CERTIFICATION

This is to certify that this research paper titled "**EVALUATION OF AIRBORNE BACTERIA IN THE IN-PATIENT SECTIONS OF SELECTED PRIMARY HEALTH CARE CENTRES IN OGUN STATE"** was carried out by ISINKAYE, Esther Oluwadamilola with the Matric Number **15010101005**. This project report meets the requirement governing the award of Bachelor of Science (B. Sc.) Degree in Microbiology, Department of Biological Sciences of Mountain Top University, Ogun State, Nigeria.

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Mr. G.E. Adebami Date

(Project Supervisor)

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Dr. A. A. Adeiga Date

(Head of Department)

DECLARATION

I hereby declare that this project report written under the supervision of Mr G.E. Adebami, is a product of my own research work. Information derived from various sources has been duly acknowledged in the text and a list of references provided. This research project has not been previously presented anywhere for the award of any certificate or degree.

_____ _____

ISINKAYE, Esther O. **Date**

DEDICATION

I dedicate this research to Almighty God for the strength, wisdom and divine direction given unto me to carry out this project successfully.

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My profound gratitude goes to my parents, Mr & Mrs Isinkaye for their endless moral, financial and prayer supports

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My sincere prayer is that God will reward you with the abundance of good things and that all your heart desires will come to manifestation. God bless you all.

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ABSTRACT

Healthcare facilities is said to contain different types of microorganisms. However, poor indoor quality in these facilities may result in nosocomial infections caused by microbes. Among these microorganisms, airborne bacteria aremajor source of contaminationsespecially in the in-patient sections which are responsible for airborne bacterial diseases. In this study, the diversity of the airborne bacteria was investigated in the in-patient sections of five selected primary health centers in Ogun State. These included three government owned (Wawa Primary Health Center, Ibafo Primary Health Center, Ofada Primary Health Center) and two private owned (Mountain Top University Clinic and MFM, Prayer City Clinic). The room temperature of the wards and the number of in-patients in each health centers were observed. Sterile Nutrient agar plates were exposed at 100 cm height to indoor air in the general wards of the health care centres for 10-30 minutes at the operated room temperature. The isolates were however identified using morphological and biochemical procedures for bacteriological identifications. Six bacteria genera were isolated, these included *Staphylococcus* sp, *Pseudomonas* sp, *Bacillus* sp, *Micrococcus* sp, *Arthrobacter* sp *and Klebsiella* sp. These results revealed the need to carry out microbiological hospital surveillance in order to minimize the occurrence of nosocomial infections, and to also educate the health care staffs on the significance of controlling infections

CHAPTER ONE

1.0 INTRODUCTION

Large portion of our time is spent in a variety of enclosed environments (indoor) and therefore, indoor air quality could have a major impact on our overall quality of life (Hospodsky *et al*., 2012). Exposure to aerosols in one of the greatest threat to public health because of the adverse effects on humans, animals and plants (Durugbo *et al*., 2013; Fernstorm and Goldblat, 2013). Fungi and bacteria are the major types of microorganisms present in hospitals environment.

Airborne transmission is one of the causes of a number of nosocomial infections(Claudete *et al*., 2006). Some bacteria such as *Corynebacterium diphtheriae, Mycobacterium tuberculosis*, *Neisseria meningitidis,* and *Streptococcus pyogenes* are primarily known to be transmitted from infected people by airborne droplets cause nosocomial infection (Sarica *et al*., 2002).

Although indoor environments are deemed to be protected, they may become contaminated with particles that pose distinct and sometimes severe hazards if their levels exceed the recommended maximum exposure boundaries (Banerjee, 2008). Nevertheless, according to Prescott *et al*., (1999), because bacteria do not develop in the atmosphere, they may have arisen from sources such as human, soil, animal, food, water or plant. This transforms the airborne microbial flora of enclosed hospital rooms. Prescott and his colleagues indicated thatonly when trapped and suspended in air droplets can pathogens survive in air and this can be a cause of transmission of these pathogens to people who inhale them since they can stay viable in air droplets for days. However, the microbial load of clean rooms in hospitals and clinics such as maternity wards, operating rooms, intensive care units, etc, could rely on the prevailing

environmental conditions within and out of the hospital at a particular time, the air nutritional content and the microbial load outside the hospital (Dong-Uk *et al*., 2013).

The Hospital environment is highlighted as potential reservoir for many airborne pathogens which include bacteria and fungi. However, exposure to many microorganisms in hospital environment is inevitable (Park *et al*., 2013). Hospital-acquired infections (HAI) are accountable for about 10% of the patients in hospitals, according to some research. Bioaerosols are also known to cause nosocomial infections in patients admitted in the hospital, particularly those requiring extensive treatments and intensive care (Hung *et al*., 2013). In addition, bioaerosols come in different dimensions, shapes and structures based on the source, aerosolization processes and flourishing environmental circumstances at the site (Heo *et al*., 2014). Hospital contamination is mainly caused by air, dust, visitors, patients and weather (Beggs, 2003). Hospital indoor air quality is of great concern because it includes a broad variety of airborne infectious airborne microorganisms that can trigger hospital infections (Sudharsanam *et al*., 2012; Hoseinzadeh *et al*., 2013).

In hospital environment, Indoor air quality (IAQ) is an essential issue that has to be considered with careful attention. Indoor as well as outdoor air pollution is mostly regarded the main cause of environmental health issues (Yousef *et al*., 2013). The environmental health research community, environmental regulatory authorities, companies and the public are becoming increasingly concerned about air pollution and effects on public health (Jank *et al*., 2015; Zahra, 2015).Most importantly, a long-term exposure to poor IAQ could deteriorate and aggravate diseases like lung-related disease as well as blood-related health problems among patients and hospital staffs (Brauer *et al*., 2012; Zhang *et al*., 2014). In a hospital environment, IAQ is a significant issue needed to be considered with great caution. Indoor and outdoor pollution,

however, is often seen as the major cause of environmental health issues (Yousef, Elshareef, Ibraheem, & Alsayed, 2013).

1.1 STATEMENT OF PROBLEM

Aerofloral contamination in hospitals can lead to hospital-acquired infection (HAI) also known as Nosocomial Infection, an infection obtained in hospitals, outpatient clinic or other clinical setting, is sometimes referred to as health care-associated infection (HAI or HCAI) (HAI Data and Statistics, 2018). Infection spreads through different means to the vulnerable patient in the clinical environment. Besides contaminated equipment, bed linens, or air droplets, healthcare personnel can spread infections (HAI Data and Statistics, 2018). The infection may also come from the outside environment, another infected patient or in some cases cannot determine the origin of the infection (CDC, 2016). Though the patient may have contracted the infection from their own skin, the infection is still considered nosocomial since it develops in the health care setting (CDC, 2016).

However, those usually susceptible to nosocomial infections includes people with weak immune systems, infections that happen because a person's immune system is weak are called opportunistic infections. Some individuals have weak immune system; others may have a disease illness that attacks the immune system like HIV/AIDS. Some medicines, like corticosteroids or cancer chemotherapy, can also reduce the capacity of the body to fight infections. Organ transplant patients, cancer patients, hospitalized patients, stem cell transplant patients are also susceptible to fungal infections (CDC, 2016).

1.2 JUSTIFICATION

The evaluation of the measurement and diversity of airborne bacteria in the hospital setting can be used as a useful indicator of the cleanliness of the hospital setting (Hoseinzadeh *et al*., 2013).

