INCIDENCE OF SURGICAL SITE NOSOCOMIAL INFECTIONS IN FEMALE AND MALE SURGICAL WARDS OF AHMADU BELLO UNIVERSITY TEACHING HOSPITAL, ZARIA, NIGERIA

BY

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B.Sc (Microbiology), ABU

M.Sc/PharmSci/11642/2007-2008

OCTOBER, 2012

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A THESIS SUBMITTED TO THE POST GRADUATE SCHOOL AHMADU BELLO UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF M.Sc PHARMACEUTICAL MICROBIOLOGY

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OCTOBER, 2012

DECLARATION

I declare that the work in the thesis entitled "Incidence of surgical sitenosocomial infections in male and female surgical wards of Ahmadu Bello University Teaching Hospital, Zaria" was carried out by me in the Department of Pharmaceutics and Pharmaceutical Microbiology under the supervision of Prof.Y.K.E. Ibrahim, Prof V.I. Odigie and Dr (Mrs.) G.O.Adeshina.

The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree.

_____ _____ _____

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CERTIFICATION

This thesis entitled "INCIDENCE OFSURGICAL SITENOSOCOMIAL INFECTIONS IN MALE AND FEMALE SURGICAL WARDS OF AHMADU BELLO UNIVERSITY TEACHING HOSPITAL, ZARIA, NIGERIA" by Bello, Elizabeth Adenike meets the regulations governing The Award of the Degree of Master of Science (Pharmaceutical Microbiology) of Ahmadu Bello University Teaching Hospital, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

To the glory of God. This work is dedicated to my sweetheart, Bunmi, and my lovely kids Oluwatobi and Omotola for their support, prayers and encouragement, God bless you.

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ABSTRACT

Incidence of surgical site nosocomial infections and antibiotics susceptibility profiles of bacterial isolates in Ahmadu Bello University Teaching Hospital, Zaria Kaduna State, Nigeria were investigated. A 2- year retrospective study was carried out followed by 6-months prospective study and then a follow – up study on surgical site nosocomial infection.

The retrospective study was carried out by assessing patients' medical files and microbiology laboratory records, which were analysed for the determination of the prevalence of surgical site nosocomial infections. The results were statistically evaluated using Chi-square test. The prospective study used bacteriological analysis of air in the modular theatre and surgical wards of the Teaching Hospital. A 6 months follow- up study of nosocomial surgical site infections was carried out for patients who underwentelective surgeries with antibiotic prophylaxis, bacteriological monitoring of the surgical sites from time of surgery until the wound healing occurred or on their discharge from the hospital. Antibiotic susceptibility profiles of the bacterial isolates were determined using the agar diffusion methods as described in official monographs.

The result of the retrospective study of surgical site nosocomial infections in surgical wards of Ahmadu Bello University Teaching Hospital, Zaria showed prevalence rates of surgical site nosocomial infections, of 10.5 % and 8.32% respectively for the two years. Superficial surgical sites were more frequently infected compared with other sites. The leading causative agents of nosocomial infection in the retrospective study were *S. aureus, E.coli, S.epidermidis, and Ps. aeruginosa* in decreasing order of frequencies in the two years of study. Antibiotic susceptibility tests showed that all the bacterial isolates were multiple antibiotics resistant (MAR) with more than 65% of the isolates having MAR index > 0.2 in the two years of study.

The result of the bacteriological study of nosocomial infection in surgical wards of ABUTH, Zaria among patients showed the incidence of nosocomial infection to be 33.0%. *S.aureus*was the most commonly isolated organism followed by *S.epidermidis*. The result of the follow-up study of patients who hadelective surgery and antibiotic prophylaxis in the hospital showed that the risk factors played a significant role in causing surgical site infection.

Bacteriology of air atAhmadu Bello University Teaching Hospital, showed that a total of 24 bacteria were isolated both in the wards and the theatre. The results showed that the antibiotic susceptibility profile of most *Bacillus*spp isolated from the air in the wards and theatres were resistant to all the antibiotics except Ciprofloxacin and Nitrofurantoin of the test antibiotics. All the bacterial isolated from the air were multiple antibiotics resistant (MAR),with MAR index of >0.2.

Most of the bacterial isolated from wounds were multiple antibiotics resistant (MAR) with over 68% of the wound pathogen having an MAR index of > 0.2.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 NOSOCOMIAL INFECTIONS

A nosocomial infection (also called "hospital acquired infection") is defined by Gaynes*et al* (2001) as an infection acquired in hospital by a patient who was admitted for a reason other than that infection. It is also defined as an infection that occurs in a patient in a hospital or other health care facility in which the infection was not present or incubating at the time of admission. This includes infections acquired in the hospital but appearing after discharge (Benenson, 1995). Nosocomial infections are produced by pathogens that develop within a hospital or other type of clinical care facility and are acquired by patients while in that facility. It is estimated that about one patient in ten acquires an infection as a direct result of being hospitalized (Prescott *et al.*, 2005).

Nosocomial infections, even in this modern era of antibiotics, continue to remain an important and formidable consequence/challenge of hospitalization. It has been estimated that about 3.5% of patients leave the hospital after having acquired infections, depending on the case, hospital size and multiple other factors (Boschert, 2002).

Hospital-wide nosocomial infection prevalence varied between 2.5% and 14.8% in Algeria, Burkina Faso, Senegal and the United Republic of Tanzania (Dia*et al.*, 2008) .Overall nosocomial cumulative incidence in surgical wards ranged from 5.7% to 45.8% in studies conducted in Ethiopia and Nigeria (Kesah*et al.*, 2004)

Nosocomial infections may be classified either as endemic or epidemic. Endemic infection are common, meaning that they are at the level of usual occurrence within the setting, epidemic infections occur when there is an unusual increase in infection above baseline for a

specific infection or organism (Ducel*et al.*, 2002).Nosocomial infections are most frequently associated with the urinary tract, surgical wounds, lower respiratory tract, and gastroenteritis, maternal and newborn infections (WHO, 2002).

1.2 MINIMIZING NOSOCOMIAL INFECTIONS: HISTORICAL DEVELOPMENT

A Century ago, a few scientists were persecuted or subjected to ridicule for suggesting that infections were caused by microorganisms too small to be seen and more importantly, that doctors themselves were frequently responsible for carrying infection from one patient to another (Krishna, 2010). It was reported that inanimate objects such as doctors' coats and instruments such as blood pressure cuffs, thermometers and other instruments used by both doctors and nurses, could carry infection from one patient to another or even to another healthy individual (Emori*et al.*, 1993).

Realizing the negative impact of nosocomial infection, several measures were introduced to minimize incidences of nosocomial infection in hospitals and health – care settings by renowned medical scientists notable among them are:

1. IgnazSemmelweis who in 1861 insisted that doctors wash their hands with chlorinated lime before surgery so as to reduce infection.
2. Joseph lister who in 1879 was given the credit for the first antiseptic surgery, that reduced the incidences of infection by spraying carbolic acid into the air of the operating room during surgery.
3. GustaoNeubar who in 1883 introduced the use of masks and gowns in surgery.
4. William Stewart Halsted in 1890 that introduced the use of rubber gloves in surgery and
5. Von Bergman in 1896 who discovered Steam sterilization.

All these measures further increased the safety of surgery and contributed greatly in bringing down rates of infection by use of aseptic and antiseptic techniques (Krishna, 2010). However contemporarily, nosocomial infection is still a surgical/scientist challenge.

1.3 FACTORS INFLUENCING THE DEVELOPMENT OF NOSOCOMIAL INFECTIONS

1.3.1 Microbial agents

The patient is exposed to a variety of microorganisms during hospitalization. Contact between the patient and a microorganism does not by itself necessarily result in the development of clinical disease; other factors influence the nature and frequency of nosocomial infections. The likelihood of exposure leading to infection depends partly on:

- The characteristics of the microorganisms
- Resistance to antimicrobial agents,
- Intrinsic virulence
- Amount (inoculum) of infective material.

Many different bacteria, viruses, fungi and parasites may cause nosocomial infections. Infections may be caused by a microorganism acquired from another person in the hospital (cross-infection) or may be caused by the patient's own flora (endogenous infection). Some organisms may be acquired from an inanimate object or substances recently contaminated from another human source (environmental infection).

