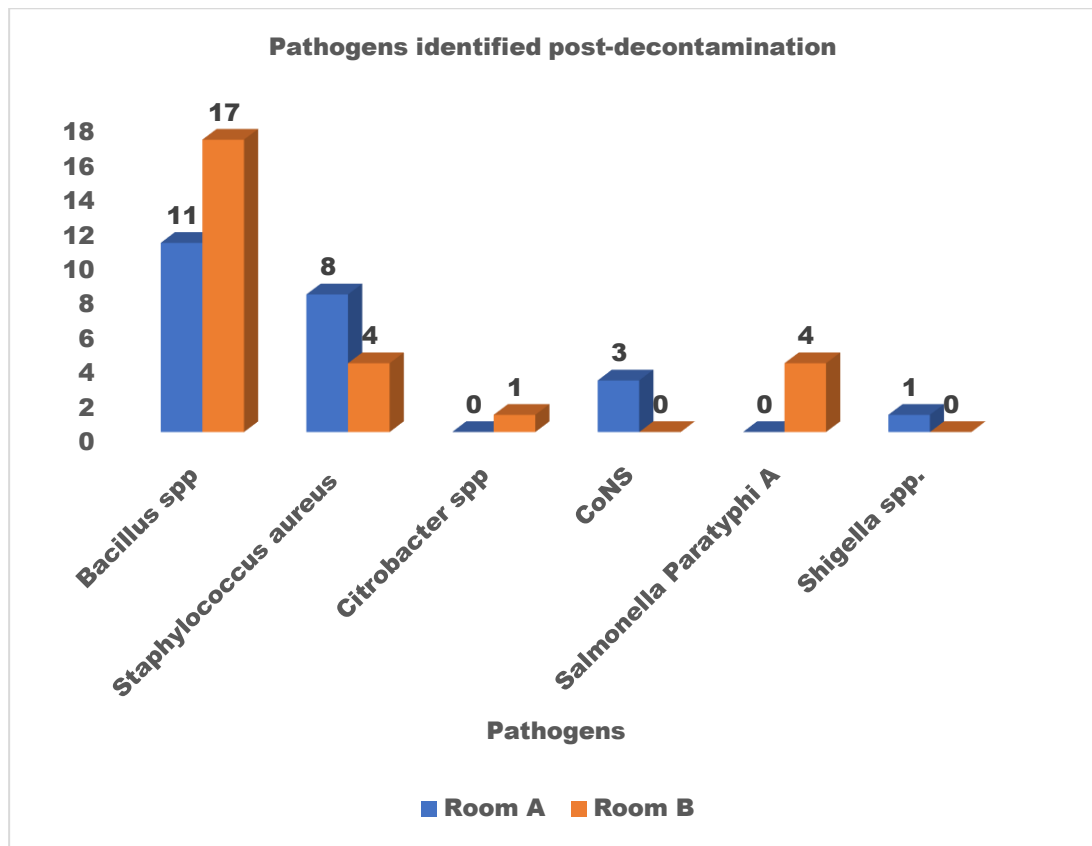
**Table 4.5: Number of samples and the number of bacterial growth post-decontamination**

Equipment/accessories	Number of samples per item	Number of bacterial growth per item	
		Room A	Room B
Exposure button	2	1	2
Horizontal Bucky surface	4	4	4
Cassettes	3	1	3
35cm x 43cm	3	2	3
24cm x 30cm			
Control buttons	2	2	1
Door handles	2	2	2
Erect Bucky surface	3	2	3
Erect Bucky handle	2	2	1
Lead apron	3	3	3
Tube head handles	2	2	2
Tube head collimators	2	1	1
Horizontal Bucky handle	2	1	0
Horizontal Bucky knobs	2	0	1
Total	32	23	26

The following information is displayed by Table 4.5. The 32 samples taken from Room A post-decontamination with chlorine bleach resulted in the identification of 23 bacterial growths. The two samples taken from each of the exposure button, the tube head collimators and the horizontal Bucky handle resulted in one bacterial growth for each sample. The two samples taken from each of the control buttons, the erect Bucky handle, the door handles and the tube head handles recorded two bacterial growths for each item. Each three samples taken from the erect Bucky surface and the lead apron recorded two and three bacterial growths respectively. Four samples taken from the horizontal Bucky surface had four bacterial growths while the cassettes recorded three bacterial growths for six samples

taken. However, no bacterial growth was recorded for the two samples taken from the horizontal Bucky knobs.

Comparatively, the 32 samples taken from Room B post-decontamination with methylated spirits led to the identification of 26 bacterial growths. The two samples taken from the exposure button, the door handles and the tube head handles resulted in two bacterial growths each. For the control buttons, the erect Bucky handle, the tube head collimators and the horizontal Bucky knobs the two samples had one bacterial growth for each item, while three samples taken from the erect Bucky surface and the lead apron recorded three bacterial growths each. The four samples from the horizontal Bucky surface had four bacterial growths. Six samples taken from the cassettes resulted in six bacterial growths. No growth was detected at the horizontal Bucky handle.



**Figure 4.13 Number of bacterial growth identified post-decontamination with chlorine bleach (Room A) and with methylated spirits (Room B)**

As shown by Figure 4.13 four different bacteria were isolated post-cleaning with chlorine bleach. The frequency of occurrence of these bacteria isolated was 23. The majority type of bacteria recorded was *Bacillus* spp. being 11 while eight for *Staphylococcus aureus*,

three for *Coagulase Negative Staphylococcus* and one for *Shigella* spp. were recorded following post-decontamination with chlorine bleach.

In Room B with the frequency of occurrence of bacteria isolated as 26, the majority 17 of the isolated bacteria identified post decontamination with methylated spirits were *Bacillus* spp., one was *Citrobacter* spp. while four for each of *Staphylococcus aureus* and *Salmonella* Paratyphi A were identified.

**Table 4.6: Bacterial growth from Room A post-cleaning with chlorine bleach**

Equipment/ Accessories	Bacterial growth per item				Total
	<i>Bacillus</i> spp.	<i>Staphylococcus</i> <i>aureus</i>	CoNS	<i>Shigella</i> spp.	
Exposure button	1	-	-	-	1
Horizontal Bucky surface (table top)	1	1	1	-	3
Cassettes 35cm x 43cm 24cm x 30cm	1 1	- 1	- -	- -	1 2
Control buttons	2	-	-	-	2
Door handles	-	2	-	-	2
Erect Bucky surface	1	1	-	-	2
Erect Bucky handle	1	1	-	-	2
Lead apron	3	-	-	-	3
Tube head handles	-	1	1	-	2
Tube head collimators	-	1	-	-	1
Horizontal Bucky handle	-	-	1	1	2
Horizontal Bucky knobs	-	-	-	-	0
Total	11	8	3	1	23

Table 4.6 shows that four main bacteria namely *Bacillus* spp., *Shigella* spp., *Staphylococcus aureus* and CoNS were identified after chlorine bleach was used as the mode for cleaning of the selected radiology equipment and accessories. The exposure button recorded one bacterial growth for *Bacillus* spp. but showed no records for the other

bacteria isolated. The erect Bucky handle had a bacterial growth for each of *Bacillus* spp. and *Staphylococcus aureus* but none for *Shigella* spp. and CoNS. The horizontal Bucky knobs had no record for any of the four bacteria identified. Table 4.6 demonstrates that the four types of bacteria were not detected on all the items and that *Bacillus* spp. was still the majority type of bacteria isolated.

**Table 4.7: Bacterial growth from Room B post-cleaning with methylated spirits**

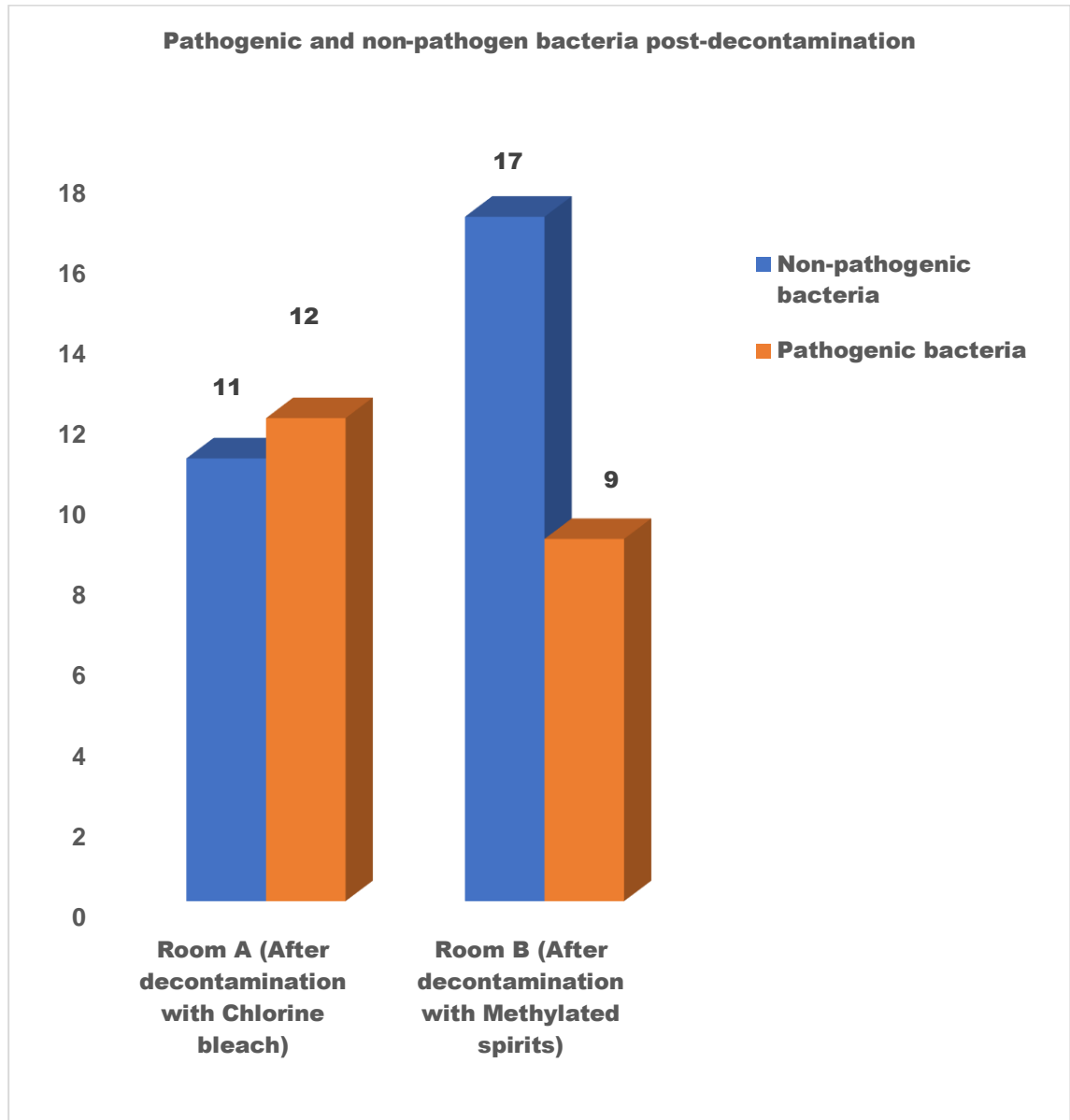
Equipment / Accessories	Bacterial growth per item				Total
	<i>Bacillus</i> spp.	<i>Staphylococcus aureus</i>	<i>Citrobacter</i> spp.	<i>Salmonella</i> Paratyphi A.	
Exposure button	1	-	-	1	2
Horizontal Bucky surface	3	-	-	1	4
Cassettes					
35cm x 43cm	2	-	-	1	3
24cm x 30cm	2	1	-	-	3
Control buttons	-	-	1	-	1
Door handles	2	-	-	-	2
Erect Bucky surface	3	-	-	-	3
Erect Bucky handle	1				1
Lead apron	-	2	-	1	3
Tube head handles	2	-	-	-	2
Tube head collimators	1	-	-	-	1
Horizontal Bucky handle	-	-	-	-	-
Horizontal Bucky knobs	-	1	-	-	1
Total	17	4	1	4	26

Table 4.7 shows that four main bacteria namely *Bacillus* spp., *Staphylococcus aureus*, *Citrobacter* spp. and *Salmonella* Paratyphi A. were identified after methylated spirits was used as the mode of cleaning for the selected radiology equipment and accessories.