Therefore indoor air quality evaluation in hospitals will assist to determine the origin of the infection thereby providing help in the reduction of bacterial nosocomial infection rates. This study was targeted at indoor airborne bacteria profile ofsome selected wards of the Ibafo Primary Health center, Wawa Primary Health center, Ofada Primary Health center, Mountain Top University Clinic and MFM, Prayer City Clinic, all in Ogun State.

1.3 AIM AND OBJECTIVES:

This research aims at identifying and characterizing bacterial species in the indoor environment of selected primary health centers in Ogun State.

The objectives of this research included:

I. To sample the air in the in-patient sections of selected primary health centers in Ogun State, and to isolate bacteria from the samples using pure culture techniques
II. To determine the morphological and biochemical characteristics of the isolates
III. To test antibiotic sensitivity of the isolated bacterial species

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 AN OVERVIEW OF NOSOCOMIAL INFECTION

A hospital-acquired Infection is an infection acquired in hospital from a patient admitted for a reason other than that infection (WHO, 2002). This involves infections obtained in the hospital but which appear after release as well as occupational infections among the facility's personnel (World Health Organization, Department of Communicable Disease Surveillance and Response 2002). In other words, nosocomial infections are those infections acquired in hospital or healthcare units that appear 48 hours or more after hospital admission or within 30 days after discharge from in-patient care (Nazir and Kadri, 2014). These infections are connected with invasive instruments such as catheters and ventilators used in contemporary health care (Center for disease control and prevention).

Hospital-acquired

infection (HAI) is a localized or systemic condition arising from negative reactions to the existen ce of an infectious agent not present or incubated at the time of hospital admission from the Cent er for Disease Control (Horan and Gaynes, 2004). These infections are a phenomenon globally. Patient care is given in environments ranging from small clinics with fundamental equipment to big advanced, extremely equipped, state-of-the-art hospitals

Despite advancement in public health and hospital care, infections in patients admitted in hospital and also in hospital staff continue to evolve (WHO, Department of Communicable disease, surveillance and response, 2002). Of every hundred patients in hospital, seven in

developed and ten in developing countries can develop one of the health related diseases (Raja and Annadurai, 2014). Populations involved include patients in Intensive Care Unit (ICU), burn units, those undergoing organ transplant and neonates. The World Health Organization(WHO) has called H AIs a significant cause patients' death and disability. A HAI research showed that more than 1.4 million individuals globally suffer from diseases in treatment facilities at any moment with an estimate of 80,000 deaths per year.

2.1.1 TYPES OF NOSOCOMIAL INFECTIONS

There are five types of nosocomial infections. They include: Nosocomial Pneumonia, Urinary Tract Infection, Surgical site infection (SSI), Nosocomial Bloodstream Infection, Skin and Soft Tissue Infections (SSTI)

2.1.2 NOSOCOMIAL PNEUMONIA

Pneumonia is one of the most frequently occuring nosocomial infections in patients in hospital. Hospital-acquired pneumonia (HAP) is pneumonia that occurs after admission for over 48 hours (American Thoracic Society, 2005) and without any previous signs of infection during admission to hospital. Health care–associated pneumonia is a similar entity, occurring in patients who have been hospitalized in the last 90 days, resides in nursing facilities, or wound care chemotherapy, has received recent intravenous antibiotics, or who attends a hemodialysis clinic. (CDC, 2003).

Hospital-acquired pneumonia has a major effect on morbidity and mortality of the patient, as well as on the cost of health care (Rello, 2005). Accounting for 15% of all hospital-acquired infections, nosocomial pneumonia is a continual lethal complication of hospitalization (Rello, 2005)

Nosocomial pneumonia occurs in diverse patient groups. The most significant are patients on ventilators in intensive care units, where the rate of pneumonia is 3% per day. There is a high case of death rate associated with ventilator-associated pneumonia, although the attributable risk is hard to determine because patient comorbidity is so high (WHO, 2002). Microorganisms take over the upper airway and bronchi, stomach, and cause lung infection (pneumonia): they are often endogenous (digestive system or nose and throat) and can be exogenous, often due to contaminated respiratory equipment. Besides ventilator-associated pneumonia, patients with seizures or reduced level of consciousness are at risk for nosocomial infection, regardless of not being intubated. Viral bronchiolitis (Respiratory Syncytial Virus, RSV) is common in children's units, while influenza and secondary bacterial pneumonia may occur in institutions for the elderly as well as in highly immuno-compromised patients (WHO, 2002).

2.1.3 NOSOCOMIAL URINARY TRACT INFECTION

Catheter-associated urinary tract infections are one of the most recurrent classifications of nosocomial infection (Warren,2001), resulting in enhanced morbidity and health care costs for patients. According to acute care hospital stats in 2011, Urinary Tract Infections account for over 12% of reported infections (CDC, 2016).CAUTIs are triggered by patients' indigenous endogenous microflora. Gram negative opportunistic bacteria including *Klebsiellapneumoniae* is a prominent cause of nosocomial urinary infections in persons with indwelling urinary catheters (Ronald, 2002; Frank *et al*., 2009). The attachment of the catheter spreads the bacteria to the typically sterile bladder, and the presence of an indwelling catheter is believed to be a site for bacterial attachment, and enables long-term colonization. Fimbria adhesins mediated attachment n Gram-negative *enterobacteria* to host cell surfaces (Elliott and Justiz-Vaillant, 2018). It has been shown that up to 80% of nosocomial infections are associated with indwelling medical

devices and many of these kinds of infections can be predicted to be mediated by biofilm (Richards *et al*., 2000; Guiton *et al*., 2010). The insertion of these devices becomes a site for biofilm formation and down regulates some of the natural host immune defenses (Hansch *et al*., 2014; Schroll *et al*., 2010).

Risk factors for catheter-associated UTIs include urolithiasis, diabetes mellitus among others. In a Spanish study it was reported that 457 patients were hospitalized. Of them, nearly 12% have had a previous UTI. The most repeatedly isolated pathogens were *E. Escherichia coli*, followed by *Klebsiella*, *Enterococcus spp*, and *Pseudomonas* in another research conducted in Spain. Enterobacteriaceae other than *E. coli* were more predominant in older and male patients. The prevalent nosocomial pathogen found in urinary catheters was *Enterococcus.* CAUTI can result in complications such as, orchitis, epididymitis and prostatitis in males, and pyelonephritis, cystitis and meningitis in all patients (CDC, 2016)

2.1.4 SURGICAL SITE INFECTION (SSI)

SSIs are nosocomial infections that fall in 2%–5% of surgical patients. These are the second most frequent form of nosocomial infections mostly caused by *S. aureus* resulting in extensive hospitalization and death risk (Anderson, 2011). The pathogens that cause SSI are the result of the patient's endogenous microflora. The incidence may be as high as 20% dependent upon the method and surveillance criteria used (Owens, 2008).

SSI leads to serious implications, including increased costs due to its treatment (Anderson *et al*., 2014) and increase in hospital duration of stay (Engemann *et al*., 2003; Anderson *et al*., 2014). The risk of death in patients with SSI is amplified when compared to those who did not develop an infection (Engemann *et al*., 2003)

2.1.5 PRIMARY BLOODSTREAM INFECTION (BSI)

Primary Bloodstream infection (BSI) is a major complication of infectious diseases in critically ill patients (Martin *et al*, 2003). It represents about 15% of all nosocomial infections (Richard *et al.*, 2000; Hugonnet *et al*., 2004,) and affects about 1% of all patients in hospital, with an incidence rate of 5 per 1,000 central-line days {National Nosocomial Infections Surveillance (NNIS), 2002}. The effect on patient‘s outcome is enormous; BSI increases the rate of death, extends patient stay in an intensive care unit (ICU) and in the hospital, and procreates substantial extra costs (Rello, 2000). BSI monitoring and prevention are high priorities for these reasons, , and several procedures have proven efficient (Coopersmith, 2000; Crnich and Maki, 2002; Sherertz, 2002).