The bacteria that commonly cause nosocomial infections include *Staph. aureus,* Coagulase negative *Staphylococci, Streptococcus spp., Enterococci, Ps aeruginosa*, and members of the Entero-bacteriaceae Family such as *E. coli, Pr. mirabilis, Salmonella spp., Sermarcescens and Kl. pneumoniae*(Esposito and Leone, 2007; Shittu, *et al.*, 2002; Nwobu, 2004; Chikere*et al*., 2008 and Zhanel*et al*., 2008). *Staph aureus* remains the dominant species in surgical

wound infection, followed by Pseudomonas, Entero- bacteria, Bacteroides spp. along with other gut bacteria, Very often in mixed growth is found typically in wounds (Ayliffe, 2003). These organisms were once limited to large hospitals but have now become ubiquitous in health care facilities throughout the USA. Some of these organisms are now seen in the general community with alarming frequency (Rizzo, 2001).

The causative organisms of nosocomial infections are usually resistant to several commonly used antibiotics which lead to use of more expensive and often more toxic drugs which in turn leads to increased length of infection and subsequent hospital stay and cost (Courvaline and Weber, 2005).

1.3.2 Patient susceptibility

Predisposing factors that make patients susceptible to these infections include

- Prosthetic devices
- Surgery
- Immunosuppressive agents
- Administration of broad-spectrum antibiotics, and emergence of multidrug resistant pathogens (Horan *et al., 1992*).

Other risk factors include

- Age of patient
- Long duration of hospitalization
- Invasive surgical procedure
- Concurrent infections / Co-morbid conditions e.g renal obesity, cancer, diabetes, tumors or overcrowding in the hospital wards, immunosuppression, malnutrition and steroid therapy.

The extremes of life (infancy and old age) are associated with a decreased resistance to infection. Patients with chronic disease such as malignant tumours, leukaemia, diabetes mellitus, renal failure, or the acquired immunodeficiency syndrome (AIDS) have an increased susceptibility to infections with opportunistic pathogens. The latter are infections with organism(s) that are normally innocuous, e.g. part of the normal bacterial flora in the human, but may become pathogenic when the body's immunological defences are compromised (Horan *et al*., 1992).

1.3.3 Environmental factors

Health- care settings are environments where both infected patients and staff are at increased risk of infection when congregated. Patients with infections or carriers of pathogenic microorganisms admitted to hospital are potential sources of infection for both patients and staff. Patients who have become infected in the hospital are a further source of infection. Crowded conditions within the hospital, frequent transfers of patients from one unit to another, and concentration of patients highly susceptible to infection in one area (e.g. newborn infants, burn patients, and intensive care) all contribute to the development of nosocomial infections. Microbial flora may contaminate objects, devices, and materials which subsequently contact susceptible body sites of patients (WHO,2002).

1.3.4 Bacteria Resistance

Through selection and exchange of genetic resistance elements, antibiotics promote the emergence of multidrug resistant strains of bacteria; microorganisms in the normal human flora sensitive to the given drug are suppressed, while resistant strains persist and may become endemic in the hospital.

The indiscriminate use of antimicrobials for therapy or its abuse gives rise to bacterial resistance.

Antimicrobial agents are, in some cases, becoming less effective because of resistance. As an antimicrobial agent becomes widely used, bacteria resistant to this drug eventually emerge and may spread in the health care setting. Many strains of Pneumococci, Staphylococci, Enterococci, and Tubercle bacilli are currently resistant to most antimicrobials which were once effective. *MultiresistantKlebsiella*and *Ps.aeruginosa*are prevalent in many hospitals. This problem is particularly critical in developing countries where more expensive second-line antibiotics may not be available or affordable (Bergogne – Berezin and Towner, 1996).

1.3.5 Prevention of hospital-acquired infections

Most nosocomial infections can be prevented with readily available, relatively inexpensive strategies, such as:

1. Adhering to recommended infection prevention practices, especially hand hygiene and wearing gloves;
2. Paying attention to well-established processes for decontamination and cleaning of soiled instruments and other items, followed by either sterilization or high-level disinfection and
3. Improving safety in operating rooms and other high-risk areas where the most serious and frequent injuries and exposures to infectious agents occur.

Significant progress has been made in preventing and controlling nosocomial infections since the problem was recognized over a Century ago, however, nosocomial infections continue to be a major source of morbidity and mortality, affecting more than million patients annually (Samuel*et al.,* 2010). Therefore, knowledge about the frequency and distribution of nosocomial infections is important to improve infection control measures as well as to develop effective preventive and curative strategies which, in turn, will help in decreasing incidence, morbidity, mortality and associated treatment cost (Shar*et al.,* 2010)

Unfortunately, not all nosocomial infections are preventable. For example, some reflect the influence of advanced age, chronic diseases such as diabetes, end-stage kidney disease or advanced pulmonary emphysema, severe malnutrition, treatment with certain drugs (e.g., antimicrobials, corticosteroids and other agents that decrease immunity), the increasing impact of AIDS (e.g., opportunistic infections) and irradiation (Mangram*etal*., 2009).

1.4 STATEMENT OF PROBLEM

Nosocomial infection is a recognized public health problem world-wide. In Nigeria the prevalence rates range between 5.7% to 45.8 (Kesah*et al.,* 2004). Several studies have also reported high prevalence rates of nosocomial surgical site infections. From ObafemiAwolowo University, Ife Onipede*et al* (2004), reported an average nosocomial infections incidence rate of 38.3% while 27.9 % was reported from the University College Hospital Ibadan, by Oni *et al* (2006)and Ige*et al*., (2011) also reported as high as 48.3% of surgical site infections from the surgical wards .In a study at the University of Ilorin Teaching Hospital in Ilorin, Atata, (2010) observed that incidence of nosocomial infections at different surgical sites in hospitals was much higher, about 26.1%. Atata also reported about 1.27% for average nosocomial infection rates for 3 years beside the figure for surgical cases. The above findings clearly demonstrated that nosocomial infection is common in Nigerian hospitals (Odimayo et al.,2008). In Jos, Egah*et al* (2011) reported an incidence of 9.1% on surgical site infections.

Nosocomial surgical site infections has become increasingly obvious that infections acquired in the hospital lead to increased morbidity and mortality which has added noticeably to the economic burden such as increase costs, functional disability, emotional stress and may, in some cases, lead to disabling conditions that reduce the quality of life (Horan *et al.,* 1992).

Over the years, little progress has been made in addressing the basic problems responsible for the increasing rates of nosocomial surgical site infections in many countries, and in some countries, conditions are actually worsening (Ponce-de-Leon, 1991).

In the U.S these infections are responsible for about 90,000 deaths per year and approximately 10% of patients (2 million every year) acquire these infections with an annual cost of 4.5 – 11 billion dollars (Alausa and Onile, 1984). According to the Centres for Disease Control and Prevention (CDC, 2002), 2.7% of surgical procedures are complicated by nosocomial surgical-site infections (SSIs), resulting in increased morbidity, hospitalization, and costs (Josephine *et al.*, 2010). Over 1.5million cases of nosocomial surgical site infections in long term care facilities and in nursing homes each year have been discovered by the CDC. On an average approximately two million cases of nosocomial infections and with more than 5000 deaths annually in the United States (Manangan*et al.*, 2001).In France, the prevalence of nosocomial infections was between 6.9% -7.5%, In Italy in 2000, about 6.7% of hospitalized patients were infected (Julie, 2002).

Ahmadu Bello University Teaching Hospital Zaria is the largest and premier national tertiary referral and Teaching Hospital in Northern Nigeria that provides referral servicesfor patients from most part of Northern Nigeria. In addition to this, many procedures particularly surgical operations which are risk factors for nosocomial infections are performed in this hospital. Patients infected in this hospital may act as carriers of infection elsewhere in the community with attendant problems.There is a need for current and reliable up-to-date information on susceptibility pattern ofmicroorganisms, which changes over time especially bacterial pathogens causing nosocomial infection. Outcome of this study will improve healthcare delivery and promote further work on surgical site nosocomial infections in the Ahmadu Bello University Teaching Hospital, Zaria.