The exposure button recorded one bacterial growth for each of *Bacillus* spp. and *Salmonella* Paratyphi A. but showed no records for the other bacteria isolated. The erect Bucky surface had three bacterial growths for *Bacillus* spp. but none for the other three bacterial isolates. The horizontal Bucky handle had no record for any of the four bacteria isolated. The control buttons had one bacterial growth for *Citrobacter* spp. whereas none was identified for the other three bacteria isolated. The 35cm x 43cm cassette was contaminated with two *Bacillus* spp. and one *Salmonella* Paratyphi A. while the 24cm x 30cm cassette was contaminated with two *Bacillus* spp. and one *Staphylococcus aureus*, however, each cassette size had no record of *Citrobacter* spp. Table 4.7 demonstrates

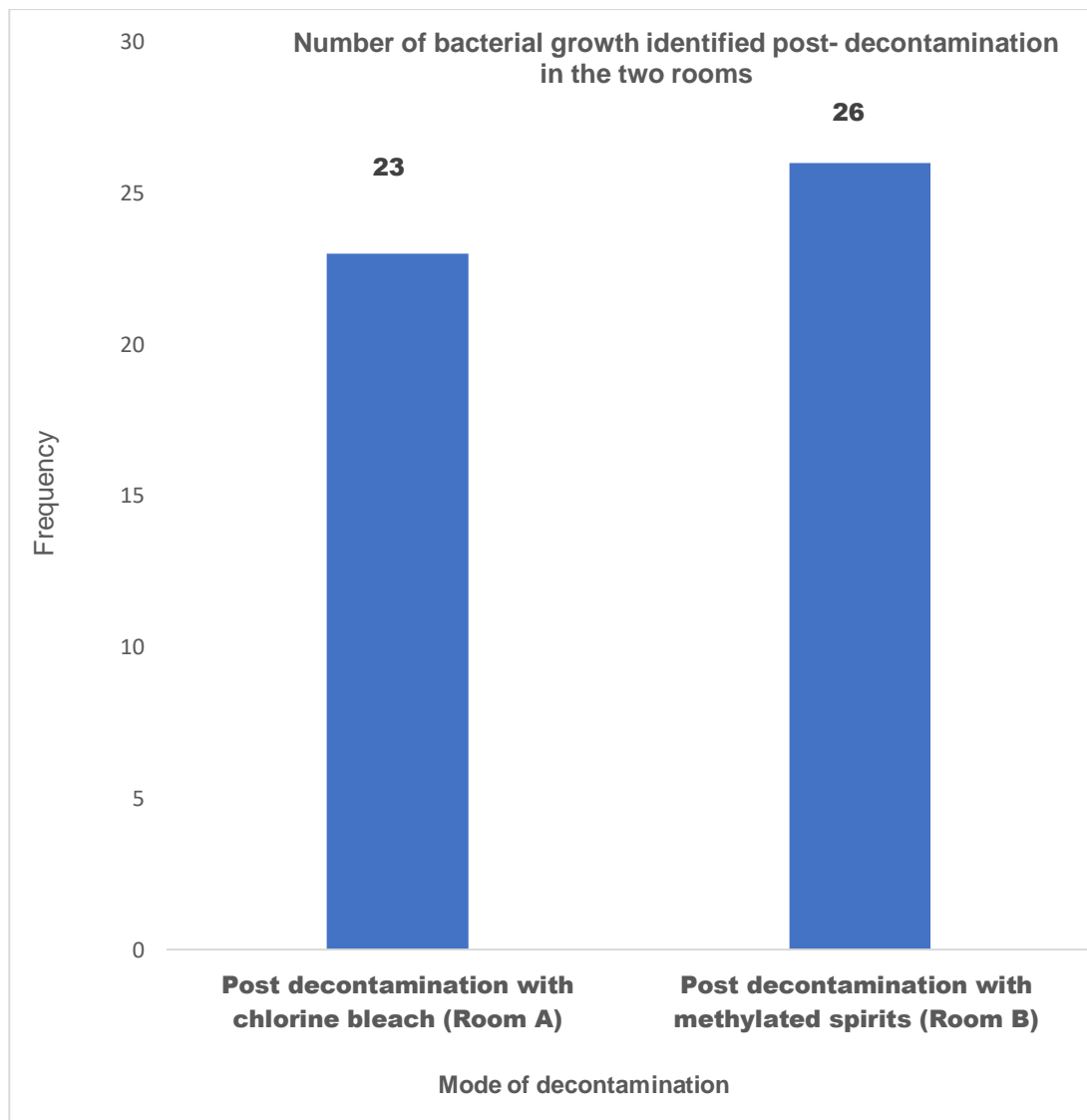


that the types of bacteria were not detected on all the items and *Bacillus* spp. was still the majority type of bacteria isolated and was present on most items.



**Figure 4.14 Distribution of pathogenic and non-pathogenic bacterial post-decontamination**

After decontamination Room A recorded a higher growth of pathogenic isolates namely *Staphylococcus aureus*, CoNS and *Shigella* spp. As shown by Figure 4.14 it was identified that 12 out of 23 growths were pathogenic compared to Room B which recorded nine out of 26 pathogenic isolates. In both rooms the non-pathogenic isolate was *Bacillus* spp. while the others were all pathogenic isolates including *Staphylococcus aureus*.



**Figure 4.15 Number of bacterial growth identified post-decontamination with chlorine bleach (Room A) and with methylated spirits (Room B)**

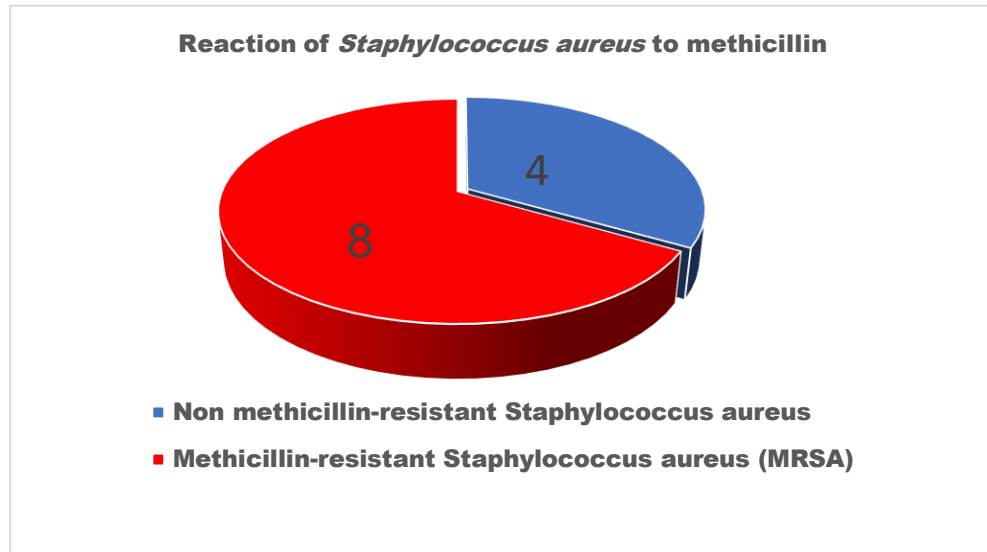
Figure 4.15 shows that a total of 26 bacteria remained on equipment surfaces when Methylated spirits were used as a mode of decontamination while 23 bacteria remained when chlorine bleach was used as a mode of decontamination. Statistically, there was no significant difference ( $p= 0.5835$ ) between the occurrence of bacterial isolates in the two rooms after decontamination.

**Table 4.8: Number of samples and bacterial growth**

	<b>Pre-cleaning Room A</b>	<b>Pre-cleaning Room B</b>	<b>Post-cleaning with chlorine bleach (Room A)</b>	<b>Post-cleaning with methylated spirits (Room B)</b>	<b>Total</b>
Number of samples	32	32	32	32	128
Bacterial growths (isolates)	34	38	23	26	-
Samples with No Bacterial Growth (NBG)	-	-	9	7	-

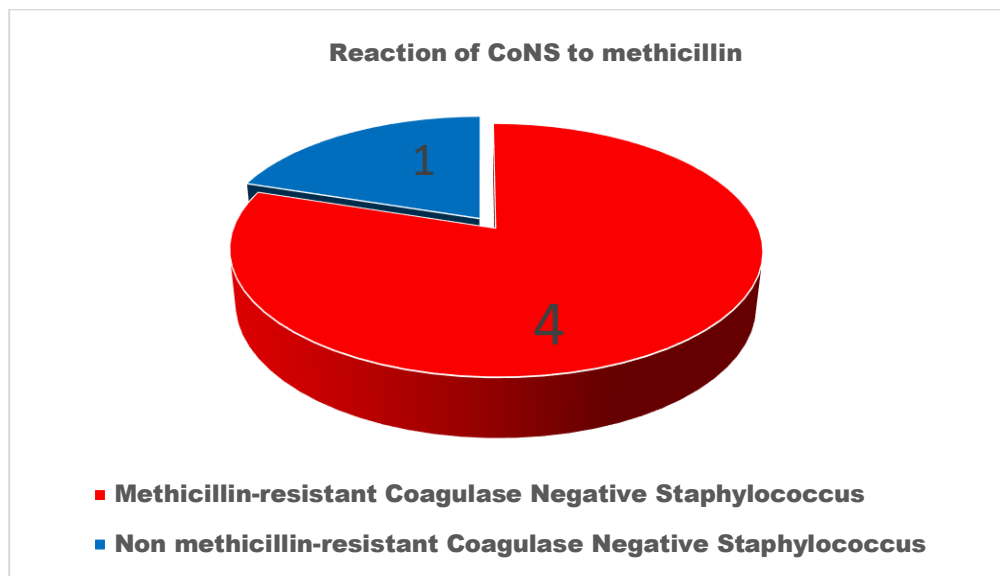
Table 4.8 shows that the total of 32 (n=32) samples taken pre-decontamination of equipment and accessories from Room A and Room B resulted in 34 and 38 bacterial growths respectively. The 32 (n=32) samples taken post decontamination with chlorine bleach led to the identification of 23 isolated bacteria in Room A while 32 samples taken post decontamination with methylated spirits led to the identification of 26 isolates in Room B. After decontamination, there were nine samples with No Bacterial Growth in Room A against seven samples with No Bacterial Growth in Room B. These samples were taken from the following items: the erect Bucky, the tube head collimators, the lead apron, the control panel, the exposure button, the cassettes and the horizontal Bucky handle in both rooms.

There was no significant difference ( $p=0.1149$ ) between the number of pathogens identified before and after decontamination in Room A. Similarly, there was no significant difference ( $p=0.2198$ ) between the number of pathogens identified before and after decontamination in Room B. There was however a significant difference in number ( $p=0.0267$ ) between pathogenic and non-pathogenic isolates identified before decontamination in both rooms. There was also a significant difference ( $p=0.0007$ ) in occurrence of types of isolates before decontamination in Room A and Room B.



**Figure 4.16** Reaction of *Staphylococcus aureus* to methicillin

The majority eight out of the 12 *Staphylococcus aureus* identified pre-decontamination were methicillin-resistant and four were sensitive to methicillin (Figure 4.16).



**Figure 4.17** Reaction of CoNS to methicillin

The majority four of CoNS identified pre-decontamination was methicillin-resistant and one was sensitive to methicillin (Figure 4.17).

**Table 4.9: Types of bacteria identified**

Types of bacteria	Microorganism	Pathogenic	Non-pathogenic	Room identified	
				Room A	Room B
Gram-negative bacteria	<i>Shigella</i> spp.	√		+	+
	<i>Shigella sonnei</i>	√		-	+
	<i>Citrobacter</i> spp.	√		+	+
	<i>Enterobacter</i> spp.	√		-	+
	<i>Klebsiella</i> spp.	√		-	+
	<i>Providencia rettgeri</i>	√		-	+
	<i>Salmonella</i> Paratyphi A	√		-	+
	<i>Salmonella</i> Typhi	√		-	+
Gram-positive bacteria	<i>Staphylococcus aureus</i>	√		+	+
	<i>Bacillus</i> spp.		√	+	+
	<i>Coagulase Negative Staphylococcus</i>	√		+	+

Note: Bacterium present in the room: + Bacterium not present in the room: -

Table 4.9 shows that out of the 11 bacteria isolated, eight were gram-negative while three bacteria were identified as gram-positive.

#### 4.4 Conclusion

The study demonstrated that radiology equipment and accessories are fomites of nosocomial pathogens and that they were highly contaminated with pathogenic *Shigella* spp., *Shigella sonnei*, *Citrobacter* spp., *Enterobacter* spp, *Klebsiella* spp., *Providencia rettgeri*, *Salmonella* Paratyphi A, *Salmonella* Typhi, *Staphylococcus aureus* and CoNS as well as with non-pathogenic *Bacillus* spp. These pathogens were identified pre and post decontamination with methylated spirits or chlorine bleach. There was however no significant difference ( $p=0.1149$ ) between the number of pathogens identified before and after decontamination in Room A. Similarly, there was no significant difference ( $p=0.2198$ ) between the number of pathogens identified before and after decontamination in Room B.

It was observed that radiographers partially practised infection control measures regarding washing of hands and cleaning of radiology equipment and accessories.

The next chapter will discuss the results presented in this chapter. The discussion will follow the objectives and aims of this study.

## CHAPTER FIVE

### DISCUSSION

#### 5.1 Introduction

A research discussion is the logical presentation of thought, systematic explanation and interpretation of the results obtained from a study compared with existing research related to a study (Annesley, 2010:1671). This study investigated radiology equipment and accessories as possible fomites of nosocomial pathogens. It also investigated the effectiveness of the two main chemical disinfectants used at the study site. Moreover, this study was undertaken to observe the cleaning procedure and practice by radiographers in general radiography.

The results of the study have demonstrated that radiology equipment and accessories used in the radiology department are reservoirs of nosocomial pathogens. The bacteria identified were *Bacillus* spp., *Enterobacter* spp., *Staphylococcus aureus*, *Coagulase negative Staphylococcus*, *Citrobacter* spp., *Providencia rettgeri*, *Salmonella Paratyphi A.*, *Klebsiella* spp., *Salmonella Typhi*, *Shigella* spp. and *Shigella sonnei*.

This chapter discusses the results of the study guided by the research objectives.