The center for disease control and prevention (CDC) surveillance definitions of BSI demarcate two distinct entities: infections that are microbiologically documented, and thus that are not, called clinical sepsis (Hugonnet *et al.*, 2004). Although surveillance of the former can be laboratory based, detection of clinical sepsis requires prospective on-site surveillance (Hugonnet *et al*., 2004). The surveillance strategy determines whether clinical sepsis will be detected, thus affecting the overall BSI incidence rate.

2.1.6 SKIN AND SOFT TISSUE INFECTIONS (SSTI)

Nosocomial infections that affects the skin and soft tissues include the medical presentation of pain, skin sloughing, edema, cutaneous blood loss, erythema, skin anesthesia, violaceous bullae, rapid evolution, and gas in the tissue (Stevens *et al*., 2014). Skin and soft tissue infections (SSTIs) result from incursion of the skin, and typically occur owing to trauma or surgery. SSTIs can be categorized as simple, necrotizing or suppurative (Ramakrishnan *et al*., 2015). Risk

factors of acquiring SSTIs include older age, alcohol abuse, immune-compromise, diabetes mellitus, and prolonged hospitalization (Ki and Rotstein, 2008).

The prevalence of SSTIs among hospital patients is estimated at 7% to 10% (Vinh and Embil, 2005; Ki and Rotstein, 2008). SSTI is one of the major infections among hospital patients, with augmented incidence among men (Ki and Rotstein, 2008). *Staphylococus aureus, Pseudomonasaeruginosa, Enterococcus,* and *Escherichia coli* are commonly isolated from SSTI-related patients.

The choice of antibiotic treatment may be varying and ineffective. Site of care is reliant on the severity of SSTI. Oral therapy is given to mild lesions while intravenous therapy is administered to moderate to severe lesions. The length of treatment is determined by continuous observing and clinical judgment (Nadimpali *et al*., 2016; Li *et al*., 2016; Corcione and De Rosa, 2018; Kamath *et al*., 2018; Urdiales-Galvez, 2018)

Penicillin is administered as first line treatment for group A *Streptococcus (Streptococcus pyogenes)* organisms identified from SSTIs. Alternative treatments for *Streptococcus pyogenes* include first generation cephalosporin, macrolides, clindamycin, glycopeptides or expanded spectrum fluoroquinolones. For SSTIs instigated by group B *Streptococcus(Streptococcus algalactiae)* organisms first line high doses of penicillin G intravenously with clindamycin are administered. Cephalosporins, betalactamase inhibitors, cabapenems, fluoroquinolones or aminogylcosides are given to treat *Klbsiellapneumoniae, Eschericheria coli*, and *Serratiamarcescens* identified from SSTI-associated patients (Vinh and Embil, 2005; Moet *et al*., 2007; Casellas, 2011). First line anti-pseudomonal beta lactam joined with aminoglycoside treatments are given for *Pseudomonas aeruginosa* identified isolates associated with SSTIs (Aliaga *et al*., 2002; Ho *et al*., 2010)

2.2 EPIDEMIOLOGIC FACTORS AFFECTING NOSOCOMIAL INFECTIONS

There are three major related factors. They are: host factors, agent factors and environmental factors.

2.2.1 HOST FACTORS

Host factors affect a person's likelihood of exposure and resistance to infection. Patients admitted to hospitals are usually in a bad health condition, with weakened immune system against bacteria and other infectious agents, therefore, they are vulnerable to nosocomial infections. Premature birth, advanced birth or immunocompromised individuals (due to drugs, illness, or irradiation) pose a general danger, while certain illnesses pose certain hazards. For example, Chronic Obstructive Pulmonary Disease (COPD) increases the possibility of respiratory tract infection. Additional host factors associated to an increased risk of HAIs include, infection with human immunodeficiency virus (HIV), diabetes mellitus, severe malnutrition, bronchopulmonary disease, coma, open wound, circulatory impairment, , severe burns and certain skin diseases and trauma.(International Federation of Infection Control, 2016)

Human reservoirs include patients(Hall, 2000; Bridges, *et al*., 2003; Zawacki *et al*., 2004; Saiman, 2008) healthcare personnel(Foca *et al*., 2000; Wang, 2001; CDC, 2003; Mermel *et al*., 2003; Barnes *et al*., 2003; Zawacki, 2004; Gupta *et al* 2004)and members of the household and other visitors. Such sources may have active infections, may be during an infectious disease's asymptomatic and/or incubation period, or may be colonized with pathogenic microorganisms transiently or chronically, particularly in the respiratory and gastrointestinal tracts. Patients' endogenous flora (e.g., bacteria residing in the respiratory or gastrointestinal tract) is also the cause of HAIs (Perl *et al*., 2002; Sarginson *et al*., 2004; Donskey, 2004)

2.2.2 AGENT FACTORS

A bacterium, virus, fungus, or parasite may be an infectious agent. Most hospital acquired infections are caused by bacteria while viruses and fungi occur occasionally, parasites seldom cause HAIs. There are two main kinds of bacteria that cause HAIs, Gram positive (e.g., , *streptococci, staphylococci, C. diffile*) and Gram negative (e.g., *Klebsiella,Pseudomonas, Enterobacter, Acinetobacter,*) (WHO, 2002). For a long period of time, many of these pathogens can survive on surfaces. Infections may be caused by a microorganism acquired in the hospital from another person (cross-infection) or by the patient's own flora (endogenous infection). Some organisms may be obtained from an inanimate object or newly contaminated substances from another human source (environmental infection). (WHO, 2002)

2.2.3 ENVIRONMENTAL FACTORS

Environmental factors associated with HAIs include both the animate and inanimate environment of patients. The animate environment i.e, which entails life, refers to healthcare personnel, other patients in the same unit, families, and visitors. Patients with infections or hospitalized carriers of pathogenic microorganisms are potential sources of infection for patients and staff. Hospital-based crowded conditions, frequent transfer of patients from one unit to another and highly vulnerable patient concentration in one area (e.g. newborn infants, burn patients, and intensive care) all add to the development of nosocomial infections (WHO, 2002).

The inanimate environment i.e, the environment without life, refers to medical equipment and instruments, therapeutic and diagnostic maneuvers, and environmental surfaces. Microbial flora may contaminate objects, devices, and materials which subsequently contact susceptible body sites of patients (WHO, 2002)

Other factors related to the healthcare environment include sanitation, cleanliness, temperature and humidity of the unit.

Therapeutic and diagnostic procedures may increase the risk of HAIs, especially those that transect contaminated/infected tissues or involve the insertion of a foreign body; Dialysis; Transfusion; Hyperalimentation, administering of immunosuppressive drugs, antimicrobials; Radiation therapy; Indwelling catheters, especially intravenous and urinary catheters; and Tracheostomy or endotracheal intubation, mechanically respiratory ventilation, and anesthesia. All invasive procedures can ignore the patient's natural defense mechanisms and provide an easy route for infection. (International Federation for Infection Control, 2016).

2.3 PATHOGENS RESPONSIBLE FOR NOSOCOMIAL INFECTION

Pathogens accountable for nosocomial infections are bacteria, viruses and fungal parasites. These microorganisms differ depending upon diverse patient populations, medical facilities and even alteration in the environment in which the care is given.