1.5 JUSTIFICATION OF THE STUDY

There are several reasons why nosocomial infections are still alarming in the 21st Century. These include

- Hospitals housing large number of people who are sick and whose immune systems are often in suboptimal state.
- Increase invasive procedures that bypass the body's natural protective barriers.
- Contact between patient to patient thus providing a way for pathogens to spread.
- There are inadequate sanitation supervision protocols regarding uniforms.
- Routine washing of handsand other preventive measures that may either be unheeded by hospital personnel / a break to sufficiently isolate patients from infectious agents.
- Over use of anti-microbial agents in hospitals creates selection pressure for the emergence of the resistant strains of microorganisms which has resulted in the emergence and reemergence of difficult-to-treat nosocomial infections in patients. This is as a result of use of antimicrobial drugs in long-term care facilities and transfer of patients between these facilities and hospitals which have created a large reservoir of resistant strains in hospitals (Kainer*et al.,* 2007).
- Intensive care and critical ill patients.

Surgical site nosocomial infections constitute an important health problem throughout the world. They result in high morbidity and mortality, prolonged hospital stays, greater use of antibiotics, and increased costs (Horan *et al.*, 2008).

Surgical site nosocomial infections are often caused by insufficient hand washing by hospital personnel after handling infected materials and patients. In fact, hand washing compliance rates are typically as low as 15-35% as inconvenient sink locations and forgetfulness create barriers to proper hand washing behavior (Mananga*et al.*, 2001).

Most hospitals in developing countries, especially Africa, have no effective infection control programmes and there is lack both of awareness of the problem and of personnel trained in infection control practices (Samuel *et al.*, 2010).

Among the difficulties faced that have also been identified as mitigating against an effective infection control programme in the hospital are inadequate and ageing infrastructure including poor water supply, erratic supply of electricity, surgical and medical consumables e.g gloves, masks, disinfectants etc, lack of an effective antibiotic policies which is due to the fact that often times these policies are written without due consultation with those that will prescribe and without taking into consideration the antibiotic resistance profile of local organisms. Unfortunately, this information is unavailable in many developing nations due to poor or absent antibiotic resistance surveillance programmes which is part of the functions of the infection control team, poor funding of nosocomial infection programme, poor laboratory backup, lack of awareness of the activities of the infection control team or the cost benefits of an efficient control programme, the presence of family members in hospital, limited isolation facilities and in some cases patient presenting in advanced state of the disease process rendering isolation difficult (Samuel *et al.*, 2010).

Health care-associated infections (HAI) occur worldwide and affect both developed and developing countries. In developed countries, between 5% and 10% of patients acquire one or more infections and 15%–40% of patients admitted to critical care are thought to be affected (Pittet, 2005). In low resource / developing countries, rates of infection can exceed 20% (Pittet, 2005), but available data are scanty and more research is urgently needed to assess the burden of disease in developing and transitional countries.

It is recommended that the cost of hospital infection control programme should be included in the health budget of the country and fund allocated for the infection control committee for routine control purposes and to bear the cost of outbreaks. Also there is need for adequate

staffing and continuous education of staff on the principles of infection control, especially hand washing which is the single most important effective measure to reduce the risk of these infections (Samuel *et al*.,2010).

1.6 LIMITATIONS OF THE STUDY

- Excluded from the study are: Medical Intensive Care Unit, Paediatric and Gynecology and Obstetrics wards in which high incidences of nosocomial infections are often reported.
- The study is designed to cover only aerobic bacterial pathogens involved in surgical site nosocomial infections. It does not include anaerobic any other known pathogens of nosocomial infection.
- Patients who developed surgical site nosocomial infections after being discharged from the hospital were not included in this study.

1.7 GENERAL OBJECTIVE (AIM)

The main objective of this research is to determine the occurrence (rate and causes) of surgical site nosocomial infections in the surgical wards of Ahmadu Bello University, Teaching Hospital, Zaria with a view for its eventual control.

1.8 SPECIFIC OBJECTIVES

- Carry out a retrospective analysis of the surgical site nosocomial infections in Ahmadu Bello University Teaching Hospital Zaria, by assessment of patient medical profiles or records in the medical records, surgical outpatient department and the microbiology departments.
- Carry out a prospective study on the prevalence of surgical site nosocomial infections by monitoring and isolating the aerobic pathogens using swabbing technique.

- Characterize the isolates using standard microbiological tests and administration of data collection form on surgical site infections.
- Monitor, isolate and identify aerobic microbial contaminants in female and male surgical wards of the hospital and the operating theatre.
- Determine the antibiotic sensitivity patterns of the nosocomial isolates by the agar diffusion technique.
- Determine effect of factors such as length of hospitalization and post surgery on the incidence of surgical site nosocomial infection.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ORIGIN OF NOSOCOMIAL INFECTIONS

Prior to the 1800's, typhus was recognized as a "hospital" infection, running rampant in city hospitals caring for the poor and in military hospitals. Once surgery became more prevalent during the 19th Century, other hospital acquired bacterial infections became a frequent occurrence (Angelo *et al.*, 2011).

Before 1890, "Erysipelas" (streptococcus skin infection) was considered a part of hospital life, especially after surgery (Angelo *et al.,* 2011). In the 1830's, the term "hospital-acquired infections" was introduced by James Simpson in England, who called the problem "Hospitalism" (Angelo *et al.,* 2011). The prevailing theory at the time for the spread of infection was that poor ventilation and stagnant air ("corruption of the air," "divine wrath") was the culprit, not direct contact from infected source to patient. Therefore, physicians were more than strong in their opinions as to how to prevent infection: open the window and prevent overcrowding. "Germ theory" was not yet in favor, so the concept of personal hygiene was not a consideration (Angelo *et al.,* 2011) .

In 1848, IgnazSemmelweis who was a surgeon in Vienna at the obstetrical clinic noted that infections rates in the obstetrical clinic run by physicians "puerperal fevers" were at least twice that of a second clinic run by midwives. Apparently, the physicians used to teach anatomy in the mornings in the postmortem area, and then moved from there to operate in the clinic. The midwives, on the other hand, came straight from the homes. Semmelweis therefore introduced the idea of hand washing and use of antiseptic solution for hands and surgical instruments for the physicians whenever they moved from the autopsy area to the

operating theater. He met great resistance from his colleagues. Within two years of his idea, he was forced to quit medicine altogether. In the end, he died in an asylum for the mentally unstable (Angelo *et al.,* 2011).

It took another 40 years before Joseph Lister could convince his colleagues to accept the same idea of Semmelweis. He introduced antiseptic theory, following the extensive use of carbolic acid to pack wounds, especially of compound fractures, sterilize instrument, sutures, and decontaminate his hands also as an air spray. He observed that these practices could greatly reduce the incidence of suppuration and gangrene, which quite commonly occurred in limb amputations. (Krishna, 2010).

In another setting, Angelo noted that Florence Nightingale hygiene made a difference in the incidence of infection occurring in surgical patients. In 1854, during the Crimean War, Florence Nightingale demonstrated that cleaning up the military hospital with fresh linens, and scrub–brushed floors would ultimately result in a reduction of the death rates among wounded combats from 40% to 2% in a matter of six months, an infection rate that is the accepted "risk standard" for modern surgical procedures today .

Hospital surgical infection rates continue to range between 2–15% until the advent of production-level penicillin in 1941. Thereafter, post-operative pneumonia death rates fell from over 30% to below 10%, and surgical wound infection rates fell to below 5% towards the end of World War II. With the gradual introduction of an ever-widening array of the sulfonamides and other antibiotics, surgical infection rates fell to as low as 2% by the 1960' (Angelo *et al.,* 2011).

2.2 NOSOCOMIAL INFECTION SITES

Nosocomial infections are infections acquired by patients during hospitalization which may manifest during the hospitalization or after discharge. Several types of nosocomial infections have been described largely based on infection sites (Fig2.1), The Center for Disease Control and Prevention (USA) has published guidelines for the classification of nosocomial infections, which are meant to serve as operational definitions used for surveillance purposes (WHO,2002).