#### 5.2 Current cleaning procedures

At the study site observations were made on how the selected radiology equipment and accessories (exposure button, horizontal Bucky surface, control buttons, door handle, erect Bucky surface, erect Bucky handle, tube head handle, tube head collimators, horizontal Bucky handle, horizontal Bucky knob, cassette and lead apron) were cleaned. It was observed that there were no scheduled cleaning procedures for equipment and accessories. There was evidence of ad hoc cleaning done by radiographers between patient procedures especially when equipment or accessories come into contact with blood or other body fluid. Equipment and accessories that often come into direct contact with patients are the horizontal Bucky surface, the x-ray cassette and the erect Bucky surface. Additionally, radiographers at the study site did damp dusting or physical removal of dirt from equipment and accessories when it was evident that these items had accumulated a substantial amount of atmospheric dust or dirt. They did this by cleaning the equipment and accessories with cotton wool moistened with either chlorine bleach or methylated spirits. This practice of the radiographers at the study site is in congruence with a study in Nigeria by Eze,

Chiegwu and Okeji (2013:1407) where it was found that equipment and accessories were mainly cleaned by wiping with damp cloths. Chingarande and Chidakwa (2014:21) indicated that damp dusting using a lemon-based disinfectant is inadequate for the removal of microorganisms from equipment and accessories. Furthermore, the cleaning time was not enough as the study revealed that no radiographer spent more than three minutes per item to clean equipment and accessories, in contrast to the recommendation that the application of disinfectants requires an exposure time of at least 5–10 minutes (Abreu *et al.*, 2013:2723). The contact time for chlorine bleach was too short, but not for methylated spirits. The minimum contact time for chlorine bleach is 10 minutes (Leas, Sullivan, Han, Pegues, Kaczmarek & Umscheid, 2015:1). The contact time for methylated spirits containing 90% ethanol is a few seconds (CDC, 2018).

Regarding the use of gloves, it was observed that no radiographers wore gloves except in cases where it was evident that body fluid was present. All radiographers wore disposable gloves when cleaning equipment and accessories which were contaminated with body fluid. Although no radiographer washed his/her hands before gloves were worn, it was observed that all radiographers washed their hands after the use and disposal of gloves. In order to ascertain the availability of gloves in the department, a visit was made to the department's store room where it was found that there was an adequate supply of gloves available in the department. The unit managers however have to order them from the store and the observation demonstrated that they all regularly put in request for the disposable gloves.

Further observation revealed that there were no dedicated cassette covers available in the department however, when radiographers were examining body parts soiled with body fluid some of them covered the cassettes with x-ray envelopes especially when the part being examined had to come into direct contact with the cassette. The lack of cassette covers was partially attributed to the financial incapability of the department to acquire them as noted by Chingarande and Chidakwa (2014:19). Alternatively, some radiographers did place the contaminated body parts directly in contact with the cassettes and then cleaned them with chlorine bleach after exposure. On the other hand, radiographers did not cover equipment when the soiled body parts were in direct contact with them. The part to be imaged was placed in direct contact with the equipment e.g. the table Bucky surface which was later cleaned with either methylated spirits or chlorine bleach. In cases of blood being the body fluid, all radiographers cleaned the equipment or accessories with chlorine bleach. When there was no evidence of body fluid present, radiographers did not clean the equipment

which had direct contact with the patient. A similar study in Nigeria by Okaro, Eze and Ohagwu (2010:5) found that many radiographers do not clean equipment and accessories after every patient, making the spread of nosocomial pathogens likely.

Hand washing is an essential aspect of infection control procedures. The principal sources for the spread of pathogens are infectious patients and especially the hands of service providers (Viana, Santos & Oliveira, 2016:465-469). The most significant and effective method to prevent infection within the health-care setting including the radiology department is the appropriate application of hand hygiene by radiographers (Ontario Agency for Health Protection and Promotion, 2014:9). Observing the hand washing practices of radiographers at this study site demonstrated that radiographers did not routinely wash their hands after each patient. However, when these procedures involved body fluid hand washing was always practised. The procedure observed was that the hands were washed under running tap water using an antibacterial liquid detergent. In situations of water shortage radiographers used an alcohol-based hand sanitizer (Bactigel; Hydroalcoholic solution) to decontaminate the hands. The principal sources for the spread of pathogens are infectious patients and especially the hands of service providers (Viana, Santos & Oliveira, 2016:465-469). The most significant and effective method to prevent infection within the health-care setting including the radiology department is the appropriate application of hand hygiene by radiographers (Ontario Agency for Health Protection and Promotion, 2014:9).

According to literature health-care professionals practise inadequate washing of hands, cleaning of hospital equipment and items, and other aseptic procedures due to inadequate information and understanding of infection prevention and control procedures (Ghana Ministry of Health, 2015:2). However, the average time used for the hand washing procedure per radiographer during this study was within standard limits. According to WHO (2009b:2) the time period for an entire clinical hand wash procedure is 40 to 60 seconds. The failure of radiographers to wash their hands before and after each patient and also to clean or wipe cassettes, equipment and accessories before and after each patient could be attributed to a high workload (Fox & Harvey, 2008:308).

The results of this study then confirm the results of previous research studies that radiographers do not apply proper infection control. This information is therefore not new to the body of knowledge. Workload at this study site could also have played a role as the rooms (and radiographers) selected were the only functioning rooms during the study's data collection period, as all the other five rooms were non-functioning. This intensely increased the workload of radiographers at the study site.



### 5.2.1 **Storage area for equipment**

All the x-ray cassettes in the rooms observed for this study were stored on the floor due to no shelves being available for cassette storage at the study site. The department recently changed from a conventional radiography system to a computed radiography system therefore darkrooms including cassette hatches were no longer available. The storage of cassettes on the floor could be one of the reasons for the x-ray cassettes being predominately contaminated by *Bacillus* spp. as these organisms are found in soil/dust (Dwivedi & Tomar, 2016:230). The shoes of patients and staff might have carried grains of sand into the Radiology Department. The rooms under study have no hangers or rails for lead aprons, leaving them to be hung on tables, tops of cupboards or other available surfaces. Due to the weight of the lead aprons they frequently fell off these places on to the floor and were therefore also at risk of being contaminated by *Bacillus* spp. In a study by Boyle and Strudwick (2010:297) it was found that even when lead aprons were properly stored, they were inadequately cleaned by radiographers, making them accumulate dust which then presented them as possible fomites of nosocomial pathogens. All lead aprons used in Rooms A and B were contaminated with *Bacillus* spp. and *Staphylococcus aureus*. These organisms are found in soil and in health-care facilities (Dwivedi & Tomar, 2016:230).

### 5.3 **Pathogens identified pre-decontamination**

Eleven bacterial isolates in total were identified in Room A and Room B before the equipment and accessories were decontaminated. They were *Bacillus* spp., *Enterobacter* spp., *Staphylococcus aureus*, *Coagulase Negative Staphylococcus*, *Citrobacter* spp., *Providencia rettgeri*, *Salmonella Paratyphi A*, *Klebsiella* spp., *Salmonella Typhi*, *Shigella* spp. and *Shigella sonnei*.

The results from this study showed the presence of pathogenic bacteria. The only non-pathogenic isolate identified was *Bacillus* spp. representing one out of 11(9.09%) types of isolates. There was therefore a significant difference in number ( $p=0.0267$ ) between pathogenic and non-pathogenic isolates identified before decontamination in both rooms. There was also a significant difference ( $p=0.0007$ ) in occurrence of types of isolates before decontamination in Room A and Room B. With the exception of *Bacillus* spp. *Citrobacter* spp., *Staphylococcus aureus* and *Coagulase negative staphylococcus* which were identified in both Room A and Room B, *Providencia rettgeri*, *Enterobacter* spp., *Salmonella Paratyphi A*, *Klebsiella* spp., *Salmonella Typhi*, *Shigella* spp. and *Shigella sonnei* were only identified in Room B. This presented

Room B as having significantly ( $p=0.0007$ ) more types of nosocomial pathogens identified than Room A. The possible reason for the increased number and types of bacteria found in Room B could be attributed to the higher workload of the room due to its location. Patients preferred to be examined in Room B which is located on the ground floor instead of proceeding to Room A which is located on the first floor. Furthermore, in the event of a malfunctioning lift, most patients were examined in Room B. According to Fox and Harvey (2007:308) radiographers when busy do not regularly clean equipment and accessories. This information could be applicable to Room B.

*Bacillus* spp. was the only non-pathogenic organism and was also the most predominate bacteria detected. A total of 37 of these isolates were identified before decontamination. This number consisted of 23 (62.16%) bacterial isolates of *Bacillus* spp. identified in Room A and 14 (37.83%) isolates identified in Room B. The extent of colonisation in both rooms could be explained by the fact that *Bacillus* spp. is ubiquitous in nature with their spores able to resist environmental changes and withstand dry heat and certain chemical disinfectants for moderate periods (Narayanasamy, 2013:350). Non-pathogenic bacteria like *Bacillus* spp. can cause infections in numerous immuno-compromised patients. It is therefore essential that decontamination processes remove them adequately and effectively.

Ten out of 11 (90.90%) of the types of bacteria identified were pathogenic. *Staphylococcus aureus* was the most frequent (12 bacterial isolates) pathogenic organism identified. This included 3 (25%) and 9 (75%) bacterial isolates identified in Room A and Room B respectively. There were therefore 50% more *Staphylococcus aureus* isolates identified in Room B before decontamination. *Staphylococcus aureus* is listed amongst the organisms with the highest potential of causing nosocomial infections. *Staphylococcus aureus* organisms are transmitted by infected people, animals, indoor air, as well as external air which circulates into buildings and could contaminate equipment and accessories (Cheng, Sun, Zheng, Wu & Rui, 2014:6). *Staphylococcus aureus* is the leading cause of surgical site infections which is the second leading cause of HAIs according to Khan, Baig and Mehboob (2017:479). Foley *et al.* (2011:22) found that twenty two percent of the total number of HAIs comprises surgical site infections. Patients undergoing surgery do visit the radiology department for pre-and post-operative assessment. It is therefore essential to uphold infection control measures to help eliminate the cross infection of *Staphylococcus aureus* to equipment and accessories.

Next in frequency of occurrence of bacteria isolated were *Citrobacter* spp. (7) and *Coagulase negative staphylococcus* (5). There were 5 (71.43%) *Citrobacter* spp identified in Room A and 2 (28.57%) identified in Room B. Among the *Citrobacter* spp. identified in the study were *Citrobacter freundii* and *Citrobacter koseri* (*C. diversus*). A large number of *Citrobacter* strains are isolated frequently from patients or subjects as a secondary opportunistic pathogen (Dos Santos *et al.*, 2015:795). They are normally present in the human gastrointestinal (GI) tract. These *Citrobacter* strains rarely cause sporadic and epidemic episodes of meningitis, with a high incidence of brain abscesses and endocarditis in hospitalised patients, due to the impairment of their immune system by unrelated diseases (Dos Santos *et al.*, 2015:795). Although *Citrobacter freundii* was a commensal organism frequently found in the intestinal tract of human beings, it has lately been identified as the cause of a variety of infections particularly in hospitalised patients (Pepperell, Kus, Gardam, Humar, & Burrows, 2002:3555; Fung *et al.*, 2016: 634). These infections of the respiratory tract, the urinary tract, the gastrointestinal tract and of colonising wounds are caused by contaminated medical equipment and accessories (Dos Santos *et al.*, 2015:795).

*Coagulase negative staphylococcus* recorded 3 (60%) bacterial isolates in Room A and 2(40%) in Room B. CoNS are distinguished from the nearly related but more virulent *Staphylococcus aureus* by their failure to produce free coagulase (Roger & Fey, 2009:74). Presently, there are more than forty recognised species of CoNS which are found in healthy human skin and mucus membranes. Clinicians are often confronted with CoNS as contaminants of microbiological cultures. The frequent use of medical related devices and the practises of nursing procedures have increasingly presented CoNS as one of the major nosocomial pathogens (Roger & Fey, 2009:74; Becker, Heilmann & Peters, 2014:873). Furthermore, the authors noted that CoNS are more resistant to drugs (antibiotics) than *Staphylococcus aureus*. Tests showed that majority of CoNS and *Staphylococcus aureus* identified pre-decontamination during this study were methicillin-resistant. CoNS accounts substantially for foreign body-related infections (e.g. infections associated with the use of medical devices and implants) and infections in preterm new-borns (Becker, Heilmann & Peters, 2014:873).

There were two bacterial isolates identified for *Klebsiella* spp in Room B. A similar finding by Ochie and Ohagwu (2009:34) identified *Klebsiella* spp as the most predominant nosocomial pathogen whereas *Bacillus* spp was identified as the most predominant bacteria in this study. There are at least five species of *Klebsiella*. Amongst them are *Klebsiella pneumoniae* and *Klebsiella oxytoca* which are

associated with chronic respiratory tract infections, chronic atrophic rhinitis, and rhinoscleroma which are predominant in the tropics (Long, Prober & Fischer, 2018:138). According to Boonsarngsuk, Thungtitigul and Suwatanapongched (2011:1663), patients who suffer from chronic Klebsiella pneumonia visit the radiology department for various diagnostic procedures such as chest x-rays. The visits of such patients may lead to radiology equipment and accessories being possible fomites of nosocomial pathogens. Klebsiella spp. was identified on the erect Bucky surface as well as on the tube head handles during this study. It is therefore important for radiographers to properly clean erect Buckys after chest x-rays. The tube head handles must also be cleaned after each examination. They could have been contaminated by the radiographers' hands during these examinations. It again emphasises the importance of the hand washing procedure.