2.3.1 BACTERIA

Bacteria are the most common pathogens that cause nosocomial infections. Some are part of the patient's natural flora and cause infection only when the immune system of the patient turns out to be susceptible to infections. Commonly isolated bacteria are:

2.3.1.1 Acinetobacter: This is the genre of pathogenic bacteria accountable for infections occurring in Intensive Care Units. It is embedded in soil and water and accounts for 80% of reported infections (Suresh and Joshi, 2013).

2.3.1.2 *Bacteroides fragilis*: This is a commensal bacteria found in intestinal tract and colon. It causes infections when joined with other bacteria (Jayanthi, 2014).

2.3.1.3 ***Clostridium difficile:***Spores of *C. difficile* can last for months and become a disinfectants and cleaning agent problem. Inanimate items and patients with infected intestines are significant reservoir sites. Hospital staffs alongside with hospital settings are also playing their part to a greater level (Gu *et al*., 2015). Pathogenic *C.difficile* is also transferred by healthcare personnel from an infected patient to others through improper cleansed hands (Jayanthi, 2014). *Clostridium difficile* cause inflammation of colon leading to antibiotic-associated diarrhea and colitis, mainly due to elimination of beneficial bacteria.

2.3.1.4 ***Enterobacteriaceae:*** Enterobacteriaceae (carbapenem resistance) cause diseases to be transported from the intenstine to other areas of the body. Enterobacteriaceae establish Klebsiella species and Escherichia coli. Their great resistance towards carbapenem makes it harder to resist them (CDC, 2016).

2.3.1.5 ***Staphylococcus aureus:*** Amongst many species of Staphylococcus genus, *S. aureus* is considered one of the most important pathogens responsible for nosocomial infections. It is Gram-positive cocci, non-spore forming, catalase- and coagulase-positive, immotile, facultatively anaerobe (Vandenesch, 2012). It is not only a disease-causing organism but also a commensal organism. It colonizes mainly in nasal passages. It is extremely resistant to beta-lactams antibiotics (CDC, 2016). Hospitalized patients with reduced immunity and immunocompetent people are more susceptible to *S. aureus* infections. *S. aureus* infects not only the apparent but also the deep tissues and local abscess lesion.Transmission of *S. aureus* is through the skin or contact of infected people through shared items and surfaces such as door handles, benches, towels and taps (Al Laham *et al*., 2015). By direct contact, open wounds and contaminated hands, Methicillin-resistant *S. aureus* (MRSA) transmit. By travelling from organs or bloodstream, it triggers sepsis, pneumonia and SSI (Al Laham *et al*., 2015). Toxin-mediated

diseases of *S. aureus* include food poisoning, due to ingestion of enterotoxins, while toxic shock syndrome toxin 1 is responsible for toxic shock syndrome (Al Laham *et al*., 2015) and exfoliative toxins cause staphylococcal scalded skin syndrome. Virulence mechanisms of *S. aureus* include toxins, enzymes and immune modulators (Vandenesch, 2012).

2.3.1.6 ***Pseudomonas aeruginosa*:**This contributes to 11% of all nosocomial diseases, leading to increased rates death and disease. It is non-fermenter Gram-negative organism instigating diseases particularly among immune-compromised people. Colonization sites include kidney, urinary tract and upper respiratory tract (Balasoiu *et al*., 2014).. It is a cause of surgical and wound infections, pneumonia, cystic fibrosis, UTI and bacteremia. Some of significant virulence factors are adhesions, hemolysins, exotoxins, proteases and siderophores (Balasoiu *et al*., 2014). Common contaminationreservoirs include breast pumps, incubators (Jones *et al*., 2000), sinks and hands of hospital personnel and hand soaps (Rabier *et al*., 2008).

2.3.1.7 ***Klebsiella pneumoniae:***In hospital settings, *K. pneumonia* can be spread by person-to-person contact and especially when healthcare specialists do not wash or clean hands after contaminated patient has been examined. The origin of its source may be respiratory machines, catheters or exposed wounds. The transmission of *K. pneumoniae* is through stool (77%), patients' hands (42%) and pharynx (19%) (Lin *et al*., 2015)

2.3.2 VIRUSES

Apart frm bacteria, viruses are also significant causes of nosocomial infection. Usual surveillance has shown that 5% of all the nosocomial infections are caused viruses (Aitken, 2001). They can be distributed through hand-mouth, respiratory route and fecal-oral route (Ducel and Nicolle, 2002). Hepatitis is the chronic virus disease. Healthcare delivery can transmit

hepatitis viruses to patients as well as staff (CDC, 2016). The transmission of Hepatitis B and C is commonly through hazardous injection practices (CDC, 2016). Influenza, HIV, rotavirus, and herpes-simplex virus are other viruses (Ducel and Nicolle, 2002).

2.3.3 FUNGAL PARASITES

Fungal parasites act as opportunistic pathogens instigating nosocomial infections in immune-compromised individuals. *Aspergillus spp.* can cause infections by contamination of the environment (Ducel and Nicolle, 2002). *Candida albicans*, *Cryptococcus neoformans* are also responsible for infection in the course of hospital stay (Ducel and Nicolle, 2002). Candida infections are caused by the endogenous microflora of the patient while *Aspergillus* infections are caused by inhalation of fungal spores from contaminated air during construction or renovation of health care facility (Emily and Syndor, 2011).

2.4 MODES OF TRANSMISSION

Several types of pathogens including bacteria, viruses, fungi, parasites, and prions can cause infection (CDC, 2005). A pathogen can spread by a single or several routes.Some are transmitted mainly by direct or indirect contact, (e.g., Herpes simplex virus [HSV], respiratory syncytial virus, *S. aureus*), others through droplets, (e.g., influenza virus, *B. pertussis*) or airborne routes (e.g., M. tuberculosis) (CDC, 2005). Other infectious agents, such as bloodborne viruses (e.g., hepatitis B and C viruses [HBV, HCV] and HIV are rarely transmitted through percutaneous or mucous membrane exposure in healthcare environments (Beltrami, 2000). Importantly, not all infectious agents are transmitted from person to person. The principal routes of Hospital-acquired Infection (HAI) transmission are as follows:

2.4.1 CONTACT TRANSMISSION

Contact is the most occurring route of HAI transmission; it is divided into three groups: direct-contact, indirect-contact, and droplet transmission.

2.4.1.1 DIRECT-CONTACT TRANSMISSION

Transmission of direct-contact includes a direct surface-to-body contact involving the physical transfer of microorganisms between a susceptible host and an infected individual. Chances for direct contact transmission between patients and healthcare staff have been abridged in the Guideline for Infection Control in Healthcare Personnel, 1998 (Bolyard *et al*., 1998) and include; blood or other body fluids that contains a patient's blood directly enters a caregiver's body through contact with a mucous membrane (Rosen, 1997) or breaks (such as cuts, abrasions) on the skin (Beltrami *et al*., 2003)

2.4.1.2 INDIRECT-CONTACT TRANSMISSION

Indirect-contact transmission involves contact of a vulnerable host with an intermediate object.Examples of indirect contact transmission possibilities include:

• Hands of healthcare personnel may transfer pathogens to a patient or a contaminated nonliving object after touching an infected body site, if hand hygiene is not noted before another patient is touched (Bhalla *et al*., 2004; Duckro *et al*., 2005)

• Patient-care devices (e.g., electronic thermometers, glucose monitoring devices) may transfer pathogens if blood or body fluids contaminated equipment are shared between patients without cleaning and disinfecting after each use (Desendos *et al*., 2001; CDC, 2005)

• Shared toys can be used to transfer respiratory viruses (e.g., respiratory syncytial virus (Hall, 2000) or pathogenic bacteria (e.g., *Pseudomonas aeruginosa*80) among pediatric patients.