The most common types of nosocomial infections are urinary infections, surgical site infection, respiratory tract infection, nosocomial bacteremia and skin and soft tissue infections.

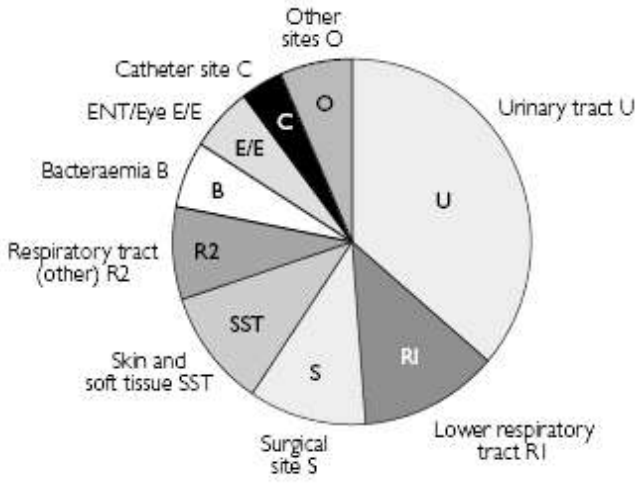


Figure 2.1. Sites of the most common nosocomial infections: distribution according to the French national prevalence survey (1996) (Adapted from WHO, 2002)

2.2.1 Urinary Tract Infection

Urinary tract infections (UTIs) are the most common type of nosocomial (hospital-acquired) infections, accounting for 40% of all infections in hospitals. Several studies have reported that about 80% of nosocomial UTIs occur following instrumentation and primarily catheterization (Burke *et al.,* 1999). Since nearly 10% of all hospitalized patients are catheterized, preventing UTIs is a major factor in decreasing nosocomial infections. Organisms attacking any portion of the urinary system cause urinary tract infections: the kidneys (pyelonephritis), bladder (cystitis), prostate (prostatitis), urethra (urethritis) or urine (bacteriuria). Once bacteria infect any of these sites, all other areas are at risk (Ducel*et al.,* 2002).

The diagnosis of lower UTIs (cystitis and urethritis) is usually made on the basis of signs and symptoms and then confirmed by culture. Most episodes of short-term catheter-associated bacteriuria (greater than 10^5 organisms per ml of urine), however, are without symptoms. If present, symptoms usually consist of slight fever, burning, urgency and pain on urination. Similar symptoms or findings may occur in long-term catheterized patients, but these patients may also experience obstruction, urinary tract stones, renal failure and (rarely) bladder cancer ((Ducel*et al.,* 2002).

In upper UTIs (pyelonephritis), flank pain, fever, blood in the urine (hematuria) and other physical findings may be present. Because of suboptimal state in elderly patients, the typical signs and symptoms of a UTI may be absent either biological or physiological (Ducel*et al.*, 2002). Moreover, bacteriuria, whether from an upper or lower UTI, is the most common cause of nosocomial gram-negative sepsis and has been linked to increased mortality ((Ducel*et al.,* 2002).

a. Epidemiology and microbiology of urinary tract infection

In several prospective studies, rates of catheter-associated urinary tract infection ranging from 9% to 23% have been reported (Johnson *et al*., 1990). The wide range of rates may stem, in part, from recent improvements in care and technology (closed collection systems and better preventive care), as the highest rates were observed in studies prior to 1980. The incidence of nosocomial UTIs depends, to a large extent, on the duration of catheterization and the type of drainage system (closed versus open) (Ducel*et al*., 2002).

There is a greater risk of UTI with increased duration of catheterization. For example, about 50% of patients catheterized longer than 7–10 days typically develop an infection, but this increases to over 90% in patients catheterized more than 30 days (Garibaldi *et al.*, 1988).

Most nosocomial UTIs are caused by Gram-negative coliform bacteria, particularly *Escherichia coli*, *Pseudomonas spp*, and organisms from the Enterobacter group. Collectively, they account for more than 80% of culture-positive UTIs. While the most common organism is *E. coli*, infections with fungi, such as the candida species, have increased with the advent of HIV/AIDS and widespread use of broad spectrum antibiotics (Haley *et al*., 1985).

b. Risk factors for nosocomial urinary tract infection

Risk factors for nosocomialurinary tract infection associated with catheterization can be broken down into those that are not alterable and those that are. Factors that are not alterable include: female gender, postpartum status, older age, severe underlying illness and high blood creatinine level. Factors that can be altered to reduce the risk of infection include: the wrong reason for catheterization, contamination during insertion, errors in catheter care and use of antibiotics (Soleto*et al.,* 2003).

Factors that can lead to bacteriuria and UTIs include:

- passage of organisms from the urine bag to the bladder (retrograde contamination) that occurs in 15–20% of patients with indwelling catheters (i.e., those left in place for several days or weeks); and
- ability of some organisms to grow on the outside or inside of the tubing and even in the urine itself.

Although these factors may not be alterable, preventing contamination of the collection bag, the bladder-to-bag tubing, the emptying tube on the bag or the mucosa lining the urethra can minimize the risk of infection (Ducel*et al.,* 2002).

c. Reducing the risk of nosocomial urinary tract infection

Except for the end of the urethra or penis, the urinary system is normally sterile. The ability to completely empty the bladder is one of the most important ways the body has to keep the urine sterile and preventurinary tract infection. If the bladder empties completely during the voiding process, bacteria do not have the chance to infect tissue or grow and multiply in the bladder (Garibaldi *et al.*, 1988).

Generally, the normal defense against a urinary tract infectionis an unobstructed urethra, the voiding process and normal bladder mucosa. The insertion of a catheter, however, bypasses these defenses, introduces microorganisms from the end of the urethra or penis since the urethra in male is long and has valves, and provides a pathway for organisms to reach the bladder. Organisms may reach the bladder in two ways: either through the inside of a catheter (i.e., the backward flow of urine) or by traveling up the space between the outer surface of the catheter and the urethral mucosa (Garibaldi *etal*., 1988).

Therefore, once the catheter is inserted, any back-and-forth movement of the catheter (e.g., raising the collection bag above the level of the bladder), or allowing urine to be collected in an open drainage system (bag or container) should be avoided because each of these activities potentially enables organisms to enter the bladder. The backward flow of urine in the catheter is the more common infection in men. The migration of organisms into the bladder along the outside of the catheter is more common in women in part because of their shorter urethra. As a consequence, women are more likely to develop a urinary tract infectionfrom organisms located in the vagina (Garibaldi *et al*., 1988).

Placement of an indwelling catheter should be performed only when other methods of emptying the bladder are not effective, and it is particularly important to limit the duration as much as possible (Garibaldi *et al*., 1988). The accepted indications for catheterization are:

- For short-term duration management of incontinence or retention not helped by other methods
- Measuring urine output over several days in critically ill patients
- Instilling medications
- Treatment of urinary outlet obstruction (blockage of the tube leading from the bladder to the outside, the urethra)
- Postoperative management of surgical patients with impaired bladder function (the most common routine use).

2.2.2 Surgical Site Infections

Surgical site infections are frequent with incidence ranging from 0.5% to 15%, depending on the type of surgery and the underlying patient status (Horan, *et al.*, 2008). A surgical infection is indicated by the presence of pain, inflammations (local or systemic symptoms) purulent discharge around the wound or the insertion site of a drain, or by the presence of

cellulites, emanating from the wound. Infections of the surgical wound (whether above or below the aponeurosis), and deep infections of organs or organ spaces are identified separately (WHO, 2002).

Surgical site infection is often acquired during the operation itself; either exogenously (e.g. from the air, medical equipment, surgeons and other staff), endogenously from the flora on the skin or in the operative site or, rarely, from blood used in surgery (WHO, 2002). The infecting microorganisms are variable, depending on the type and location of surgery, and antimicrobials received by the patient. The main risk factor is the extent of contamination during the procedure (clean, clean contaminated, contaminated, dirty), which is to a large part dependent on the length of the operation, and the patient's general condition (Haley *et al*, 1985*)*. Other factors include

- The quality of surgical technique.
- The presence of foreign bodies including drains.
- The virulence of the microorganisms and quantity of inoculum
- Concomitant infection at other sites.
- The use of preoperative shaving
- Underlying patient status.
- Operating room environment.
- The experience of the surgical team (WHO, 2002).