In this study there were two bacterial isolates identified for each of *Shigella* spp. and *Shigella sonnei* in Room B pre-decontamination. One bacterial isolate was identified for each of the following: *Salmonella* Paratyphi A, *Providencia rettgeri* and *Salmonella* Typhi (S. Typhi). The annual global approximate calculations for new infections of S. Typhi and S. Paratyphi A were 21 and 5 million respectively. These two types of organisms are responsible for the deadly bacterial infection, enteric fever (Buckle, Walker & Black, 2012:7). *Shigella* spp. causes diarrhoea which when not given immediate medical attention to can result in morbidity and death. According to the WHO (2011b) about 1.7 billion cases of childhood diarrhoeal disease occurs globally with approximately 1.9 million deaths annually. Almost a quarter of the deaths (525,000) occur amongst children below five years of age. There has also been an increasing resistance of *Shigella sonnei* to a variety of widely used antimicrobials leading to a noteworthy amount of indisposition and death linked with diarrhoea (Thompson, Duy & Baker, 2015:8). Asamoah, Ameme, Sackey, Nyarko and Afar (2016:1) noted that diarrhoea kills 14000 Ghanaian children annually. These authors stressed that the occurrence of diarrhoea is a result of inadequate cleaning of work environment and related equipment and accessories. One bacterial growth of *Providencia rettgeri* was identified in Room B pre-decontamination on the horizontal Bucky surface (table top surface). Not only has *Providencia rettgeri* been found to strongly build a resistance to antibiotics, it is also ranked the most common cause of catheter associated UTIs in the elderly (Wie, 2015:167). Hand-hygiene and the proper disinfection of the horizontal Bucky surface after each examination is therefore very important.

*Enterobacter* spp was identified to contaminate the erect Bucky surface and the exposure button in room B before decontamination of the items. *Enterobacter* spp. is a member of the genus *Enterobacter* that are motile gram-negative enteric bacilli belonging to the family *Enterobacteriaceae*. *Enterobacter* spp. appears well adapted for survival and threats to cause nosocomial infections (Patel & Patel, 2016:532). These nosocomial infections include bacteremia, lower respiratory tract infections, intra-abdominal infections and UTIs. It can spread through the faecal-oral route or through blood products (Sievert et al, 2013:5; Sartelli, 2010:2). The fact that it was also found on the exposure button again point to the dirty hands of the radiographer. The radiographer could have contaminated the erect Bucky as well as the exposure button after touching faeces/blood of a patient. The exposure buttons should also be cleaned especially after infectious patients' examinations have been done. Blood or other body fluid should immediately be removed using gloves. During this study the radiographers were however very aware of protecting themselves against body fluid.

#### 5.4

##### **The effectiveness of chemical disinfectants**

The effectiveness of chlorine bleach and methylated spirits were investigated. These were the two routinely used chemical disinfectants at the study site. A particular chemical disinfectant was assigned to each of the rooms. Swabs were taken after the chemical disinfectants were used to decontaminate the equipment and accessories. Comparisons were made between the number of bacteria identified pre-and post-decontamination with the chemical disinfectants.

*Bacillus* spp., *Staphylococcus aureus*, *Coagulase negative staphylococcus* and *Shigella* spp. were identified in Room A after chlorine bleach was used as the mode of decontamination. The 23 *Bacillus* spp. identified before decontamination reduced to 11, the number of bacterial isolates for CoNS identified before decontamination remained the same (3) after cleaning with the chlorine bleach. The number (3) of *Staphylococcus aureus* identified before decontamination with chlorine bleach increased to 8 after decontamination. Although no *Shigella* spp. was identified in Room A before the use of chlorine bleach, one *Shigella* spp. was identified post decontamination with chlorine. An interesting finding to mention is that the last swab taken post decontamination with chlorine showed a decrease of 24 *Bacillus* spp. to 11 isolates which is non-pathogenic in relation to the number of pathogenic isolates which showed an increase after decontamination. This increase could be due to the time frames discussed further on (which is a limitation of the study) as well as a resistance

to the disinfectant used. Limitations of this study will be discussed thoroughly in the following section.

On the other hand, four different bacteria namely *Bacillus spp.*, *Staphylococcus aureus*, *Citrobacter spp.* and *S. Paratyphi A* were identified in Room B after the use of methylated spirits. This time the number of *Bacillus spp.* (non-pathogenic isolates) identified before decontamination with methylated spirits showed an increase from 14 to 17 bacterial isolates after decontamination. However, *Staphylococcus aureus* recording 9 bacterial growths decreased to four after decontamination with methylated spirits. Additionally, *S. Paratyphi A* increased from two to four bacterial growths. The number of *Citrobacter spp.* decreased from two before decontamination to one after decontamination with methylated spirits. Despite the increase in the number of bacterial growth for *Bacillus* and *S. Paratyphi A*, the bacterial isolates *Enterobacter spp.*, *Providencia rettgeri*, *Klebsiella spp.*, *S. Typhi*, *Shigella spp.*, *Shigella sonnei* and CoNS identified pre-decontamination were not identified after cleaning with methylated spirits at Room B.

The following interesting patterns in the findings per room after the decontamination process were recorded:

The non-pathogenic isolates showed an increase after using methylated spirits in Room B, while most of the pathogenic isolates showed a decrease. This is in contrast with Room A, where the opposite was found after using chlorine (the non-pathogenic isolate *Bacillus spp.* showed a decrease, while the pathogenic isolates showed an increase). As indicated previously in chapter four, there was however no significant difference ( $p=0.1149$ ) between the number of pathogens identified before and after decontamination in Room A. Similarly, there was no significant difference ( $p=0.2198$ ) between the number of pathogens identified before and after decontamination in Room B.

Statistically, there was no significant difference ( $p=0.5835$ ) between the total occurrence of bacterial isolates identified in both rooms after decontamination. This disagrees with a study in Nigeria, where it was found that chlorine bleach was a more effective chemical disinfectant than methylated spirits, Chloroxylenol and Dichloroxylenol (Ochie & Ohagwu, 2009:33). These findings could be attributed to the following factors:

- The time frames between the first group of swabs taken, the decontamination process and the second group of swabs taken, were too long and also different for the two rooms. During that time the rooms were used and were likely to be

contaminated more. Organisms could have grown or rooms could have been cleaned therefore the initial swab count for both rooms could have increased adding more types of bacteria (especially in Room A) or could have decreased.

- Chlorine bleach was used for more than one day by the radiographers. This contravenes the recommendation by the Ghana Ministry of Health (2015:50), suggesting that chlorine bleach should be prepared for daily usage only.
- Some bacterial isolates could have been resistant to the type of disinfectant.

No definite conclusion can be drawn regarding the effectiveness of the two disinfectants due to the limitations of this study. These limitations will be further explained in more detail in the next section.

## **5.5 Limitations of study**

According to the researcher the knowledge of the radiographers about the research and the presence of the researcher in the rooms could have influenced them to act differently. The equipment and accessories had different surface areas which led to more swabs used to cover the bigger surface areas of certain items. This gave rise to different number of swabs taken from each of them, which could have led to the different findings of bacterial growth identified on them. The number of bacterial isolates identified on the different items per room could therefore not be compared. However, the same number of swabs per item was used for both rooms.

Furthermore, the time frames between the first group of swabs taken and the decontamination process (and post-decontamination swabbing) were long and also different for the two rooms and detergents used. The difference in swabbing dates was because all the equipment at the study site except those of Room A and Room B were under repair which led to an intense workload in both rooms and resulted in a delay of the research process. Room B had a higher workload due to its location (ground floor) and this presented access constraints with increased delays which was the reason for the later swabbing dates than Room A. As mentioned in the previous section this could have impacted on the findings regarding the bacterial growth in the two rooms at the time of decontamination. During the time that the rooms were used they could have been contaminated more or organisms could have grown more, or the items could have been cleaned, therefore the initial swabs counts could have increased also adding more types of bacteria (especially in Room A) or could have decreased due to the cleaning processes. The two rooms (and the effectiveness of the detergents) can therefore not be compared with one another due to the different time frames used.

Another limitation of the study was the fact that chlorine bleach was not prepared for daily use only and could have lost some of its effectiveness.

## 5.6 Recommendations

In future studies the decontamination process (and post-contamination swabbing) must be done immediately after the initial swabs are taken to know exactly how many organisms are present before and after decontamination. The dates must also be identical for all rooms and detergents tested. In this study a different number of certain types of pathogens were identified post-cleaning with the two detergents. The focus of future research could therefore be to determine which bacteria are resistant to certain detergents. Those detergents could be used in turn for the same surfaces to determine the best combination resulting in the least bacterial growth after decontamination.

Further chemical tests should be done on the *Bacillus* spp. to know whether *Bacillus cereus* and *Bacillus anthracis* are present on equipment and accessories as these species of *Bacillus* are pathogenic (Islam, Rahman, Pandey, Jha & Aeron, 2016:2).

The following are recommended to management and radiographers to help curb the spread and burden of HAIs;

- Hangers should be provided for the storage of lead aprons. In rooms where the lead aprons are not routinely used for a certain period of time, radiographers should still clean them regularly to prevent accumulation of dirt and dust.
- X-ray cassettes should not be stored on the floor. Instead cassettes should be stored in open boxes with dividers for different sizes or on shelves and should be cleaned daily by radiographers.
- Chlorine bleach used for cleaning should be prepared daily as chlorine bleach loses its effectiveness over time.
- Radiographers should be made aware of the contact time (10 minutes) of chlorine bleach.
- An effective infection control protocol and specific procedures for the cleaning of equipment and accessories should be established and observed by radiographers as essential methods to reduce cross contamination. This should include regular cleaning of the entire x-ray room (walls, door, etc.).
- The habit of hand washing should be cultivated. Radiographers should wash their hands thoroughly with soap and water or use an alcohol-based rub or other antiseptics pre and post each patient's procedure.
- Radiographers should be made aware of the rule that accessories and parts of equipment that come into direct contact with patients should be cleaned after every patient.
- X- ray cassettes used for procedures involving body fluid or for mobile examinations should be covered with disposable and water proof covers.
- The hand washing procedure should be discussed with staff and made visible at wash basins.



- Periodic screening of the bacterial load on radiographic equipment and accessories is important to assess the rate of bacterial growth as well as to assess the effectiveness of the decontamination methods.
- There was a shortage of methylated spirits at certain times in the department. The head of department is therefore urged to request enough of it from the central store.
- Audits of the infection control practices could be arranged on a regular basis (inspection by independent person from the infection control department).
- Lectures on new developments in infection control practices should be arranged during in-service training sessions.

## 5.7 Conclusion

The research established that radiology equipment and accessories which are often exposed to pathogens are possible fomites of nosocomial pathogens. In spite of the absence of documented departmental infection control procedures and policies at the study site, the radiographers partially practised infection control measures. They however did not wash hands or clean the equipment and accessories properly before and after each patient. Their hands and accessories were only washed after completing examinations where body fluids were involved. It was also observed that cassettes and lead aprons were not properly stored. Cassettes were kept on the bare floor while lead aprons and skirts were hung on to tables, tops of cupboards or other convenient surfaces. This could contaminate the cassettes and lead aprons with *Bacillus* spp. and *Staphylococcus aureus* presenting them as fomites for HAIs.

Strains of dangerous pathogens namely *Shigella sonnei*, *Shigella* spp., *Citrobacter* spp., *Enterobacter* spp., *Klebsiella* spp., *Providencia rettgeri*, *S. Paratyphi A*, *S. Typhi*, *Staphylococcus aureus* and CoNS, and *non-pathogenic Bacillus* spp. were identified to contaminate radiology equipment and accessories pre or post-decontamination with chlorine bleach and methylated spirits. It appeared that both the disinfectants (chlorine bleach and methylated spirits) which were applied with the intention of removing pathogens, could not effectively remove all bacterial isolates, but only specific ones. It is also noted that the majority of CoNS and *Staphylococcus aureus* were methicillin-resistant.

In summary, a brief list of the most important findings of this study, are the following:

- No documented departmental infection control protocol or procedures existed at the research site during the data collection period.
- Infection control measures were not properly applied by radiographers.
- The disinfectants (chlorine bleach and methylated spirits) were not 100% effective or not used properly.

- Dangerous bacterial isolates were identified as present on all the radiological equipment and accessories tested.
- The majority of CoNS and *Staphylococcus aureus* were methicillin- resistant.

Nosocomial pathogens were identified on radiologic equipment and accessories, and therefore, these items are possible fomites of nosocomial pathogens which are potential causes of nosocomial infections. It is important that the radiology equipment and accessories should be pathogen-free because the presence of any number of pathogen is sufficient to cause a significant threat to immuno-suppressed patients and overworked health-care workers.