• Instruments that are cleaned ineffectively before disinfection between patients (e.g., surgical instruments) (Schelenz and French, 2000; Weber and Rutala, 2001) or that have production deficiencies that impedes the reprocessing efficiency (Kirschke *et al*., 2003; Srinivasan *et al*., 2003) may transfer bacterial as well as viral pathogens.

2.4.1.3 DROPLET TRANSMISSION

Droplet transmission occurs when droplets are generated from a human reservoir, mainly during coughing, sneezing, or talking, or during the performance of certain procedures, such as bronchoscopy (Atkinson *et al.,* 2009). Transmission occurs when droplets containing thepathogens from the infected person are pushed a short distance (< 1 m) through the air and deposited on the host. It can also occur when an infected person coughs, sneezes (Jane *et al*., 2007) or in the course of processes such as suctioning, endotracheal intubation (Scales *et al*., 2003; Loeb *et al*., 2004; Fowler *et al*., 2004), cough induction by chest physiotherapy (Jane *et al*., 2007) and cardiopulmonary resuscitation (Christian *et al*., 2004)

Examples of infectious agents transmitted through droplet route include *Bordetella pertussis*, influenza virus (Bridges *et al*., 2003), adenovirus (Musher, 2003), rhinovirus, *Mycoplasma pneumoniae*, SARS-associated coronavirus (SARS-CoV) (Varia *et al*., 2003; Scales *et al*., 2003; Seto *et al*., 2003), group A streptococcus, and *Neisseria meningitides*

2.4.2 AIRBORNE TRANSMISSION

Airborne transmission happens by distribution of airborne droplet nuclei (small-particles, <5 μm in size of evaporated droplets containing microorganisms) that remain in the air for long periods of time or particles of dust comprising an infectious agent. Droplet nuclei, dust particles, or skin squamae containing microorganisms are transmitted by air currents; they may become inhaled by a vulnerable patient within the same room or over a longer distance from the source patient

entering that new person's system through contact with his/her conjunctivae, nasal mucosa or mouth. Special ventilation is essential to avoid airborne transmission.

2.4.3 VEHICLE TRANSMISSION

Vehicle transmission applies to microorganisms spread through contaminated items, such as food, water, medical devices and equipment, medications, toys, and biological products, such as blood, tissues or organs.

2.4.4 VECTOR-BORNE TRANSMISSION

Vector-borne transmission occurs when vectors like mosquitoes, flies, rats, and other vermin, transmit microorganisms. Transmission occurs through simple contamination by animal or arthropod vectors or their actual penetration of skin or mucous membranes.

2.5 PREVENTION OF NOSOCOMIAL INFECTION

Being an important cause of illness and death, nosocomial infections need to be prevented from the base line so that their spread can be controlled (Khan *et al.*, 2017).

2.5.1 Transmission from environment

Unhealthy environments are the best source for the pathogenic organism to flourish (Zhang, 2015). Air, water and food can get contaminated and spread to the patients under healthcare delivery (Collins, 2008). There must be guidelines to guarantee the cleaning and use of cleaning agents on walls, floor, beds, windows baths, toiletsand other medical devices (Ducel and Nicolle, 2002). Appropriately ventilated and fresh filtered air can eradicate airborne bacterial contamination (Ducel and Nicolle, 2002). Consistent check of filters and ventilation systems of general wards, operating theatres and ICUs must be maintained and documented. Infections

attributed to water are due to failure of healthcare organizations to meet the standard criteria. Microbiological monitoring methods should be used for water analysis. Infected patients must be given separate baths. Improper food handling may cause food borne infections. The area should be cleaned and the quality of food should meet standard criteria (Ducel and Nicolle, 2002).

2.5.2 Transmission from staff

Infections can be transmitted from healthcare staff. It is the obligation of healthcare professionals to take role in infection control. Personal hygiene is essential for all and sundry so staff should maintain it. Poor hand hygiene is accountable for 40% of infections transmitted in hospitals. Studies have revealed that the improvement in amenability with hand washing decreases nosocomial infection. Hand sanitization is required with suitable hand disinfectants after being in contact with infected patients. Availability of the hand washing stations and the use of alcohol gels increases compliance with hand washing. Alcohol gel dries rapidly, and is bactericidal, fungicidal and virucidal. Several studies have revealed that doctors wash their hands less regularly than nurses and backs of hands, tips of fingers, web spaces and thumb are frequently missed areas (Inweregbu *et al*., 2005).

Safe injection practices and sterilized equipment should be used. (Ducel and Nicolle, 2002). Protective dresses such as gloves and aprons are obligatory for health providers exposed to body fluid, e.g, oropharyngeal fluids, sweat, blood or urine. These dresses should be worn for handling body fluids. High efficiency particulate air (HEPA) filter masks are endorsed for sputum smear positive patients with tuberculosis, particularly for cough-inducing procedures. . Hands must be thoroughly washed after glove removal as contamination of the hands can still occur (Inweregbu *et al*., 2005).

2.5.3 Hospital waste management

Waste from hospitals can act as a prospective reservoir for pathogens that needs appropriate handling. 10–25 % of the waste generated by healthcare facility is termed as hazardous. Infectious healthcare waste should be deposited in the area with limited approach. Waste comprising high heavy metal content and surgical waste, infected persons, contaminated with blood and sputum and that of diagnostic laboratories must be distinctly disposed of. Healthcare staff and cleaners should be educated about hazards of the waste and it's proper management (Ducel and Nicolle, 2002).

2.6 OTHER INFECTION CONTROL PRECAUTIONS

The use of invasive methods increases the risk of nosocomial infections. For venous access, this risk can be reduced by use of specific sites such as subclavian vein rather than internal jugular or femoral veins. Tunneling the catheter decreases the risk of nosocomial infection. Antimicrobial impregnated catheters can decrease catheter related infections. The use of a strict, aseptic technique is paramount in the insertion of intravascular catheters (Dockery, 2012).

By using isolation rooms for patients with MRSA, *C. difficile*, VRE and resistant Gram-negative infections, the spread of infection can be reduced owing to improved awareness of the implementation of appropriate infection control precautions (Inweregbu, 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

The following materials were used for the experiment: Petridishes, cover slips, slides, conical flask, inoculating needle, cotton wool, aluminum foil, dropper, durham tubes, MacCartney bottles, Bijou bottles, measuring cylinder, test tubes, test tubes rack, immersion oil.

3.1.1 Equipment

The following equipment was used for the experiment: Bunsen burner, water bath, incubator, autoclave, magnetic stirrer, weighing balance.

3.1.2 Media

Nutrient agar, Simmons citrate agar, Sensitivity medium, Starch agar, MRVP broth and Buffered peptone broth.

3.1.3 Reagents

Hydrogen peroxide,70% alcohol, Crystal violet, Gram's iodine, Safranin, Kovac's Reagent, Methyl red.

3.2 AIR SAMPLING PROCEDURE

The air samples were collected by open plate method (Uzochukwu and Nkpouto, 2013) .This method uses settle plates, which are petridishes containing culture media of Nutrient Agar. The plates were exposed to the indoor air in the outpatient section of the hospitals for a given period of time (10 – 30 minutes) in order to gather biological particles for the sediment quality evaluation (Napoli *et al*., 2012). The Petri-dishes were put at a height of 150 cm above the

ground level during sampling. After exposure, the plates were kept in a clean container and taken to the laboratory for microbiological examination.