In the 20th century, the two key factors that have enabled surgical advances, such as open heart surgery and kidney transplants, to become routinely possible and safe are improved anesthesia and scientifically sound infection prevention practices. Despite improvements in operating room practices, instrument sterilization methods, better surgical technique and the best efforts of infection prevention practitioners, surgical site infections (SSIs) remain a

major cause of nosocomial (hospital-acquired) infections—and rates are increasing globally (Creamer *et al.*, 2002).

Moreover, in countries where resources are limited, even basic life-saving operations, such as appendicectomy and cesarean sections, are associated with high infection rates and mortality. In these countries, therefore, it makes sense to focus on preventing SSIs in those procedures most frequently performed and/or those having the highest SSI rates (Lilani*et al*., 2005). To reduce the risk of nosocomial SSIs in developing countries, a systematic but realistic approach must be applied with awareness that this risk is influenced by characteristics of the patient, the operation, the healthcare staff and the hospital. In theory, reducing risk is relatively simple and inexpensive, especially when compared to the cost of the infections themselves, but in practice, it requires commitment at all levels of the healthcare system (Sohn*et al*., 2002).

The problems responsible for the high nosocomial rates (i.e., lack of training, supervision, infrastructure and resources) have not changed over the years, so also the recommended solutions (Horan *et al* 2008).

a. Classification of wound infection

Surgical wound infections are classified into four:

i. Class I—clean wound:

Vascular Procedures e.g Neurological procedures Endocrine procedures, Eye surgery ,Orthopedic procedures (unless: traumatized wounds, old wounds, amputation), Skin (mastectomy, lumpectomy, lesions, lipoma, cosmetic, old wounds, inflamed wounds, infected wounds), Exploratory Laparatomy (no bowel involvement)

Miscellaneous procedures (lymph node excision unless inflamed or infected wounds, splenectomy, they are wounds, in which the risk of infection is less than 2%, and does

notrequire antibiotic prophylaxis. It is an uninfected operative wound with no inflammation not involving opening into the respiratory, gastrointestinal (GI), genital and urinary tracts e.t.c. clean wounds are closed at surgery and, if necessary, drained with closed drainage. Common exceptions are procedures in which infection would be disastrous—for example, prosthesis placements, central nervous system operations, or cardiac procedures that use cardiopulmonary bypass. A first generation cephalosporin, such as cefazolin, is commonly used; if the patient is allergic to penicillin, Vancomycin is a good alternative (Horan *et al.*, 1992).

ii. Class II—clean-contaminated:

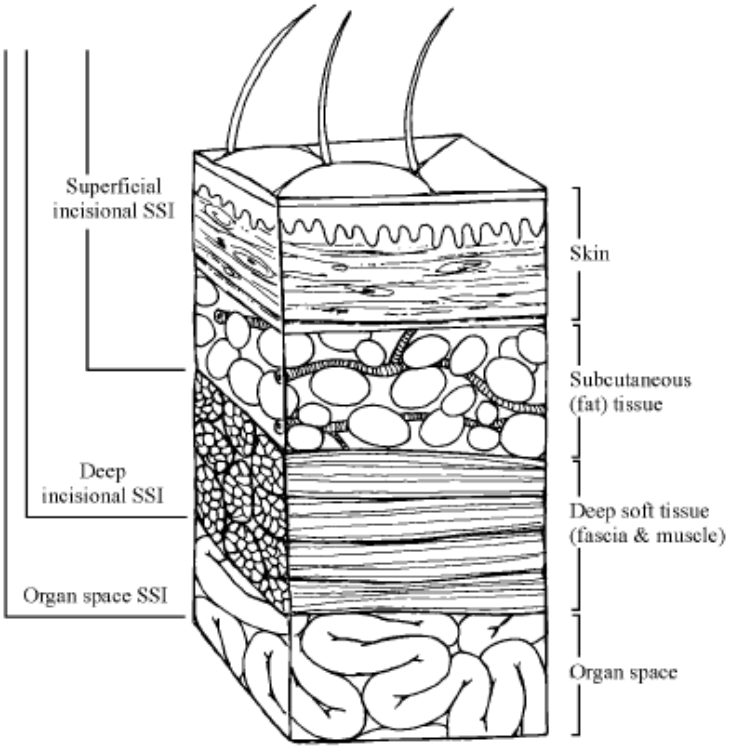
Wound in which the respiratory, GI, genital or urinary tract(s) were entered into under controlled conditions but without unusual contamination or spillage of contents inflammation, infected IV, foreign body), gastrointestinal procedures (including: laparoscopy, colonoscopy, gastroscopy) (gross spillage, acute inflammation, fresh accidental wound, Ear surgery (infected wounds), Nose/Oropharynx procedures (infected wounds), gynecological procedures (Oophorectomy) (Horan *et al.*, 1992).

iii. Class III—contaminated:

Open, fresh accidental wound or an operation with a major break(s) in aseptic technique (e.g., open cardiac massage) or gross spillage from the gastrointestinal tract. Also included are incisions in which acute but no purulent inflammation is found e.g Inflammation, Gross spillage, Fresh accidental wound (Horan *et al*., 1992).

iv.Class IV—dirty or infected:

Old wounds with dead tissue and those that involve existing clinical infection or a perforated bowel, suggesting that the pathogens causing the postoperative infection were present in the wound before the surgery Infected e.g abscess and wound debridement (Horan *et al.*, 1992).



Adapted from: Horan et al 1992.

Fig 2.2 Classification of wound infection (Adapted from Horan *et al.*, 1992)

b. Epidemiology and microbiology of surgical wound infection

Among surgical patients, SSIs is the most common nosocomial infection. In most studies about two thirds of these can be classified as superficial incisional, while the remaining involve either organs or spaces entered during surgery or are deep incisional SSIs. On average, having an SSI increases a patient's hospital stay by 7–10 days, with organ/space and deep incisional SSIs accounting for the longest stays and highest costs (Mangram*et al*., 2009). Organisms associated with SSIs vary with the type of procedure and the anatomic location of the operation. *Staphylococcus aureus*(Coagulase negative staphylococci), Enterococcus species and *Escherichia coli* are the three most frequently isolated pathogens (Mangram*et al*., 2009). An increasing number of SSIs are caused by antimicrobial-resistant

pathogens, and the incidence of fungal SSIs has risen significantly in the last decade in part because of the dramatic increase in the number of HIV/AIDS patients (Soleto*etal*., 2003). For most SSIs, the source of the pathogen(s) comes from the patient's skin, mucous membranes or bowel and rarely from another infected site in the body (endogenous sources). Exogenous sources of SSI pathogens are occasionally responsible. These include:

- organisms from members of the surgical team (e.g., hands, nose or other body parts);
- contaminated surfaces in the operating room, including air; and
- Contaminated instruments, such as surgical gloves or other items used in the surgery (Giacometti *etal*., 2000).

Exogenous organisms are primarily aerobic Staphylococci or Streptococci species (with the exception of tetanus endospores). Although fungi are widely present in the environment, they rarely cause SSIs. The mechanisms by which microorganisms infect tissue and produce disease are complex and incompletely understood. For example, some pathogens may contain or produce toxins and other substances that increase their ability to invade a patient's tissue, produce damage or survive in the tissue (Sahu*et al*., 2011).

c. Pathogenesis of surgical wound infection

By the end of an operation, bacteria and other microorganisms contaminate all surgical wounds, but only a small number of patients actually develop a clinical infection (Fry, 2003). Infection does not develop in most patients because their defense mechanisms effectively eliminate the contaminating organisms at the surgical site. Whether a potential infection occurs depends on several factors, with the most important being:

- number of bacteria entering the wound (innoculum)
- type and virulence of the bacteria;
- host defense mechanisms (e.g., effectiveness of inflammatory response

and status of the immune system); and

- external / co morbid factors, i.e. {intrinsic or extrinsic} being in the hospital several days before surgery or the operation lasting more than 4 hours (Cruse and Ford,1980).