## REFERENCES

- Abubakar, I., Stagg, R.H., Cohen, T. & Rodrigues, LC. 2016. Oxford specialist handbook of *Infectious disease epidemiology*. London: Oxford university press.
- Abreu, A.C., Tavares, R.R., Borges, A., Mergulhão, F. & Simões, M. 2013. Current and emergent strategies for disinfection of hospital environments. *Journal of Antimicrobial Chemotherapy*, 68(2):2718–2732, December.  
<https://www.semanticscholar.org/paper/Current-and-emergent-strategies-for-disinfection-of-Abreu-Tavares/3177a3605edcbb77e2777991d416a8b4ca8e30ca> [12 October 2019].
- Aitken, C. & Jeffries, D.J. 2001. Nosocomial spread of viral disease. *Clinical Microbiology Review*, 14(3):528-46, July. <https://cmr.asm.org/content/14/3/528> [15 March 2018]
- Allegranzi, B. & Pittet, D. 2008. Preventing infections acquired during health-care delivery. *The Lancet*, 372 (9651):1719–1720, November.
- Alvarez, C., Labarca, J. & Salles, M. 2010. Prevention strategies for methicillin-resistant *Staphylococcus aureus* (MRSA) in Latin America. *Brazilian Journal of Infectious Diseases*, 14(2):107-118, December.  
[http://www.scielo.br/scielo.php?script=sci\\_arttext&pid=S1413-86702010000800006](http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1413-86702010000800006) [1 July 2019].
- Anderson, D.J. 2011. Surgical site infections. *Infectious Disease Clinics of North America*, 25(1):135-53, March.  
<https://www.id.theclinics.com/article/S0891-5520%2810%2900091-7/abstract> [4 June 2016].
- Annesley, T.M. 2010. The Discussion Section: Your Closing Argument. *Clinical Chemistry*, 56(11):1671–1674, August. <https://www.ncbi.nlm.nih.gov/pubmed/20833779> [4 June 2016]
- Apanga, S., Adda, J., Issahaku, M., Amofa, J., Mawufemor, K.R.A. & Bugr, S. 2014. Post-Operative Surgical Site Infection in a Surgical Ward of a Tertiary Care Hospital in Northern Ghana. *International Journal of Research in Health Science*, 2(1):207-12, January.  
<http://www.ijrhs.org/sites/default/files/IntJResHealthSci-2-1-207.pdf> [16 July 2017]
- Asamoah, A., Ameme, D.K., Sackey, S.O., Nyarko, K.M. & Afar, E.A. 2016. Diarrhoea morbidity patterns in Central Region of Ghana. *The Pan African Medical Journal*, 25(1):17, October. <https://www.ncbi.nlm.nih.gov/pubmed/28149442> [12 August 2017].
- Becker, K., Heilmann, C. & Peters, G. 2014. “Coagulase-Negative Staphylococci.” *Clinical Microbiology Reviews*, 27(4): 870–926, October. <https://cmr.asm.org/content/27/4/870> [12 August 2017].
- Belmont Report. 1979. Basic principles of the Belmont report.  
<file:///C:/Users/Owo/Downloads/Basic%20Principles%20of%20the%20Belmont%20Report.pdf> [13 June 2016].
- Berg, K.E. & Latin, R.W. 2004. *Essentials of research methods in health, physical education, exercise science, and recreation*. Baltimore: Lippincott Williams & Wilkens.
- Bhattacharjee, A. 2012. *Social science research: principles, method and practical*. 2<sup>nd</sup> ed. Florida: Scholar Commons.
- Boonsarngsuk, V., Thungtitigul, P. & Suwatanapongched, T. 2011. Chronic Klebsiella pneumonia: a rare manifestation of Klebsiella pneumonia. *Journal of Thoracic Disease*,

7(9):1661-1664, September. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4598526/> [18 May 2017].

Boothe, D.M. 2012. *Small animal clinical pharmacology and therapeutics*. 2<sup>nd</sup> ed. St Louis: Elsevier Saunders.

Boye, A., Siakwa, P.M., Boampong, J.N., Kuffour, G.A., Ephraim, R.K.D., Amoateng, P., Obodai, G. & Penu, D. 2012. Asymptomatic urinary tract infections in pregnant women attending antenatal clinic in Cape. *Ghana Journal of Medical Research*, 1(6):74-83, January. <https://www.semanticscholar.org/paper/Asymptomatic-urinary-tract-infections-in-pregnant-Boye-Siakwa/92a9fd41608484a756aae0937b9c0db7c17a8a72> [11 May 2017].

Boyle, H. & Strudwick, R.M. 2010. Do lead rubber aprons pose an infection risk? *Radiography*, 16(4):297-303, November. <https://www.sciencedirect.com/science/article/abs/pii/S1078817410000386> [11 November 2016].

Buckle, G.C., Walker, C.L.F. & Black, R.E. 2012. Typhoid fever and paratyphoid fever: systematic review to estimate global morbidity and mortality for 2010. *Journal of Global Health*, 2(1):1-9, June. <https://www.ncbi.nlm.nih.gov/pubmed/23198130> [11 May 2017].

Campeau, F.E. & Fleitz, J. 2010. *Limited radiography*. 3<sup>rd</sup> ed. New York: Delmar Publishers. Centers for Disease Control and Prevention. 2011. Vital signs: Central line-associated blood stream infections – United States, 2001, 2008, and 2009. *Annals of Emergency Medicine*, 58(5):447-450. <https://www.ncbi.nlm.nih.gov/pubmed/21368740> [11 May 2017].

Centers for Disease Control and Prevention. 2016. Diseases and organisms in health-care settings. Health-care associated infections (HAIs). Atlanta, Georgia. <https://www.cdc.gov/hai/organisms/> [25 June 2018].

Centers for Disease Control and Prevention. 2017. 2017 National and State Health-care-Associated Infections Progress Report. [www.cdc.gov/hai/progress-report/index.html](http://www.cdc.gov/hai/progress-report/index.html) [22 June 2018].

Centers for Disease Control and Prevention. 2016. Chemical Disinfectants: Guideline for Disinfection and Sterilization in Healthcare Facilities 2008. <https://www.cdc.gov/infectioncontrol/guidelines/disinfection/disinfection-methods/chemical.html> [22 January 2020].

Chang, S., Sethi, A.K., Stiefel, U., Cadnum, J.L. & Donskey, C.J. 2010. Occurrence of skin and environmental contamination with methicillin-resistant *Staphylococcus aureus* before results of polymerase chain reaction at hospital admission become available. <https://doi.org/10.1086/652775> [02 January 2019].

Cheng, C., Sun, J., Zheng, F., Wu, K. & Rui, Y. 2014. Molecular identification of clinical “difficult-to-identify” microbes from sequencing 16S ribosomal DNA and internal transcribed spacer 2. *Annals of Clinical Microbiology and Antimicrobials*, 13, 1-7. <http://www.ann-clinmicrob.com/content/13/1/1> [14 July 2017].

Chingarande, G.R & Chidakwa, L. 2014. Infection control in a resource constrained radiology department: a case study of a Zimbabwean hospital. *The South African Radiographers*, 52(1):1-21, May. <https://www.sar.org.za/index.php/sar/article/view/278> [12 December 2016].

Chiesa, M. & Hobbs, S. 2008. Making sense of social research: how useful is the Hawthorne effect? *European Journal of Social Psychology*, 38(1):67-74, September. <https://onlinelibrary.wiley.com/doi/abs/10.1002/ejsp.401> [19 December 2018].

- Chu, K., Maine, R. & Trelles, M. 2014. Cesarean section surgical site infections in Sub-Saharan Africa: A multi-country study from Medecins sans Frontieres. *World Journal of Surgery*, 35, 1169–1172, October. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4300431/> [12 December 2016].
- Conceição, T., Coelho, C., Santos, S.I., de Lencastre, H. & Aires-de-Sousa, M. 2016. Methicillin-resistant *Staphylococcus aureus* in the community in Luanda, Angola: blurred boundaries with the hospital setting. *Microbial Drug Resistance*, 22(1):22-27, January. <https://www.liebertpub.com/doi/10.1089/mdr.2015.0236> [19 December 2018].
- Corey, G.R. 2009. Staphylococcus aureus bloodstream infections: definitions and treatment. *Clinical Infectious Disease*, 48(4):254-259. [http://cid.oxfordjournals.org/content/48/Supplement\\_4/S254.full.pdf+html](http://cid.oxfordjournals.org/content/48/Supplement_4/S254.full.pdf+html) [ 6 August 2015].
- Cox, S., Burahee, A., Lucier, A., Fernando, C. & Mugambi, M.S. 2016. Identity tags: A vector for cross-infection? *South African Medical Journal*, 106(5):494-496, May. <https://www.semanticscholar.org/paper/Identity-tags%3A-A-vector-for-cross-infection-Cox-Burahee/88ee21ecbd6ea368473f907fd7e7f1cd32eba722> [ 6 August 2017].
- Creswell, J.W. 2014. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* 4<sup>th</sup> ed. Los Angeles: Sage Publications Limited.
- Dancer, S.J. 2014. Controlling hospital-acquired infection: focus on the role of the environment and new technologies for decontamination. *Clinical Microbiology Reviews*, 27(4):665-690, October. <https://www.ncbi.nlm.nih.gov/pubmed/25278571> [ 6 August 2017].
- Dancer, S.J., Stewart, M., Coulombe, A.C. & Viridi, M. 2012. *Surgical site infection linked to contaminated surgical instrument*. [http://infectioncontrolplus.com.au/wp-content/uploads/2013/08/Dancer\\_2012\\_JHI-SSI-Due-To-Contaminated-Instruments.pdf](http://infectioncontrolplus.com.au/wp-content/uploads/2013/08/Dancer_2012_JHI-SSI-Due-To-Contaminated-Instruments.pdf) [18 April 2015].
- Da Silva, N., Taniwaki, M.H., Junqueira, V.C.A., Ailveira, N.F.A., Do-Nascimento, M.S. & Gomes, R.A.R. 2013. *Microbiological examination methods of food and water: A laboratory manual*. Boca Raton: CRC Press.
- Doll, M., Hewlett, A.L. & Bearman, G. 2016. Infection Prevention in the Hospital from Past to Present: Evolving Roles and Shifting Priorities. *Current Infectious Diseases Report*, 18(5):16-21, May. <https://link.springer.com/article/10.1007/s11908-016-0523-z> [21 May 2018].
- Donlan, R.M. 2008. Biofilms on central venous catheters: is eradication possible? *Current Topics in Microbiology Immunology*, 322, 133–161, January. [https://link.springer.com/chapter/10.1007/978-3-540-75418-3\\_7](https://link.springer.com/chapter/10.1007/978-3-540-75418-3_7) [21 May 2018].
- Dos Santos, G., Solidônio, E.G., Costa, M., Melo, R., De Souza, I., Silva, G.R. & Sena, K.X.F.R. 2015. “Study of the Enterobacteriaceae group CESP (Citrobacter, Enterobacter, Serratia, Providencia, Morganella and Hafnia): a review,” in *The Battle Against Microbial Pathogens: Basic Science, Technological Advances and Educational Programs*, ed A. Méndez-Vilas (Badajoz: Formatex), 794–805.
- Ducel, J.F. & Nicolle, L. 2002. *Prevention of hospital-acquired infections: A practical guide*. Geneva: WHO. <https://apps.who.int/iris/handle/10665/67350> [19 June 2019].
- Du-Plooy-Cilliers, D.F. 2014. Research paradigms and traditions. In Plooy-Cilliers, F., Davis, C. & Bezuidenhout, R.M. (eds.) *Research Matters*, Cape Town: Juta & Company Ltd. 18-35.
- Dwivedi, P. & Tomar, R.S. 2016. Growing of Staphylococcus aureus cells with soil components enhances virulence in mice caused by soft tissue infections. *International*

*Journal of Pharma and Bio Sciences*, special edition, 230-235, April. -  
<https://www.researchgate.net/publication/301683650> Growing of *Staphylococcus aureus* cells with soil components enhances virulence in mice caused by soft tissue infections [7 April 2019].

Easy Tract Ghana. 2019. Map of Ghana.  
[https://www.easytrackghana.com/travel-information-ghana\\_maps.php](https://www.easytrackghana.com/travel-information-ghana_maps.php) [12 June 2019].

Ehrlich, R.A. & Coakes, D.M. 2013. *Patient care in radiography with introductory to medical imaging*. 8<sup>th</sup> ed. St. Louis: Mosby Elsevier.

Ehrlich, R.A. & Daly, J.A. 2009. *Patient care in radiography*. 7<sup>th</sup> ed. St. Louis: Mosby Elsevier.

Eisenberg, R.L. 2004. *Radiology and the Law: Malpractices and other issues*. New York: Springer-Verlag.

European Centre for Disease Prevention and Control. 2013. *Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals. 2011-2012*.  
<http://www.ecdc.europa.eu/en/publications/Publications/healthcare-associated-infections-antimicrobialuse-PPS.pdf> [23 March 2016].

European Centre for Disease Prevention and Control. 2015. *Healthcare-associated infections*.  
[http://ecdc.europa.eu/en/healthtopics/Healthcare-associated\\_infections/Pages/index.aspx](http://ecdc.europa.eu/en/healthtopics/Healthcare-associated_infections/Pages/index.aspx) [13 August 2015].

Eze, J.C., Chiegwu, H.U. & Okeji, M.C. 2013. An Investigation of X-Ray Equipment and Accessories as Possible Vectors of Nosocomial Infection in Government and Private Hospitals in Anambra State, Nigeria. *British Journal of Applied Science & Technology*, 3(4): 1405-1413, August.

Foley, S.L., Chen, A.Y., Simjee, S. & Zervos, M.J. 2011. *Molecular techniques for the study of hospital acquired infection*. New Jersey: John Wiley and sons.