3.3 INCUBATION AND CULTURING

The plates were placed in incubator at 37 °C and cultured for 24-48 hours. Colonies grown on media were enumerated.

3.4 SUBCULTURING TECHNIQUES

Distinct colonies from each culture plates were sub cultured by streaking them on fresh agar plates in order to obtain pure culture necessary for morphological characterization and biochemical tests so as to determine the identity of the organisms.

3.5 MORPHOLOGICAL CHARACTERIZATION OF THE ISOLATES

Morphological characterizations were done using colonial, cellular and pigment appearances on culture plates

3.6 BIOCHEMICAL CHARACTERIZATION OF THE ISOLATES

The tests carried out in identifying the isolates are: Gram staining, Catalase test, Oxidase test, Methyl red/Voges Proskaeur test, Coagulase test, Starch hydrolysis test, Sugar fermentation test Simmons citrate test, Indole test and Antibiotic Sensitivity test.

3.5.1 GRAMS STAINING TECHNIQUE

The inoculating loop was sterilized on a flame of a bunsen burner, then a pure culture was smeared on a sterile slide and heat fixed by passing it across the flame quickly with the smear facing up. The slides were placed on the staining rack for staining. The smear was covered with crystal violet stain and allowed to stand for 1 minute, then washed off carefully under running tap water. Gram's iodine was then used to flood the smear and allowed to stand for 1 minute, and

then drained off under gentle running tap. Afterwards, the slide was flooded with decolorizing agent (70% alcohol) and the allowed to stand for 10 seconds. The slide was then washed under running tap water, drained completely and counterstained with safranin for 30 minutes. Then, slide was washed under gently running tap water until no colour appears in the effluent and then blot dried with filter paper (Olutiola *et al*., 2000)

3.5.2 CATALASE TEST

The pure culture was smeared on a sterile slide using a sterilized inoculating loop. Then, a drop of hydrogen peroxide was dropped on the smear. The result was then observed. The presence of oxygen bubbles showed the presence of catalase and the absence of the oxygen bubbles showed the absence of catalase. (Olutiola *et al*., 2000)

3.5.3 OXIDASE TEST

The pure culture was smeared on the filter paper and few drops of the oxidase reagent was added and the results were observed. A purple colouration was produced within 10 seconds by oxidase positive cultures. Absence of purple colouration was produced by oxidase negative cultures. (Olutiola *et al*., 2000)

3.5.4 METHYL RED / VOGES PROSKAUER (MRVP) TEST

8.5gm of the MRVP broth was dissolved in 500ml distilled water, gently homogenized to dissolve the medium completely. 10ml of the broth was distributed into each test tube, covered with corks and the sterilized by autoclaving for 15 minutes afterwards was allowed to cool to room temperature. Each isolate was inoculated into each test tube while labeling them accordingly. The tubes were incubated at 37^0C and observed after 24 hours.

The content of the tubes were divided in two portions and labeled M and V respectively

For Methyl red test: To the tube labeled M, 5 drops of methyl red solution was added to each solution. Appearance of red colour indicated positive reaction while appearance of yellow colour indicated negative reaction.

For Voges Proskaeur test: 1ml from the culture was pipetted into a tube then, 0.5ml of 6% α-naphthol solution and 0.5ml KOH were added and shook. A red colouration within 5 minutes indicated a positive reaction (Olutiola *et al*., 2000)

3.5.5 COAGULASE TEST

A loopful of normal saline was added to a sterile slide and emulsified with a loopful of 24 hours culture until a homogenous suspension was obtained. Then, a drop of human plasma was added to the suspension and stirred for 5 seconds. A coagulase positive result was observed by clumping which did not re-emulsify. A negative result was observed by the absence of clumping. (Olutiola *et al*., 2000).

3.5.7 SUGAR FERMENTATION

5g of peptone, 0.5g of NaCl, 5g of the fermentable sugar (Glucose, Galactose and Maltose) and a pinch of bromocresol purple was measured into a conical flask, 500ml of distilled water was added, homogenized, dispensed to test tubes. Inverted Durham tubes were placed in each tube, covered with corks and sterilized for 15 minutes. Afterwards, each isolates were inoculated into each test tube respectively and incubated at 37^0C. After 24 hours, the results were observed. Colour change to yellow indicated that the organism was able to ferment the sugar and presence of gas in the durham tubes showed that the organism was able to produce acid (Olutiola *et al*., 2000)

3.5.8 SIMMONS CITRATE TEST

12.14gm of Simmons citrate agar was dissolved in 500ml of distilled water, gently homogenized using magnetic stirrer while gently swirling to dissolve the medium completely. Afterwards, the medium was sterilized by autoclaving at 121^0C for 15 minutes and allowed to cool to 50^0C and poured in sterile test tubes. The tubes were then stabbed with a loopful of each isolates into each test tube and then transferred to the incubator and incubated at 37^0C for 24hours. After 24 hours, the tubes were observed. The presence of blue coloration showed a positive reaction while the absence of blue colour indicated a negative reaction (Olutiola *et al*., 2000)

3.5.9 INDOLE TEST

Peptone water was prepared and poured into test tubes and inoculated with a loopful of the isolates respectively. Then, it was incubated for 5-7 days at 37^0C. Afterwards, 0.5ml of Kovac's reagent was added to the test tubes and gently shook and allowed to stand. The colour was observed. A deep red colour developed in the presence of indole which separates out in the alcohol layer while the presence of yellow colour showed the absence of indole (Olutiola *et al*., 2000)

3.5.10 ANTIBIOTIC SENSITIVITY

Sensitivity agar was prepared and poured in petridishes aseptically, and allowed to solidify. Afterwards an isolate was streaked all over the surface of agar and the antibiotic disk was placed on the surface using sterilized forceps. The plates were then incubated for 24 hours. Then, the results were observed. The presence of a zone of inhibition around the discs showed that the organism is sensitive to the antibiotic while the absence of zone of inhibition indicated that the organism is resistant to the antibiotic (Olutiola *et al*., 2000).

CHAPTER FOUR

4.0 RESULTS

From the research done on the five health centers (two private health centers and three government health centers) namely; Wawa Primary Health center, Ibafo Primary Health center, MTU, health center and MFM, Prayer City Clinic. Nutrient agar plates were exposed in the general ward of each health center for 10-30 minutes and incubated at 37^0C for 24-48 hours. The colonies were subcultured into fresh culture plates. Six organisms namely *Staphylococcus sp, Pseudomonas sp, Bacillus sp, Micrococcus sp* and *Arthrobacter sp.* were identified based on their morphological and biochemical characteristics.

4.1 PHYSICAL CONDITIONS OF THE HEALTH CENTERS

Table 4.1 summarizes the physical conditions which entails the population of the in-patients during sampling, the number of the beds in the wards as well as the temperature of the wards of each health centers. Significant difference of the population of in-patients during sampling ranging from 2^e – 6^a was observed with Ibafo Primary Health center with the highest population of in-patients during the course of the sampling and Mountain Top University Clinic with the lowest population of in-patients during the sampling. The number of beds ranged from 8^a – 3^e with Wawa Primary Health center with the highest number of beds and Mountain Top University Clinic with the lowest number of beds. The temperature ranged from 24^a – 23^c with Ibafo Primary Health Center and Mountain Top University Clinic both having the highest temperature and Wawa Primary Health center and MFM, Prayer City Clinic having the lowest temperature.