Two factors that can help minimize the number of organisms entering the wound are the skill and experience of the surgeon and use of good surgical technique. Both are important because if a surgical site is contaminated with more than 10^5 (100,000) organisms per gram of tissue, the risk of SSI is markedly increased (Krizek and Robinson, 1975). The dose required for infection can be even lower, however, if foreign material is present because foreign materials help propagate surgical site infections (James and Macleod, 1961).

While the type and virulence of the bacteria cannot be controlled, the other factors can, to a large extent be controlled. For example, tissue injury caused by making the wound incision triggers a chain of events, called the inflammatory response, that take place even before bacterial contamination occurs. The effectiveness of the inflammatory response to mobilize patient defense mechanisms (e.g., activation of various types of white blood cells that contain and destroy the bacteria before infection can occur) depends to a large extent on the patient's general health, age, obesity, smoking, some chronic diseases and the status of the immune system (Berard and Gandon, 1964).

2.2.3 Respiratory Tract Infection (RTI)

Nosocomial pneumonia, a prominent respiratory tract infection is a significant nosocomial infection problem. About 3% of patients on ventilators acquire pneumonia, which in this circumstance, has a very high case-fatality rate (Ducel*et al*., 2002). The source of the microorganism is often endogenous but may also be exogenous with transfer of an organism from the respiratory equipment (Lilani *et al*., 2005). In one example of successful reduction

of ventilator-associated pneumonia (VAP), the Owensboro Medical Health System was able to reduce the rate of VAP in the ICU to zero for eight months. They implemented the Ventilator Bundle, a series of interventions related to ventilator care. The main interventions include elevation of the head of the bed, assessment of the readiness for extubation, daily "sedation" vacations, peptic ulcer prophylaxis, and deep venous thrombosis prophylaxis. The Owensboro team particularly noted the importance of elevating the head of the bed, citing an observed association of inability to elevate the head of the bed due to clinical condition and VAP. The team also noted the importance of getting "buy-in" from the nursing staff, making changes as easy as possible for the nursing staff, teaching new staff members the importance of the ventilator bundle, identifying a physician champion of the intervention, and remembering that cultural changes take time (Ducel*et al*., 2002). Besides ventilator-associated pneumonia, there are also problems with viral bronchiolitis in children's units and influenza with secondary bacterial pneumonia in institutions for the elderly (Courvalin and Weber, 2005).

2.2.4 Blood Stream Infections (BSI)

Nosocomial bacteremia, which is another type of nosocomial infection, represents about 5% of incidences of nosocomial infections (Ducel*et al*., 2002).. Although only a small proportion of nosocomial infections have high case-fatality rates, sometimes greater than 50%. These infections may occur at the entry site of the intravascular device or along the path of a catheter (tunnel infection). The sources of infection-causing microorganism for these infections are endogenous. Bloodstream infections are among the most common hospital-acquired infections in pediatric patients, and are responsible for approximately 10% to 30% of the cases (Arnoni*etal*., 2007). Bloodstream infections usually are associated with intravascular catheters, particularly central venous catheters (CVCs). The highest BSI rates

are in intensive care unit (ICU) patients, with infections rates ranging from 2.4 to 30.0 per 1,000 CVC days (Apostolopoulou and Veldekis, 2005). Blood stream infection due to bacterial and fungal pathogens affect over 200,000 individuals annually in the United States alone and are a tremendously important cause of morbidity and mortality worldwide (CDC, 2002). The impact of specific etiologic agents on the outcome of BSI has been well documented and points to the need for a better understanding of the spectrum of pathogens causing both nosocomial and community-acquired bloodstream infection (Pfaller*et al.*, 1998). Gram-negative bacteria are the most common causative agents in hospital acquired bloodstream infections. However, Gram-positive bacteria becoming more predominant, probably due to the greater use of prophylactic antibiotics in high risk patients, such as use of intravascular devices (Arnoni*et al.*, 2007). Nosocomial pathogens have shifted away from easily treatable bacteria towards more resistant bacteria. These shifts continue to present challenges for nosocomial infection control and prevention (Kasatpibal*et al.*, 2006). In general, the common bacterial pathogens in blood stream infections are *S. aureus,* Coagulase negative staphylococci, *Ps. aeruginosa, Kl.pneumoniae, E. coli, Enterobacter*spp., *Enterococcus* spp. and *Acinetobacter*spp.

2.2.5 Other Nosocomial Infections

Besides the above described nosocomial infections, other potential sites of nosocomial infections exist. For example:

- Skin and soft tissue infections.
- Open sores (ulcers, burns and bedsores) encourage bacterial colonization and may lead to systemic infection.
- Nosocomial gastroenteritis are likely to be caused by hospital acquired flora, which may include enteric organisms with acquired antibacterial resistance or multi-resistant gram-negative bacteria, such as *P. aeruginosa*.

- sinusitis and other enteric infections.
- Infections of the eye and conjunctiva and endometritis and other infections of the reproductive organs following childbirth (WHO, 2002).

2.3 FACTORS THAT CONTRIBUTE TO NOSOCOMIAL INFECTIONS

Nosocomial or hospital acquired infections cause an increase in patient's length of stay and cost. In many cases patients find themselves ill after arriving at the hospital than before admittance. The Orlando Sentinal Reports showed that one of the leading nosocomial infection agents, Methicillin resistant Staphylococcus aureus (MRSA), killed more people than AIDS in 2007 (Bolyard*et al*., 1998). Several factors contribute to this increasing health issue.

2.3.1 Microorganisms

Nosocomial infections are usually caused by bacteria, most of which are non invasive and part of the normal microbiota with Viruses, protozoa and fungi being rarely involved (Prescott *et al.*, 2005).Majority of the bacteria causing nosocomial infections, are Gram negative bacilli and mostly micro organisms that are part of the body's flora. It has now become apparent that when organisms that are part of the body' normal flora, move to another part of body system, they could result in an infection. For instance, when organisms that are part of the normal intestinal flora such as *E. coli* or *Kl. pneumoniae* are mechanically introduced into the bladder via an indwelling catheter, they will frequently cause urinary tract infection (Prescott *et al.*, 2005). Cocci such as *S. aureus* and *Streptococcus spp* also cause nosocomial infections.

With the advent of more elaborate surgery and intensive care, combined with the use of broad-spectrum antibiotic and immunosuppressive drugs, Gram-negative bacteria have risen

in importance. Many Gram negative bacilli such as *Pseudomonas spp*. are opportunist, capable of causing infection in compromised patients. Such organisms may be found in patients' own body flora, or in damp environmental sites, including patient, equipment and medicaments. They may exhibit natural resistance to many antibiotics and antiseptics and have the ability to colonize traumatized skin such as burns and bedsores (Bolyard*et al.*, 1998).

In the last two decades, groups of micro organisms, which formerly played no recognized part in hospital infections, have emerged. These include the Coagulase- negative Staphylococcus present in normal skin flora. Viral or fungal infections, particularly of the immunocompromised patients, have also become important (Bolyard*et al.*, 1998).

The commonly occurring microorganisms in hospital infections include; *E. coli, Klebsiellaspp, Ps. aeruginosa, Proteus spp, Enterococcus spp, S. aureus,* Coagulase negative staphylococci (Prescott *et al.*, 2005).

2.3.2 Antibiotic Resistance

According to the Center for Disease Control, many patients and doctors have made it easy for these new super bugs to take hold (CDC,2002). Doctors unnecessarily prescribing antibiotics or patients who fail to complete an antibiotic regimen prescribed to them, provide a breeding ground for bacteria to grow and become stronger. The bacteria presumed gone, actually learn how to outsmart the antibiotic. The next time this infection occurs, the bacteria, is now resistant to the antibiotic once effective. The World Health Organization offers guidelines for effective prescribing (WHO, 2002). The WHO guide summarizes these ideas with the statement, "The aim of antimicrobial therapy is to choose a drug that is selectively active against the most likely pathogen(s) and the least likely to cause adverse effects or promote resistance (WHO, 2002). When transmission of resistant organisms does occur, specific

control measures must be instituted as these resistant organisms often cause nosocomial infections. Several steps that can be taken to stop transmission are:

- Improving hand washing and asepsis.
- Isolating colonized and infected patients.
- Removing common sources.
- Disinfecting the environment.
- Closing units to new admissions if necessary. The final control measure is to modify a patient's risk by controlling antibiotic use and removing compromising factors (Giacometti, 2000). Some strains of Methicillin-resistant Staphylococcus aureus are particularly capable of causing nosocomial infections. These strains are often resistant to multiple antibiotics and sometimes are only sensitive to vancomycin and teicoplanin. Infections caused by MRSA are similar to those caused by Methicillin sensitive strains (wound infections, lower respiratory and urinary tract infections, septicemia, infections of sites for invasive devices, pressures sores, burns and ulcer. MRSA has the potential for epidemic spread, regionally and nationally. Vancomycin-resistant enterococci are also known causes of nosocomial infection (Rhomberg*et al.,* 2006).