Forder, A.A. 2007. A brief history of infection control - past and present. *South African Medical Journal*, 97(11):1161-1164, November.  
<https://www.researchgate.net/publication/5601248> A brief history of infection control - Past and present [12 June 2019].

Fox, M. & Harvey, J.M. 2007. An investigation of infection control for x-ray cassettes in a diagnostic imaging department. *Radiography*, 14(4):306-311.  
<http://www.sciencedirect.com/science/article/pii/S1078817407000892> [18 March 2015].

Fung, T.C., Bessman, N.J., Hepworth, M.R., Kumar, N., Shibata, N., Kobuley, D. & Sonnenberg, G.F. 2016. Lymphoid tissue-resident commensal bacteria promote members of the IL-10 cytokine family to establish mutualism. *Immunity*, 44(3): 634–646.  
<http://doi.org/10.1016/j.immuni.2016.02.019> [8 August 2018].

Ghana Ministry of Health. 2015. *National Policy and Guidelines for Infection Prevention and Control in Health Care Settings*. Accra: Government Printer.

Guggenbichler, J.P., Assadian, O., Boeswald, M. & Kramer, A. 2011. Incidence and clinical implication of nosocomial infections associated with implantable biomaterials – catheters, ventilator-associated pneumonia, urinary tract infections. *GMS Krankenhaushygiene Interdisziplinär*, 6(1): 1-19, December.  
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3252661/> [8 August 2018].

- Hair-Jr., J.F., Celsi, M.W., Money, A.H., Samouel, P. & Page, M.J. 2011. *Essentials of business research methods*. 2<sup>nd</sup> ed. Armonk: ME Sharpe.
- Hancock, D.R. & Algozzine, R. 2017. *Doing case study research: a practical guide for beginning researchers*. 3<sup>rd</sup> ed. New York: Teachers College Press.
- Hansen, S., Schwab, F., Zingg, W., Gastmeller, P. & the PROHIBIT study group. 2018. Process and outcome indicators for infection control and prevention in European acute care hospitals in 2011 to 2012 – Results of the PROHIBIT study. *Euro surveillance*. 23(21):1560-7917, May. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6152214/> [19, December 2019].
- Hirai, Y. 1991. Survival of bacteria under dry conditions; from a viewpoint of nosocomial infection. *Journal Hospital Infection*, 19(3):191–200, November. <https://www.ncbi.nlm.nih.gov/pubmed/1685507> [19, December 2016].
- Horton, R. & Parker, L. 2002. In: *Informed infection control practice*. 2nd ed. Edinburgh: Churchill Livingstone.
- Hunter, J.D. 2012. Ventilator associated pneumonia. *British Medical Journal*, 344(3325):40-44, May. <https://pmj.bmj.com/content/82/965/172.short> [26 November 2019].
- Hussein, J., Mavalankar, D., Sharma, V.S. & D'Ambruoso, L. 2011. A review of health system infection control measures in developing countries: what can be learned to reduce maternal mortality. *Globalization and Health*, 7(14):2 -10, May. <https://www.ncbi.nlm.nih.gov/pubmed/21595872> [26 November 2019].
- IBM Corporation. 2017. IBM SPSS Statistics version 25. [www.ibm.com/legal/copytrade.shtml](http://www.ibm.com/legal/copytrade.shtml) [[26 November 2019].
- Islam, M.T., Rahman, M., Pandey, P., Jha, C.K. & Aeron, A. 2016. *Bacilli and Agrobiotechnology*. Cham: Springer.
- Khan, H.A., Baig, F.K. & Mehboob, R. 2017. Nosocomial infections: Epidemiology, prevention, control and surveillance: *Asian Pacific Journal of Tropical Biomedicine*, 7(5):478-482, December. <https://www.sciencedirect.com/science/article/pii/S2221169116309509> [26 November 2019].
- Kim, J.S., Kim, H.S., Park, J.Y., Koo, H.S., Choi, C.S., Song, W., Cho, H.C. & Lee, K.M. 2012. Contamination of x-ray cassettes with methicillin-resistant *staphylococcus aureus* and methicillin-resistant *staphylococcus haemolyticus* in a radiology department. *Annals of laboratory medicine*, 32(3):206-209, January. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3339301/> [26 November 2019].
- Klevens, R.M., Edwards, J.R., Richards, C. L. Jr., Horan, T.C., Gaynes, R.P., Pollock, D.A. & Cardo, D.M. 2007. Estimating health care-associated infections and deaths in U.S. hospitals, 2002 *Public Health Report*, 122(2):160-166. [http://www.cdc.gov/HAI/pdfs/hai/infections\\_deaths.pdf](http://www.cdc.gov/HAI/pdfs/hai/infections_deaths.pdf) [13 August 2015].
- Kothari, C., R. 2004. *Research methodology methods and techniques*. Second revised edition New Delhi: New International Publishers.
- Kowalski, W. 2012. *Hospital airborne infection control*. Florida: Chemical Rubber Company.
- Leas, B.F., Sullivan, N., Han, J.H., Pegues, D.A., Kaczmarek, J.L. & Umscheid, C.A. 2015. Environmental Cleaning for the Prevention of Healthcare-Associated Infections. *Technical Report*, 22 <file:///C:/Users/Owuo/Downloads/healthcare-infections-report-150810.pdf> [26 November 2019].

- Lerouge, S. & Simmons, A. 2012. *Sterilisation of biomaterials and medical devices* Philadelphia: Woodhead.
- Long, S.S., Prober, G.C. & Fischer, M. 2018. Principles and practises of pediatric infectious diseases. 5<sup>th</sup> ed. Philadelphia: Elsevier.
- Lutterodt, M.G., Afriyie, D.K., Asare, G., Amponsah, S.K., Abutiati, H. & Darko, D. 2014. Antimicrobial Use and Susceptibility Pattern of Uropathogens Associated with Urinary Tract Infections at the Ghana Police Hospital. *Global Journal of Pharmacology*, 8(3):306-315, April. [https://www.researchgate.net/publication/261696856\\_Antimicrobial\\_Use\\_and\\_Susceptibility\\_Pattern\\_of\\_Uropathogens\\_Associated\\_with\\_Urinary\\_Tract\\_Infections\\_at\\_the\\_Ghana\\_Police\\_Hospital](https://www.researchgate.net/publication/261696856_Antimicrobial_Use_and_Susceptibility_Pattern_of_Uropathogens_Associated_with_Urinary_Tract_Infections_at_the_Ghana_Police_Hospital) [13 August 2015].
- Mbim, E.N., Mboto, C. & Agbo, B.E. 2016. A Review of Nosocomial Infections in Sub-Saharan Africa. *British Microbiology Research Journal*, 15(1):1-11, May. [https://www.researchgate.net/publication/334549134\\_Nosocomial\\_Infections\\_in\\_Sub-Saharan\\_Africa](https://www.researchgate.net/publication/334549134_Nosocomial_Infections_in_Sub-Saharan_Africa) [13 August 2015].
- McDonnell, G. & Sheard, D. 2012. *A practical guide to decontamination in healthcare*. Chichester: Wiley black.
- McGlone, S. M., Bailey, R.R., Zimmer, S.M., Popovich, M.J., Tian, Y., Ufberg, P.R., Muder, R. & Lee, B.Y. 2012. The economic burden of Clostridium difficile. *Clinical Microbiology and Infection*, 18(3):282–289, September. <https://www.sciencedirect.com/science/article/pii/S1198743X14616335> [13 August 2015].
- McGraw-Hill Higher Education. 2003. *The CARS checklist (Credibility, Accuracy, Reasonableness, Support)*. [http://novella.mhhe.com/sites/0079876543/student\\_view0/research\\_center-999/research\\_papers30/conducting\\_web-based\\_research.html](http://novella.mhhe.com/sites/0079876543/student_view0/research_center-999/research_papers30/conducting_web-based_research.html) [9 June 2015].
- Melsen, W.G., Rovers, M.M., Koeman, M. & Bonten, M.J. 2011. Estimating the attributable mortality of ventilator-associated pneumonia from randomized prevention studies. *Critical Care Medicine*, 39(12) 1-7. [https://www.researchgate.net/publication/51498587\\_Estimating\\_the\\_attributable\\_mortality\\_of\\_ventilator-associated\\_pneumonia\\_from\\_randomized\\_prevention\\_studies](https://www.researchgate.net/publication/51498587_Estimating_the_attributable_mortality_of_ventilator-associated_pneumonia_from_randomized_prevention_studies) [9 June 2015].
- Merrill, R.M. 2013. *Introduction to epidemiology*. 6<sup>th</sup> ed. Massachusetts: Jones & Bartlett.
- Mirza, S.K., Tragon, R., Fukui, M.B. Hartman, M.S & Hartman, A.L. 2015. Microbiology for Radiologists: How to Minimize Infection Transmission in the Radiology Department. *Radio Graphics*, 35(4):1231–1244, August. <https://pubs.rsna.org/doi/full/10.1148/rq.2015140034> [25 July 2018].
- Mollura, D.J., Palmore, T.N., Folio, L.R. & Bluemke, D.A. 2015. Radiology Preparedness in Ebola Virus Disease: Guidelines and Challenges for Disinfection of Medical Imaging Equipment for the Protection of Staff and Patients. *Radiology*, 275(2):538-544, January. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4456180/> [25 June 2018].
- Morrison, E.E. 2016. *Ethics in Health Administration: A Practical approach for Decision Makers*. 3<sup>rd</sup> ed. United States of America: Jones & Bartlett.
- Muehlenbein, M.P. 2015. *Basics in human evolution*. San Diego: Academic press.
- Nagaraja, P.A. 2011. *Hospital sterilisation*. Panama: Jaypee brothers medical.
- Narayanasamy, P. 2013. *Biological Management of Diseases of Crops.: Characteristics of Biological Control Agents*. Volume 1. Dordrecht: Springer.



- Nassaji, H. 2015. Qualitative and descriptive research: Data type versus data analysis *Language Teaching Research*, 19(2):129–132, April  
<https://journals.sagepub.com/doi/full/10.1177/1362168815572747> [18 October 2016].
- Nejad, S.B., Allegranzi, B., Syed, S.B., & Ellis, B. 2011. Health-care associated infection in Africa: A systematic review. *Bulletin of the World Health Organisation*, 89(10):757-765, October. [https://www.researchgate.net/publication/51799332\\_Health-care-associated\\_infection\\_in\\_Africa\\_A\\_systematic\\_review](https://www.researchgate.net/publication/51799332_Health-care-associated_infection_in_Africa_A_systematic_review) [18 October 2016].
- Newman, M.J. 2009. Nosocomial and community acquired infections in Korle Bu Teaching Hospital, Accra. *West African Journal of Medicine*, 28(5):300-3, October.  
[https://www.researchgate.net/publication/43100770\\_Nosocomial\\_and\\_Community\\_Acquired\\_Infections\\_in\\_Korle\\_Bu\\_Teaching\\_Hospital\\_Accra](https://www.researchgate.net/publication/43100770_Nosocomial_and_Community_Acquired_Infections_in_Korle_Bu_Teaching_Hospital_Accra) [25 June 2016].
- New York State: Department of Health. 2014. *Hospital acquired infections*. Albany: Government Printer.
- Nuremberg Code. 1947. Trials of war criminals before the Nuremberg Military Tribunals under Control Council Law. *War criminal*, 10(2):181-182.  
[https://www.loc.gov/rr/frd/Military\\_Law/pdf/NT\\_war-criminals\\_Vol-II.pdf](https://www.loc.gov/rr/frd/Military_Law/pdf/NT_war-criminals_Vol-II.pdf) [02 May 2015].
- Ochie, K. & Ohagwu, C.C. 2009. Contamination of x-ray equipment and accessories with nosocomial bacteria and the effectiveness of common disinfecting agents. *African Journal of Basic and Applied Science*, 1(1-2): 31-35, September.  
[https://www.researchgate.net/publication/257421095\\_An\\_Investigation\\_of\\_X-Ray\\_Equipment\\_and\\_Accessories\\_as\\_Possible\\_Vectors\\_of\\_Nosocomial\\_Infection\\_in\\_Government\\_and\\_Private\\_Hospitals\\_in\\_Anambra\\_State\\_Nigeria](https://www.researchgate.net/publication/257421095_An_Investigation_of_X-Ray_Equipment_and_Accessories_as_Possible_Vectors_of_Nosocomial_Infection_in_Government_and_Private_Hospitals_in_Anambra_State_Nigeria) [25 December 2019]
- Okaro, A.O., Eze, C.U. & Ohagwu, C.C. 2010. Knowledge and attitude of radiographers towards HIV/AIDS patients attending radiology clinics in Enugu state, Nigeria. *European Journal of Scientific Research*, 39(3):440-447, January.  
[https://www.researchgate.net/profile/Christopher\\_Ohagwu2/publication/238739921\\_Knowledge\\_and\\_Attitude\\_of\\_Radiographers\\_towards\\_HIVAIDS\\_Patients\\_Attending\\_Radiology\\_Clinics\\_in\\_Enugu\\_State\\_Nigeria/links/53fd45460cf22f21c2f7e1bc.pdf](https://www.researchgate.net/profile/Christopher_Ohagwu2/publication/238739921_Knowledge_and_Attitude_of_Radiographers_towards_HIVAIDS_Patients_Attending_Radiology_Clinics_in_Enugu_State_Nigeria/links/53fd45460cf22f21c2f7e1bc.pdf) [11 September 2018].
- Ontario Agency for Health Protection and Promotion (Public Health Ontario), Provincial Infectious Diseases Advisory Committee. 2014. *Best Practises for Hand Hygiene in All Health Care Settings*. 4th ed. Toronto, ON: Queen’s Printer for Ontario.
- Onwuegbuzie, A.J. & Frels, R. 2016. *7 Steps to A Comprehensive Literature Review: A Multimodal & Cultural Approach*. London: SAGE Publication.
- Orellana, R.C., Hoet, A.E., Bell, C., Kelley, C., Lu, B., Anderson, S.E. & Stevenson, K.B. 2016. Methicillin-resistant *Staphylococcus aureus* in Ohio EMS Providers: A statewide cross-sectional study. *Prehospital Emergency Care*, 20(2):184-190, October.  
<https://www.tandfonline.com/doi/abs/10.3109/10903127.2015.1076098?journalCode=ipec20> [September 2018].
- Ozumba, U.C. 2005. Increasing incidence of bacterial resistance to antibiotics by isolates from the urinary tract. *Nigerian Journal of Clinical Practises*, 8(2):107–109, December.  
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5629843/> [18 June 2015].
- Patel, K.K. & Patel, S. 2016. *Enterobacter* spp.: An emerging nosocomial infection. *International Journal of Applied Research*, 2(11): 532-538, October.  
<https://pdfs.semanticscholar.org/3ef0/634d6f9aa132d0d17fff7f69320747d7ca83.pdf> [16 June 2016].