Table 4.1: Physical conditions of the health centers

Sampling Locations	Dimesnsion of the sampling wards (Length by breadth in meters)	Population of in-patient during sampling	Number of Beds	Temperature of The Ward (^{O}C)
Ibafo Primary Health centre	5.75 × 4	6[a]	7[b]	24[a]
MFM Prayer City Clinic	4.25 × 2.5	4[c]	6[c]	23[c]
Mountain Top University Clinc	5.125 × 3.25	2[e]	3[e]	24[a]
Ofada Primary Health centre	5.25 × 3.5	3[d]	4[d]	23.5[b]
Wawa Primary Health centre	4.75 × 3	5[b]	8[a]	23[c]

4.2 COLONY COUNTS OF THE SAMPLING PLATES

Table 4.2 summarizes the number of colony per plate that were exposed at 10 mins, 20 mins and 30 mins after 24 hrs and 48 hrs. Significant difference of plate exposure time of 10 mins for 24 hrs ranged from $11^{a} - 1^{e}$ and for 48 hrs ranged from $22^{a} - 8^{e}$,of 20 mins for 24 hrs ranged from $26^{a} - 3^{e}$ and for 48 hrs ranged from $55^{a} - 11^{e}$, of 30 mins for 24 hrs ranged from $30^{a} - 5^{e}$ and 48 hrs ranged from $57^{a} - 16^{e}$

Table 4.2: The colony count of the sampling plates

SAMPLE LOCATION	PLATE EXPOSURE TIME (cfu / cm^3)					
	10 mins		20 mins		30 mins	
	24 hrs	48 hrs	24 hrs	48 hrs	24 hrs	48 hrs
Wawa Primary Health Center	5^{c}	11^{d}	7^{c}	18^{d}	12^{c}	22^{d}
Ibafo Primary Health Center	11^{a}	22^{a}	26^{a}	52^{a}	30^{a}	55^{c}
Ofada Primary Health Center	9^{b}	19^{c}	12^{b}	32^{c}	19^{b}	57^{a}
Mountain Top University Clinic	1^{e}	8^{e}	4^{d}	11^{e}	5^{e}	16^{e}
Mfm, Prayer City, Clinic	2^{d}	21^{b}	3^{e}	48^{b}	7^{d}	56^{b}

Mean followed by different superscript within a column are significantly different ($P \geq 0.005$)

4.3 MORPHOLOGICAL CHARACTERISTICS OF THE ISOLATES

Table 4.3 shows that isolates were also identified based on their colour, shape, edge and elevations. The isolates were yellow, cream, white and orange in colour, circular and rhizoid in shape, had entire edges and the elevations were raised and convex. The surfaces of the colonies were observed and the colonies appeared dull, translucent and glistering.

Table 4.3: Morphological characterizations of the isolates

Sampling Locations	Isolates	Colour on Nutrient agar	Shape	Edge	Elevation	Surface
WAWA	IWN 101	Yellow	Circular	Entire	Raised	Dull
	IWN102	Yellow	Circular	Entire	Raised	Dull
	IWN 103	Cream	Circular	Entire	Raised	Dull
	IWN 104	Yellow	Circular	Entire	Raised	Dull
	IWN 201	Cream	Circular	Entire	Convex	Translucent
	IWN 202	Yellow	Rhizoid	Entire	Convex	Translucent
	IWN 203	Yellow	Circular	Entire	Convex	Dull
	IWN 301	Cream	Rhizoid	Entire	Raised	Dull
	IWN 302	Cream	Circular	Entire	Raised	Dull
	IWN 303	Cream	Circular	Entire	Convex	Dull
IBAFO	IBN 101	Cream	Circular	Entire	Raised	Dull
	IBN 102	Cream	Circular	Entire	Raised	Dull
	IBN 103	Cream	Circular	Entire	Raised	Dull
	IBN 201	White	Rhizoid	Entire	Convex	Dull
	IBN 202	White	Circular	Entire	Convex	Translucent
	IBN 301	Cream	Circular	Entire	Convex	Glistering
	IBN 302	Cream	Circular	Entire	Raised	Glistering
OFADA	ION 101	Yellow	Circular	Entire	Raised	Dull
	ION 102	Orange	Circular	Entire	Convex	Dull
	ION 201	Orange	Circular	Entire	Raised	Dull
	ION 301	Yellow	Circular	Entire	Raised	Dull
MTC	IMC 101	Yellow	Rhizoid	Entire	Raised	Dull
	IMC 102	Cream	Circular	Entire	Raised	Dull
	IMC 201	Cream	Rhizoid	Entire	Raised	Dull
	IMC 202	White	Circular	Entire	Raised	Dull
	IMC 301	White	Circular	Entire	Raised	Dull
	IMC 302	Cream	Circular	Entire	Raised	Dull
	IMC 303	Cream	Circular	Entire	Raised	Dull
MFC	IMFC 101	Cream	Circular	Entire	Raised	Glistering
	IMFC 201	Cream	Rhizoid	Entire	Raised	Glistering

	IMFC 202	Yellow	Circular	Entire	Raised	Dull
	IMFC 301	Yellow	Circular	Entire	Raised	Dull

4.4 BIOCHEMICAL CHARACTERISATION

LOCATION	ISOLATES	GRAMS STAINING SHAPE	GRAM STAINING IDENTITY	INDOLE	METHYL RED	VOGES PROSKAUER	CITRATE	STARCH HYDROLYSIS	CATALASE	OXIDASE	SUGAR FERMENTATION	GLUCOSE	MALTOSE	FRUCTOSE	PRESUMPTIVE ORGANISMS
WAWA	IWN101	CLUSTERED COCCI	+	-	+	+	+	+	+	-	AG	AG	A		STAPHYLOCOCCUS
	IWN102	CLUSTERED COCCI	+	-	+	+	+	+	+	-	A G	AG	A		STAPHYLOCOCCUS
	IWN 103	SHORT RODS	-	-	-	-	+	+	+	+	A	A	-		PSEUDOMONAS
	IWN 104	SHORT RODS	-	-	-	-	+	+	+	+	A	A	-		PSEUDOMONAS
	IWN 201	CLUSTERED COCCI	+	-	+	+	+	+	+	-	AG	AG	A		STAPHYLOCOCCUS
	IWN 202	SHORT RODS	+	-	+	+	+	+	+	-	AG	AG	A		STAPHYLOCOCCUS
	IWN 203	LONG RODS	+	-	+	+	+	+	+	-	AG	AG	A		STAPHYLOCOCCUS
	IWN 301	LONG RODS	+	+	-	+	+	+	+	+	AG	AG	A		BACILLUS
	IWN 302	CLUSTERED COCCI	+	+	-	+	+	+	+	+	A	A	A		BACILLUS
	IWN 303	CLUSTERED COCCI	-	-	-	-	+	+	+	+	A	A	-		PSEUDOMONAS
IBAFO	IBN 101	SHORT RODS	+	+	+	-	+	-	+	+	A-	AG	A-		MICROCOCCUS
	1BN 102	SHORT RODS	+	+	+	-	+	-	+	+	A-	AG	A-		MICROCOCCUS
	IBN 103	SHORT RODS	+	+	+	-	+	-	+	+	A-	AG	A-		MICROCOCCUS
	IBN 201	SHORT RODS	+	+	-	-	-	+	+	-	A	A			ARTHROBACTER
	IBN 202	CLUSTERED RODS	+	+	-	-	-	+	+	-	A	A			ARTHROBACTER
	IBN 301	CLUSTERED RODS	+	+	-	-	-	+	+	-	A	A			ARTHROBACTER
	IBN 302	CLUSTERED RODS	-	-	-	-	+	+	+	+	A	A	-		PSEUDOMONAS
OFADA	ION 101	CLUSTRED RODS	+	-	-	+	+	+	+	-	A	A	A		BACILLUS
	ION 102	CLUSTERED RODS	+	-	+	+	+	+	+	-	A	A	A		BACILLUS
	ION 201	SHORT RODS	+	-	+	+	+	+	+	-	A	A	A		BACILLUS
	ION 202	SHORT RODS	+	-	+	+	+	+	+	-	A	A	A		BACILLUS
	ION 301	CLUSTERED LONG RODS	-	-	-	-	+	-	+	-	AG	AG	AG		KLEBSIELLA