2.4 METHODS OF ACQUISITION OF NOSOCOMIAL INFECTIONS

Bacteria that cause nosocomial infections can be acquired in several ways. Endogenous infections can develop from the endogenous or transient flora of the patient. When bacteria present in the normal flora are transmitted to sites outside of their normal environment like the urinary tract, they can cause infection. Infection can also occur with tissue damage (wound) or with inappropriate antibiotic therapy that allows overgrowth of endogenous bacteria like *C. difficile*(Cruse and Ford, 1980).

Exogenous cross-infection can occur with transfer of an organism from one patient or member of the staff to another patient or member of staff. Bacteria can be transmitted between patients:

(a) through direct contact between patients hands, saliva droplets or other body fluids).

(b) in the air (droplets or dust contaminated by a patient's bacteria).

(c) via staff contaminated through patient care (hands, clothes, nose and throat) who become transient or permanent carriers, subsequently transmitting bacteria to other patients by direct contact during care.

(d) via objects contaminated by the patient (including equipment), the staff's hands, visitors or other environmental sources (e.g. water, other fluids, food) (Ducel*et al*., 2002).

Another route of acquisition is through flora from the healthcare environment. Certain microorganisms do well in the hospital environment. They may live in water, in damp areas, in sterile products or disinfectants (*Pseudomonas*, *Acinetobacter*, *Mycobacterium*), in linens, in food, in fine dust and droplet nuclei, and in equipment and supplies used in care.

People are central to all of these routes of transmission. They are the main reservoir and source for microorganisms. They are the main transmitters of organisms, and they are the receptors of organisms, in consequence becoming new reservoirs (WHO, 2002). Microorganisms are transmitted in hospitals by several routes, and the same microorganism may be transmitted by more than one route. There are five main routes of transmission -- contact, droplet, airborne, common vehicle, and vector borne (WHO, 2002).

- **Contact transmission**: This is the most important and frequent mode of transmission of nosocomial infections. It is divided into two subgroups: direct-contact transmission and indirect-contact transmission.

- **Direct-contact transmission** involves a direct body surface-to-body surface contact and physical transfer of microorganisms between a susceptible host and an infected or colonized person, such occurs when a person turns a patient, gives a patient a bath, or performs someactivities that require direct personal contact. Direct-contact transmission also can occur between two patients, with one serving as the source of the infectious microorganisms and the other as a susceptible host (WHO, 2002).
- **Indirect-contact transmission** involves contact of a susceptible host with a contaminated intermediate object, usually inanimate, such as contaminated instruments, needles, or dressings, or contaminated gloves that are not changed between patients. Additionally, the improper use of saline flush syringes, vials, and bags have been implicated in disease transmission in the US, even when healthcare workers had access to gloves, disposable needles, intravenous devices, and flushes (WHO, 2002).
  - **Droplet transmission** occurs when droplets are generated from the source person mainly during coughing, sneezing, and talking, and during the performance of certain procedures such as bronchoscopy. Transmission occurs when droplets containing germs from the infected person are propelled a short distance through the air and deposited on the host's body.
  - **Airborne transmission** occurs by dissemination of either airborne droplet nuclei (small-particle residue {5 µm or smaller in size} of evaporated droplets containing microorganisms that remain suspended in the air for long periods of time) or dust particles containing the infectious agent. Microorganisms carried in this manner can be dispersed widely by air currents and may become inhaled by a susceptible host within the same room or over a longer distance from the source patient, depending on environmental factors; therefore, special air handling and ventilation are required to prevent airborne transmission. Microorganisms transmitted by airborne transmission

include Mycobacteriumtuberculosis and the rubeola and varicella viruses (WHO, 2002).

- **Common vehicle transmission:** applies to microorganisms transmitted to the host by contaminated items such as food, water, medications, devices, and equipment.
- **Vector borne transmission:** occurs when vectors such as mosquitoes, flies and rats transmits microorganisms (WHO, 2002).

2.5 THE SOCIETAL IMPACT OF NOSOCOMIAL INFECTIONS

The impact of nosocomial infections takes on even more significance in resource-poor countries, especially those affected most by HIV/AIDS, because same findings strongly suggest that unsafe medical care may be an important factor in transmitting HIV (Gisselquist*et al.,* 2002).

As a consequence, in resource poor countries, efforts to prevent nosocomial infections must assume even greater importance if progress is to be made in improving the quality of patient care in hospitals and other healthcare facilities. In Nigeria, the inadequate knowledge of the risks of nosocomial infections and the measures of risk reduction has limited control activities. A study showed that as high as 48.3% surgical site infection rate were seen in surgical wards (Ige*et al.,* 2011). Another report indicated prevalence rates ranging between 5.7% to 45.8 (Kesah*et al.,* 2004).

The costs to society can also be studied in terms of dollars spent. Assuming an incidence of 2 million nosocomial infections per year, the estimated added expenditure is in excess of $2,000,000,000 per year (Courvalin and Weber, 2005). The work of Saito *et al* (2005) showed that length of stay for a patient with *S. aureus*infection was increased by nearly three times the average length of stay for any other type of hospitalization. This increased length of stay also means increased costs. It further reported that treating a *Methicillin-resistant S.*

aureus(MRSA) infection costs 6-10% more than treating a *S. aureus* infection that is sensitive to Methicillin (MSSA). Patients with MRSA infections also have a higher attributable death rate than MSSA patients. These statistics support the argument for increasing efforts to reduce the incidence of hospital-acquired infections so that the associated societal costs will also be reduced.

Crowding and population size are increasing, and impaired immunity is becoming more frequent. New microorganisms will develop, and existing microorganism will develop even greater resistance (Courvalin and Weber,2005). A World Health Organization prevalence study and other studies have shown that these infections most commonly occur in intensive care units in surgical and orthopedic wards (Ducel*et al*., 2002). Infection rates are also higher in patients with increased susceptibility due to old age, underlying disease, or chemotherapy (Ducel*et al*., 2002).

In a prevalence survey by the National Nosocomial Infections Surveillance (NNIS) which was conducted by the Centers for Disease control and prevention (CDC), Urinary tract infection accounted for 39% while surgical wound infection and Lower respiratory tract infection accounted for 12.3% and 18% respectively (Emmerson*et al.*, 1996). Another study in the USA, surgical wound infection accounted for 24% of all nosocomial infections (CDC, 2002). This large difference in the rates (12.3% versus 24%) is attributed to differences in the definitions of surgical wound infection. In some surveys, the definition of wound infection was based on a simple, easily observable character such as presence of pus in the wound) as against a more complex and comprehensive definition, making use of several other signs of inflammation (e.g. erythema) with an elaborate scoring system (Rizzo, 2001).

In the developing countries, the incidence of nosocomial infections may result in major disease outbreaks in hospitals and other healthcare facilities, due largely to poor

infrastructure, over-crowding, inadequate personnel and management in most hospitals (CDC,1999).

2.6 PREVENTION AND CONTROL OF SURGICAL SITE NOSOCOMIAL INFECTIONS

Besides the committees and other leaders in infection control, much of infection control lies in the hands of the personnel in direct contact with the sick patient. These healthcare employees must understand specific guidelines in prevention of infection transmission through isolation and other good healthcare habits. Much of this information is disseminated through training and educational programs given by the infection control departments (WHO, 2002).