- Pascoe, G. 2014. 'Sampling', In Plooy-Cilliers, F., Davis, C. & Bezuidenhout, R.M. (eds.), *Research Matters*, Somerset West: Juta & Company Ltd: 131-142.
- Peleg, A.Y. & Hooper, D.C. 2010. Hospital-acquired infections due to gram-negative bacteria. *The New England Journal of Medicine*, 362(19):1–15, May. <https://www.ncbi.nlm.nih.gov/pubmed/20463340> [14 August 2017].
- Pepperell, C., Kus, J.V., Gardam, M.A., Humar, A. & Burrows, L.L. 2002. Low-Virulence *Citrobacter* Species Encode Resistance to Multiple Antimicrobials. *Antimicrobial Agents and Chemotherapy*, 46(11), 3555–3560. <http://doi.org/10.1128/AAC.46.11.3555-3560.2002> [8 August 2018].
- Raka, L. & Osmani, G.M. 2012. Infection Control in Developing World, Infection Control - Updates, Christopher Sudhakar (Ed.). <http://www.intechopen.com/books/infection-control-updates/infection-control-in-developing-world> [12 August 2016].
- Roessner, V. 2014. Large sample size in child and adolescent psychiatric research: the way of salvation? *European Child & Adolescent Psychiatry*, 23:1003–1004. <https://link.springer.com/article/10.1007/s00787-014-0635-7> [25 August 2020].
- Rogers, K. 2011. *Biochemistry, Cells, and Life: bacteria and viruses*. New York: Britannica Educational.
- Roger, K.L. & Fey, P.D. 2009. Coagulase-negative staphylococcal infections. *Infectious disease clinics of North America*, 23(1):73-98, March. <https://cmr.asm.org/content/27/4/870> [12 February 2017].
- Rutala, W.A. & Weber, D.J. 1997. Uses of inorganic hypochlorite (bleach) in health-care facilities. *Clinical Microbiology Reviews*, 10(4):597–610, October. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC172936/> [23 April 2016].
- Saint, S., Krein, S.L & Stock, R.W. 2015. *Preventing Hospitals Infections: Real-World Problem. Realistic Solution*. New York: Oxford University Press.
- Sakorafas, G.H. & Tsiotou, A.G. 2005. *Septic shock: current pathogenetic concepts, optimal management and future perspective*. New York: Nova.
- Samuel, S.O., Kayode, O.O., Musa, O.I, Nwigwe, G.C., Aboderin A.O., Salami, T.A.T. & Taiwo, S.S. 2010. Nosocomial infections and the challenges of control in developing countries. *African Journal of Clinical and Experimental Microbiology*, 11(2):102-110, May. [https://www.researchgate.net/publication/273987032\\_Nosocomial\\_infections\\_and\\_the\\_challenge\\_of\\_control\\_in\\_developing\\_countries](https://www.researchgate.net/publication/273987032_Nosocomial_infections_and_the_challenge_of_control_in_developing_countries) [24 July 2018].
- Sartelli, M. 2010. A focus on intra-abdominal infections. *World Journal of Emergency Surgery*, 5:9, March. <https://wjes.biomedcentral.com/articles/10.1186/1749-7922-5-9> [14 September 2020].
- Schachner, L.A. & Hansen, R.C. 2011. *Paediatric dermatology*. 4<sup>th</sup> ed. China: Mosby Elsevier.
- Shanson, D.C. 2014. *Microbiology in Clinical Practises*. 2<sup>nd</sup> ed. Sydney: Butterworth & Co.
- Sievert, D.M., Ricks, P., Edwards, J.R., Schneider, A., Patel, J., Srinivasan, A., Kallen, A., Limbago, B. & Fridkin, S. 2013. National Healthcare Safety Network (NHSN) Team and Participating NHSN Facilities. *Infection Control & Hospital Epidemiology*, 34(1):1-14, January. <https://pdfs.semanticscholar.org/bedb/0638e2306396ccb2a618f5682a1fde2bdb5d.pdf> [09 February 2017].
- Silva, M.A.S., Martins, M.V., Medici-Filho, E., Moraes, L.C., Castilho, J.C.M. & Jorge, A.O.C. 2004. Evaluation of the efficiency of an infection control protocol in dental radiology by means

- of microbiological analysis. *Ciênc Odontol Bras*, 7(3):15-21, July.  
<https://pdfs.semanticscholar.org/bedb/0638e2306396ccb2a618f5682a1fde2bdb5d.pdf>  
 [09 February 2017].
- Solon, J.G. & Killeen, S. 2015. Decontamination and sterilization. *Surgery*, 33(11):572–578, November. <https://www.sciencedirect.com/science/article/abs/pii/S026393191500174X>  
 [09 February 2017].
- South African Medical Research Council. 2015. *Guidelines on Ethics for Medical Research: General Principles*. <http://www.kznhealth.gov.za/research/ethics1.pdf>. [24 July 2016].
- Steven, M. & Koenig, J.D.T. 2006. Ventilator-associated pneumonia: diagnosis, treatment, and prevention. *Clinical Microbiology Reviews*, 19(4):637-57, October.  
<https://cmr.asm.org/content/19/4/637> [24 July 2016].
- Suchomel, M. Kundi, M., Pittet, D., Weinlich, M. & Rotter, M.L. 2012. Testing of the World Health Organisation recommended formulations in their application as hygienic hand rubs and proposals for increased efficacy. *American Journal of Infection Control*, 40(4):328-331, May. <https://www.ncbi.nlm.nih.gov/pubmed/22134012> [24 July 2016].
- Suwangool, P. 2012. Current Management of Urinary Tract Infections. *Bangkok Medical Journal*, volume 3:101–106, February.  
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3739462/> [05 May 2018].
- Sydnor, E.R.M. & Perl, T.M. 2011. Hospital epidemiology and infection control in acute-care settings. *Clinical Microbiology Reviews*, 24(1):141-173, January.
- Tagoe, D.N.A., Baidoo, S.E., Dadzie, I., Tengey, D. & Agede, C. 2011. Potential sources of transmission of hospital acquired infections in the Volta Regional Hospital in Ghana. *Ghana Medical Journal*, 45(1): 22-26, March.  
[https://www.researchgate.net/publication/51127310\\_Potential\\_Sources\\_of\\_Transmission\\_of\\_Hospital\\_Acquired\\_Infections\\_in\\_the\\_Volta\\_Regional\\_Hospital\\_in\\_Ghana](https://www.researchgate.net/publication/51127310_Potential_Sources_of_Transmission_of_Hospital_Acquired_Infections_in_the_Volta_Regional_Hospital_in_Ghana) [03 July 2016]
- Teaching Hospital. 2016. Brief history.  
<http://kbth.gov.gh/about-us.html> [10 May 2016].
- Thompson, C.N., Duy, P.T. & Baker, S. 2015. The Rising Dominance of *Shigella sonnei*: An Intercontinental Shift in the Etiology of Bacillary Dysentery. *PLOS Neglected Tropical Diseases*, 9(6):1-13, June. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4466244/>  
 [20 August 2017].
- Timilshina, N., Ansari, M.A. & Dayal, V. 2011. Risk of infection among primary health workers in the Western Development Region, Nepal: knowledge and compliance. *Journal of Infection in Developing Countries*, 5(1):18-22, January.  
[https://www.researchgate.net/publication/49845123\\_Risk\\_of\\_infection\\_among\\_primary\\_health\\_workers\\_in\\_the\\_Western\\_Development\\_Region\\_Nepal\\_Knowledge\\_and\\_compliance](https://www.researchgate.net/publication/49845123_Risk_of_infection_among_primary_health_workers_in_the_Western_Development_Region_Nepal_Knowledge_and_compliance)  
 [25 May 2016].
- Todd, E.C.D., Michaels, B.S., Holah, J., Smith, D., Greig, J.D. & Bartleson, C.A. 2010. Outbreaks Where Food Workers Have Been Implicated in the Spread of Foodborne Disease. Part 10. Alcohol-Based Antiseptics for Hand Disinfection and a Comparison of Their Effectiveness with Soaps. *Journal of Food Protection*, 73(11):2128–2140, April.
- Tohidnia, M.R., Dezfolimanesh, J. & Almasi, A. 2012. Bacterial contamination of radiography equipment in radiology departments of Kermanshah University of Medical Sciences. *Journal of Kermanshah University of Medical Sciences*, 16(3):273-276, September.  
<http://jkums.com/en/articles/78806.html> [11 June 2016].

- Tugwell, J. & Maddison, A. 2010. Radiographic markers a reservoir for bacteria? *Radiography*, 17(2):115-120, October. [https://www.radiographyonline.com/article/S1078-8174\(10\)00118-5/abstract](https://www.radiographyonline.com/article/S1078-8174(10)00118-5/abstract) [ 02 May 2015].
- Turgeon, M.L. 2012. *Clinical laboratory science. The basics and routine techniques*. 6<sup>th</sup> ed. Maryland: Elsevier Mosby.
- Van Kleef, E., Robotham, J.V., Jit, M., Deeny, S.R. & Edmunds, W. J. 2013. Modelling the transmission of healthcare associated infections: a systematic review. *BioMed Central Infectious Diseases*, 13(294):1-13, June. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3701468/> [18 May 2019].
- Viana, R.E.H., Dos Santos, S.G. & Oliveira, A.C. 2016. Recovery of resistant bacteria from mattresses of patients under contact precautions. *American Journal of Infection Control*, 44(4):465-469, April. [https://www.ajicjournal.org/article/S0196-6553\(15\)01113-X/fulltext](https://www.ajicjournal.org/article/S0196-6553(15)01113-X/fulltext) [18 May 2019].
- Walker, J.T. 2014. *Decontamination in hospital and healthcare*. Philadelphia: Woodhead.
- Weber, D.J. & Rutala, W.A. 2013. Self-disinfecting surfaces: Review of current methodologies and future prospects. *American Journal of Infection Control*, 41(5):31-35, May. [https://www.ajicjournal.org/article/S0196-6553\(13\)00011-4/fulltext](https://www.ajicjournal.org/article/S0196-6553(13)00011-4/fulltext) [18 May 2018]
- White, L., Duncan, G. & Baumle, W. 2014. *Foundation of basic nursing*. 3<sup>rd</sup> ed. New York: Delmar.
- Wie, S.H. 2015. Clinical significance of Providencia bacteremia or bacteriuria. *The Korean Journal of Internal Medicine*, 30(2):167-169, February.
- Wolfe, C. 2018. *Foundation of infection control and prevention*. Burlington: Jones & Bartlett Learning.
- World Health Organisation. 2002. *Prevention of hospital-acquired infections: A practical guide*. 2<sup>nd</sup> ed. [http://www.who.int/csr/resources/publications/drugresist/WHO\\_CDS\\_CSR\\_EPH\\_2002\\_12/en/](http://www.who.int/csr/resources/publications/drugresist/WHO_CDS_CSR_EPH_2002_12/en/) [25 June 2018].
- World Health Organisation. 2002. *Handbook for good clinical research practises: guidance for implementation*. [http://apps.who.int/prequal/info\\_general/documents/gcp/gcp1.pdf](http://apps.who.int/prequal/info_general/documents/gcp/gcp1.pdf) [13 June 2016].
- World Health Organisation. 2004. *Practical guidelines for infection control in health care facilities*. [http://www.wpro.who.int/publications/docs/practical\\_guidelines\\_infection\\_control.pdf](http://www.wpro.who.int/publications/docs/practical_guidelines_infection_control.pdf) [23 March 2015].
- World Health Organisation. 2009a. *WHO Guidelines on Hand Hygiene in Health Care*. Geneva: World Health Organisation Press. [https://apps.who.int/iris/bitstream/handle/10665/44102/9789241597906\\_eng.pdf?sequence=1](https://apps.who.int/iris/bitstream/handle/10665/44102/9789241597906_eng.pdf?sequence=1) [21 May 2016].
- WHO. 2009b. Hand Hygiene: Why, How & When? [https://www.who.int/gpsc/5may/Hand\\_Hygiene\\_Why\\_How\\_and\\_When\\_Brochure.pdf](https://www.who.int/gpsc/5may/Hand_Hygiene_Why_How_and_When_Brochure.pdf) [23 January 2020]
- World Health Organisation. 2011a. *Health care-associated infections fact sheet*. [http://www.who.int/gpsc/country\\_work/gpsc\\_ccisc\\_fact\\_sheet\\_en.pdf](http://www.who.int/gpsc/country_work/gpsc_ccisc_fact_sheet_en.pdf) [13 May 2016].