Table 4.4: Showing the biochemical characterization of the isolates

MTC	**IMN 101**	**CLUSTERED COCCI**	**+**	**+**	**+**	**+**	**-**	**+**	**-**	**+**	**-**	**A-**	**AG**	**A-**	**MICROCOCCUS**
	IMN 102	CLUSTERED COCCI	**+**	**+**	**+**	**+**	**-**	**+**	**-**	**+**	**-**	**A-**	**AG**	**A-**	**MICROCOCCUS**
	IMN 201	CLUSTERED RODS	**+**	**+**	**-**	**-**	**-**	**-**	**+**	**+**	**-**	**A**	**A**		**ARTHROBACTER**
	IMN 202	CLUSTERED COCCI	**+**	**+**	**+**	**+**	**-**	**+**	**-**	**+**	**-**	**A-**	**AG**	**A-**	**MICROCOCCUS**
	IMN 301	CLUSTERED COCCI	**+**	**+**	**+**	**+**	**-**	**+**	**-**	**+**	**-**	**A-**	**AG**	**A-**	**MICROCOCCUS**
	IMN 302	CLUSTERED COCCI	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**-**	**AG**	**A**	**A**	**STAPHYLOCOCCUS**
	IMN 303	CLUSTERED COCCI	**+**	**+**	**-**	**-**	**+**	**+**	**+**	**+**	**+**	**A**	**A**	**A**	**BACILLUS**
MFC	IMFN 101	LONG RODS	**-**	**-**	**-**	**-**	**-**	**+**	**+**	**+**	**+**	**A**	**A**	**-**	**PSEUDOMONAS**
	IMF 201	LONG RODS	**-**	**-**	**-**	**-**	**-**	**+**	**+**	**+**	**+**	**A**	**A**	**-**	**PSEUDOMONAS**
	IMFN 202	CLUSTERED COCCI	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**-**	**AG**	**AG**	**A-**	**STAPHYLOCOCCUS**
	IMFN 301	CLUSTERED COCCI	**+**	**-**	**+**	**+**	**+**	**+**	**+**	**+**	**-**	**AG**	**AG**	**A-**	**STAPHYLOCOCCUS**

Where;

A = Acid was produced

G = Gas was produced

+ = Positive

- = Negative

Table 4.4 summaries the reaction of the organsims to biochemical tests such as Gram staining, indole test, Methyl red test, Voges Proskaeur test, Citrate test, Starch hydrolysis test, Catalase test, Oxidase test, Sugar fermentation test (Glucose, Maltose and Fructose).

4.5 ANTIBIOTIC SENSITIVITY

TABLE 4.5: Showing the sensitivity of the organisms to certain antibiotics

PRESUMPTIVE ORGANISMS	PEF	CHM	E	CN	S	CPX	AU	SXT	RX	AMP
Staphylococcus sp.	S	S	S	R	R	S	S	R	R	R
Bacillus sp.	S	S	S	S	S	S	S	S	R	S
Micrococcus sp	R	R	I	R	I	R	R	S	S	S
Klebsiella sp	S	R	I	S	S	S	R	I	R	R
Pseudomonas sp.	S	R	S	S	S	S	R	R	S	S
Arthrobacter sp.	R	S	S	S	R	S	R	R	R	R

Where;

PEF = Pefloxacin

CH = Chloramphenicol

E = Erythromycin

CN = Gentamicin

S = Streptomycin

CPX = Ciprofloxacin

AU = Augumentin

SXT = Cotimoxazole

RX = Rifampicin

AMP = Ampicillin

R = Resistance

S = Sensitive

Table 4.4 summarizes the sensitivity of *Stapylococcus* sp., *Bacillus* sp., *Micrococcus* sp., *Klesbsiella* sp., *Pseudomonas* sp. and *Arthrobacter* sp. to 10 different antibiotics namely; Pefloxacin, Chloramphenicol, Erythromycin, Gentamicin, Streptomycin, Ciprofloxacin, Augmentin, Cotimoxazole, Rifampicin and Ampicillin. From the study, *Staphylococcus* sp. and *Micrococcus* sp. appeared to be more resistant to some of the antibiotics indicating that they are more pathogenic while *Bacillus* sp., *Pseudomonas* sp., *Klebsiella* sp. and *Arthrobacter* sp. appeared to be sensitive to some of the antibiotics indicating that they are less pathogenic.

CHAPTER FIVE

5.0 DISCUSSION

A significant public health concern has been observed to be the exposure to bioaerosols (Mirhoseini *et al*., 2016). The result of this study showed significant microbiological contamination of indoor air in the in-patient section of selected primary health centers in Ogun State. High level of indoor air contamination in the hospitals has been previously reported as a factor in nosocomial infection (Ikhitiar *et al*., 2017). Nasir *et al*. (2012) compared the level of bacterial concentrations in indoor and outdoor of hospitals and showed that there was higher levels in indoor contamination unlike that of out-door samples. Moreover, the degree of ventilation, the type and number of patients, the cleanliness of the study sites as well as the type of activities carried out have been reported as added factors that influenced the type and the number of airborne bacteria in the research sites (Mirhoseini *et al*., 2016).

Moreover, in this study, the occurrences of gram positive bacteria were highly significant as compared to gram negative in all the sampling locations. This observation has been previously reported that Gram positive bacteria are the commonly found airborne bacteria in indoor environment (Zhu *et al*., 2003; Aydogdu *et al*., 2010). Furthermore, six bacteria genera were identified which included *Staphylococcus sp, Micrococcus sp, Bacillus sp, Arthrobacter* sp., *Pseudomonas* sp., *Klebsiella sp.* The occurrence of *Staphylococcus* sp., *Micrococcus* sp. *and Bacillus* sp. in the air of hospital environments has been documented (Mirhoseini *et al*., 2016). However, as seen in this research, the frequency of occurrence of gram negative bacteria such as Pseudomonas sp., *Arthrobacter* sp and *Klebsiella* sp., were so few as compared to gram negative bacteria such as *Staphylococcusaureus*.

5.1 CONCLUSION

This study was able to show that there is possibility that some Hospital acquired infections have been contracted through airborne bacteria present in the wards of these selected health centers. These wards appear to be contaminated with bacteria. It is advised that immediate interventions are taken to control environmental as well as human factors which increase the growth and development of bacteria. It is also important to control the movements of visitors in and out of these wards in the health centers. Measures should also be taken to minimize the risks of exposure of airborne bacteria in health care facilities.

5.2 RECOMMENDATION

From the study done in these health centers. The following recommendations were deduced:

A robust policy which entails the strict adherence to aseptic techniques during giving of intravenous injections, passing of fluids into the body, treatment of wounds and cuts in order to limit contamination by airborne pathogens within the wards must be put in place. These regulations include, proper and adequate disinfections of the wards, avoiding clustering of dusts, particles on the windows/vents to ensure good and clean ventilation.The use of survey data is advised which will help introduce guidelines for air quality particularly in enclosed environments in health care facilities.

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