World Health Organisation. 2011b. *Report on the Burden of Endemic Health Care-Associated Infection Worldwide*.

[http://apps.who.int/iris/bitstream/10665/80135/1/9789241501507\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/80135/1/9789241501507_eng.pdf)

[12 December 2017].

Yawson, A.E. & Hesse, A.J.A. 2013. Hand hygiene practices and resources in a teaching hospital in Ghana. *Journal of Infection in Developing Countries*, 7(4):338-347, April.

<https://www.researchgate.net/publication/236207029> Hand hygiene practices and resources in a teaching hospital in Ghana [22 April 2016].

Zhang, E. & Burbridge, B. 2011. Methicillin-resistant *Staphylococcus aureus*: implication for the radiology department. *American Journal of Roentgenology*, 197(5):1155-1159.

<http://www.ajronline.org/doi/pdfplus/10.2214/AJR.11.6584> [23 March 2015].

## APPENDICES

### APPENDIX A. Letter to the Research and Ethics Committee: CPUT

P.O. Box KB 369

Korle Bu

Accra

17th August 2016.

The Research Ethics Committee

Department of Medical Imaging & Therapeutic Sciences

Faculty of Health & Wellness Sciences

Cape Peninsula University Technology

Dear Sir/Madam,

#### REQUEST FOR APPROVAL OF RESEARCH PROPOSAL

I am a Master's of Science in Radiography student of the Cape Peninsula University of Technology. I am conducting research on the topic, "Radiology Imaging Equipment and Accessories as possible Fomites of Nosocomial Pathogens". The research involves observation of departmental practice on infection control and the swabbing of selected radiology imaging equipment and accessories for laboratory testing to identify possible organisms. The study will also evaluate the effectiveness of the disinfectants used on the radiology equipment.

I wish to obtain your approval to enable me conduct the research.

I hope my request shall meet your consideration.

Thank you.



Yours faithfully

Isaac Agyekum Adomako

Cell number: +233244142327, E-mail: [agyekumowuo@gmail.com](mailto:agyekumowuo@gmail.com),

[215171276@mycput.ac.za](mailto:215171276@mycput.ac.za)

## APPENDIX B. Approval from the Research and Ethics Committee: CPUT



### HEALTH AND WELLNESS SCIENCES RESEARCH ETHICS COMMITTEE (HW-REC)

Registration Number NHREC: REC- 230408-014

P.O. Box 1906 • Bellville 7535 South Africa  
Symphony Road Bellville 7535  
Tel: +27 21 959 6917  
Email: sethn@cput.ac.za

4 October 2016

**REC Approval Reference No:**  
**CPUT/HW-REC 2016/H24**

---

Faculty of Health and Wellness Sciences – Medical Imaging & Therapeutic Science Department

Dear Mr Isaac Agyekum Adomako

**Re: APPLICATION TO THE HW-REC FOR ETHICS CLEARANCE**

Approval was granted by the Health and Wellness Sciences-REC on 15 September 2016 to Mr Adomako for ethical clearance. This approval is for research activities related to student research in the Department of Medical Imaging & Therapeutic at this Institution.

**TITLE: Radiology Imaging Equipment and Accessories as possible Fomites of Nosocomial Infections**

**Supervisor: Prof Penelope Engel-Hills**

**Co-Supervisor: Mrs Dalene Venter**

**Comment:**

*Data collection* permission is required and has been obtained.

**Approval will not extend beyond 5 October 2017.** An extension should be applied for 6 weeks before this expiry date should data collection and use/analysis of data, information and/or samples for this study continue beyond this date.

The investigator(s) should understand the ethical conditions under which they are authorized to carry out this study and they should be compliant to these conditions. It is required that the investigator(s) complete an **annual progress report** that should be submitted to the HWS-REC in December of that particular year, for the HWS-REC to be kept informed of the progress and of any problems you may have encountered.

Kind Regards

A handwritten signature in black ink, appearing to read "N. Naidoo", with a horizontal line underneath.

*Mr. Navindhra Naidoo*

**Chairperson – Research Ethics Committee**

Faculty of Health and Wellness Sciences

**APPENDIX C. Letter to the Chief Executive Officer: TH**

P.O. Box KB 369

Korle Bu

Accra

17th June 2016.

The Chief Executive Officer

[REDACTED]

Accra - Ghana

Dear [REDACTED]e,

**PERMISSION TO USE THE RADIOLOGY AND MICROBIOLOGY DEPARTMENTS FOR RESEARCH**

I am a Master's of Science in Radiography student of the Cape Peninsula University of Technology. I am conducting research on the topic, "Radiology Imaging Equipment and Accessories as possible Fomites of Nosocomial Pathogens". The research involves observation of departmental practice on infection control and the swabbing of selected radiology imaging equipment and accessories for laboratory testing to identify possible organisms. The study will also evaluate the effectiveness of the disinfectants used on the radiology equipment.

I wish to obtain your permission in order to have access to the radiology department including radiology imaging equipment and accessories for the intended research.

I wish to conduct the above stated tasks between January and August 2017, between the hours of 8:00am to 3:00pm.

For the purposes of confidentiality, no name or identity would appear in any point of the information collection and /or in the final written report.

I will be grateful when granted the permission to conduct the study.

Thank you.

Yours faithfully,



Isaac Agyekum Adomako:

E-mail: [agyekumowuo@gmail.com](mailto:agyekumowuo@gmail.com), [215171276@mycput.ac.za](mailto:215171276@mycput.ac.za) : Cell +233244142327.



APPENDIX D. Approval from Scientific and Technical Committee(STC):TH

In case of reply the number  
And the date of this  
Letter should be quoted

My Ref. No. KE/STC/3/17  
Your Ref. No. ....



11<sup>th</sup> January, 2017

MR. ISAAC AGYEKUM ADOMAKO  
CAPE PENINSULA, UNIVERSITY OF TECHNOLOGY  
CAPE TOWN, SOUTH AFRICA

**SCIENTIFIC AND TECHNICAL COMMITTEE APPROVAL**  
**PROTOCOL IDENTIFICATION NUMBER: 1. STC 00083/2016**

The Teaching Hospital Scientific and Technical Committee (STC), on 11<sup>th</sup> January, 2017 approved your submitted study protocol.

**TITLE OF PROTOCOL: "Radiology imaging equipment and accessories as possible fomites of nosocomial infections"**

**PRINCIPAL INVESTIGATOR: Mr. Isaac Agyekum Adomako**

This approval requires that you forward your approved document to the Teaching Hospital – Institutional Review Board (IRB) for the ethical aspect of the proposal to be assessed before the project can be initiated.

This STC approval is valid till 31<sup>st</sup> September, 2017.

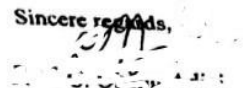
You may, however, request extension of the approval period, or renewal as the case may be, should the study extend beyond the stated period.

Upon completion, you are required to submit a final report on the study to the STC. This is to enable the STC ensure among others that, the project has been implemented as per the approved protocol. You are also required to inform the STC and Research Directorate of any publications that may emanate from the research findings.

Kindly note that, should the need arise, the STC or IRB may institute appropriate measures to satisfy itself that study is being conducted according to the highest scientific and ethical standards.

Please note that any modification to the study protocol without Scientific Technical Committee (STC) approval renders this approval invalid.

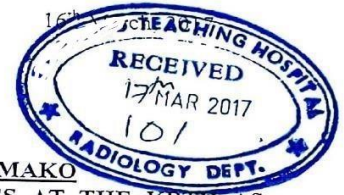
Sincerely regards,

  
Chairman, STC

APPENDIX E. Approval from Internal Review Board (IRB):TH

MEDICAL DIRECTORATE  
TEACHING HOSPITAL

THE HEAD  
DEPT. OF RADIOLOGY



LETTER OF INTRODUCTION – MR. ISAAC AGYEKUM ADOMAKO  
“RADIOLOGY IMAGING EQUIPMENT AND ACCESSORIES AT THE KBTH AS  
POSSIBLE FOMITES OF NOSOCOMIAL INFECTIONS”

I have the pleasure to introduce to you the above named student from the Cape peninsula, University of Technology, Cape Town, South Africa. Mr. Isaac Agyekum Adomako sought and has been granted approval to conduct a study entitled “Radiology Imaging Equipment and Accessories at the Teaching Hospital as Possible Fomites of Nosocomial Infections” in your Department.

He is to contact you to discuss the commencement date of the study.

Kindly accord him the needed assistance.

Attached is the Scientific and Technical Committee and Institutional Review Board approval which specifies the terms.

Sincere regards,

*[Handwritten signature]* 16/03/17

Ag. Director of Medical Affairs  
For: Chief Executive

*Approved  
for starting research.  
12/3/17*

*② HEAD  
For your attention  
please  
12/3/17*

**APPENDIX F. Letter to the Radiographers in Charge of Examination Rooms**

P.O. Box KB 369

Korle Bu Accra

17th June 2016.

The Radiographer in Charge

████████████████████

Accra – Ghana

Dear Sir / Madam,

**REQUEST FOR COOPERATION**

I am a Master's of Science in Radiography student of the Cape Peninsula University of Technology. I am conducting research on the topic, "Radiology Imaging Equipment and Accessories as possible Fomites of Nosocomial Pathogens". The research involves observation of departmental practice on infection control and the swabbing of selected radiology imaging equipment and accessories for laboratory testing to identify possible organisms.

I have been granted permission by the Scientific and Technical Committee (STC):TH Internal Review Board (IRB):TH to conduct the research.

I therefore request your cooperation during the data collection process.

I hope my request shall be granted.

Thank you.

Yours faithfully,



Isaac Agyekum Adomako:

Cell number: +27626766295, E-mail: [agyekumowuo@gmail.com](mailto:agyekumowuo@gmail.com), [215171276@mycput.ac.za](mailto:215171276@mycput.ac.za)

**APPENDIX G. Participants Informed Consent Form**

Name of researcher: ISAAC AGYEKUM ADOMAKO

Name of institution: CAPE PENINSULA UNIVERSITY OF TECHNOLOGY

Name of supervisors: PROF. PENELOPE ENGEL-HILLS, MRS. DALENE VENTER AND PROF. ERIC SAMPENE-DONKOR

Research title: **RADIOLOGY IMAGING EQUIPMENT AND ACCESSORIES AS POSSIBLE FOMITES OF NOSOCOMIAL PATHOGENS**

I have been invited to take part in the research titled above. I have been told the purpose of this research is to determine whether radiology imaging equipment and accessories are possible fomites of nosocomial pathogens. The study also aims to investigate the effectiveness of the disinfectant chemical (chlorine bleach and methylated spirit) agents used on diagnostic radiology equipment and accessories. My role in this study is to be observed on how I practice infection control measure, during work. I understand my participation is voluntary and free, and that I am not going to be subjected to any risk, danger or discomfort and can withdraw from the study at my own wish and at any time. I have been informed that the confidentiality of the information will be safeguarded and that my privacy and anonymity will be ensured in the collection, storage and publication of the research material. I am told that the day of observation would not be known to me. I am aware that information sought will be used only for the purpose of this study. I consent voluntarily to be observed by the researcher at any time the researcher deems fit.

Signature/thumbprint of participant..... Date 20/09/2016

Signature of researcher...  .....Date 20/09/2016

**APPENDIX H. CARS checklist.**

Name of author(s) or organisation(s)	Criteria	Yes	No
	<b>Credibility</b>		
	The article has been published by an established, peer reviewed organisation/journal.		
	The organisation/journal has published plentiful works on the role of radiography in the personal identification of cadavers.		
	The author is reputable and an expert on the subject of the role of radiography personal identification of cadavers.		
	The author has published other articles on this subject.		
	The author's work had been cited by other authors.		
	Appropriate medical terminology is used in the articles.		
	The keywords used by the authors correspond to the keywords in this research study.		
	The author provides adequate evidence to make the argument persuasive.		
	The author provides sufficient details to present a reasonable conclusion.		
	<b>Accuracy</b>		
	The data presented by the author corresponds to that of other sources.		
	The author does not contradict himself.		
	The author's work has been published in the timeframe of 2000 to 2020, making the information current.		
	The author does not make any vague statements.		
	The author acknowledges conflicting views and responds to them.		
	There are no limitations that could potentially manipulate the results of the research study.		
	<b>Reasonableness</b>		
	The author has no conflict of interest.		
	The author has used a sensible methodology.		
	The results discussed by the author have not been incomplete or altered to provide positive conclusions.		
	There is no reason to doubt the legitimacy of the author's results.		
	The results presented by the author are applicable to this study.		
	<b>Support</b>		
	There is a complete reference list available.		
	The author has referenced other reputable authors.		
	The publishing organisations/journals of the sources referenced are highly regarded.		
	The data are based on methodical studies.		
	The information is not based on the professional opinion of the author.		