Examples of guidelines that are essential for the healthcare worker are:

2.6.1 Hand Washing

Though simple, this measure is one of the most effective methods in the prevention of the spread of infection. The type of care being provided indicates the type of hand-washing protocol to be adopted. For example, with routine care in the hospital, healthcare workers can wash with a non-antiseptic soap or disinfect the hand by rubbing with an alcohol solution (WHO, 2002). However, when caring for patients who are already suffering infection, hands must be washed with antiseptic soap for at least one minute or disinfected by rubbing with alcohol solution (Burke &John 2003)).

2.6.2 Hygiene and Uniform

Healthcare workers must also be conscious of their personal hygiene and what they wear to work as it could help spread infection within the hospital. For example, employees must have good personal hygiene, maintain short and clean nails, and keep hair worn short or pinned up. Also, employees should wear a uniform that is covered by a white coat and must obey special

uniform rules in setting such as burn or intensive care units (Hiramatsu*et al*., 1997). Clothing must also be easy to decontaminate and cleaned daily to keep at optimum conditions. It is important that with any exposure to a possible pathogen, clothing should be changed as soon as possible (CDC, 2002). Shoes are another measure of safety in the healthcare system. Staff should wear shoes that are dedicated to the particular unit and make sure that the shoes have been cleaned.

2.6.3 Barriers: Caps, Masks, Gloves

Another important group of precautions to prevent the spread of infection is the use of barriers such as caps, masks, and gloves. In general, caps are suggested when in aseptic units, operating rooms, or when performing other invasive procedures. Masks that are made of synthetic material that can filter the air are considered good barriers against microorganisms (Mangram*et al.,* 2009). Masks made of other material such as wool, gauze, or paper is not considered effective. The use of masks is indicated for many situations and is used for both the protection of the patient and the healthcare worker. Gloves are another set of necessary barrier when working with patients with a communicable disease. Staff should wear non-sterile gloves when caring for this type of patient while when working in surgery or immuno-compromised patients, gloves used should be sterile (Courvalin and Weber, 2005). Gloves are also used for protection of both the patient and healthcare provider.

2.6.4 Injection Practices

Transmissions of blood borne pathogens are often the result of unsafe injection methods. It is recommended that all staff are aware that they should decrease unnecessary injections, to always use a sterile needle and syringe, and to dispose of the used needle and syringe in an appropriate manner, i.e. the use of a sharps container and biohazard disposals (Anderson *et al.,* 2008).

2.6.5 Equipment Safety

Another common mode of transmission of infection is through equipment and environmental causes. Though it may appeal to common sense, it is necessary that the hospital environment is thoroughly cleaned often. The hospital can be divided into four zones where different cleaning procedures can be followed.

- In zone A, there are no patients in this area and normal cleaning can be used.
- In zone B, patients are present but do not have an infection nor are susceptible to infection. Zone B should be cleaned in a manner that does not raise dust and a detergent solution may be used to improve the cleaning.
- In zone C, patients are infected and isolated.
- In zone D, patients are often highly susceptible to infection and are isolated (Courvalin and Weber, 2005).

These areas must be cleaned with a detergent or antiseptic solution and different cleaning equipment must be used for different rooms. Another important way to keep the equipment and environment safe is to disinfect through the use of other compounds than those used for cleaning. These compounds are usually non-volatile, remain safe for the patient and staff, and should be effective for a short time frame. Disinfection can be categorized as high, intermediate, or low.

- Under high-level disinfection, all microorganisms should be eliminated with the exception of heavy bacterial spore counts.
- Under intermediate disinfection, most bacteria and viruses are killed but not all spores are killed.
- Finally, in low-level disinfection, only some microorganisms are killed with some more resistant species escaping destruction (Ducel*et al.*, 2002).

One last way to ensure equipment safety is sterilization, which is destruction of all microorganisms. Sterilization can be achieved through both mechanical and chemical processes (CARA & Hoban, 2005) While equipment and device disinfection and sterilization is critical, it is also crucial that all personnel are trained properly in the use of the equipment and device.

2.6.6 Isolation

While all of the infection control methods deal with physical objects, isolation of the patient also plays a critical role in infection control. The isolation of an infected patient can often prevent the spread of disease and also protect the patient from acquisition of other infections (Coffin *et al.,* 2005). Isolation policy may vary slightly between hospitals but patient are usually evaluated before being placed under isolation.

2.6.7 Surveillance and Infection Control

Surveillance has been instituted for many years since the rise of nosocomial infections in the United States. A majority of hospitals have their own surveillance systems and some hospitals voluntarily report their findings to the CDC and the National Nosocomial Infections Surveillance (NNIS) report is written to give other hospitals an idea of how well their infection control systems are working (CDC, 2002).

Surveillance within the hospital can be gathered in several ways, they are:

a. Hospital-wide Surveillance

Hospital wide surveillance provides data on infections due to all organisms, infection sites, units including identifying clusters. This is an exhaustive method that keeps track of every patient and almost all outbreaks are detected very early by establishing baselines of infection rates. This type of surveillance also records different types of infections and may help the healthcare worker to clearly identify the clusters of infection and to formulate a plan to deal

with an emerging infection (WHO, 2002). However, this approach is usually very labor-intensive and costly as it requires meticulous data gathering.

b. Surveillance by Objective/Priority-Directed Surveillance

This approach to surveillance is becoming more common for most hospitals and is a priorities-based approach to data gathering. That is, the hospital determines which diseases or infections are of particular importance to them and those are the ones that have extensive information gathered about them. The determination of which infections to follow most closely could be based on severity of disease, total mortality/morbidity of the disease, frequency of the infection, length of stay, and cost of treating the infection (WHO, 2002). However, with this type of approach, there is a less broad coverage of data and certain disease clusters may be missed by the surveillance team.

c. Targeted Surveillance

Similar to objective-based surveillance, targeted surveillance gather data based on the site, unit, outbreak, or in a rotating manner. In site-based, data is gathered based on which types of sites the infection occurred at, such as a surgical site or different organ systems (WHO, 2002). Unit-based surveillance measures more high risk areas and may target a certain problem area in the hospital for education and follow up (Gebhart, 2002). Unit-specific surveillance may help to identify infection control personnel that require more training. Rotating surveillance is to study a particular unit periodically. This type of surveillance is time efficient and cost-effective but can also lead to missing of clusters of disease.

d. Outbreak based surveillance

Outbreak based surveillance is targeted just to specific outbreaks in a certain period of time (CDC, 2000). This approach should always be combined with other approaches as they do not provide a general view of infection control in the hospital.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 DESCRIPTION OF SAMPLE COLLECTION CENTRE

Ahmadu Bello University Teaching Hospital, Shika-Zariais the premier tertiary health establishment of northern Nigeriafor all other hospitals and health centers in Kaduna State and adjoining states such as Katsina, Zamfara and Niger States .The hospital has bed space with several departments, units and well equipped laboratories and operating theatres. There are separate wards for in-patients, presenting different health problems. It has a good number of medical personnel including consultants and specialists in various fields of medicine.

Wards 1 and 2 which house female and male surgical patientsrespectively, SOPD (surgical outpatient department) and the operating theatre were the focus of this study.

3.2. RECRUITMENT OF PATIENTS FOR THE STUDY AT THE AHMADU BELLO UNIVERSITY TEACHING HOSPITAL, ZARIA.

For the prospective study, patients that were newly admitted and slated for operations between January and June 2011 in the female and male surgical wards were recruited for the study. A total number of 239 patients were selected based on their clinical assessment from surgical wards. On admission, they were carefully examined clinically by the medical team to exclude community-acquired infections. They were monitored from the day of operation to the time of discharge for nosocomial surgical site infections.

3.3 ETHICAL CONSIDERATIONS

The research proposal was approved and ethically cleared by the Postgraduate Office, Ahmadu Bello University Teaching Hospital; Zaria .There was minimal risk associated with the process of sampling; it was the same as taking specimen for culture and sensitivity in the routine laboratory. All the information contained within the data collection form was kept confidential. All cases of nosocomial infections were treated based on antibiotic sensitivity results.

3.4 MATERIALS

3.4.1 Bacteriological Culture Media

Several bacteriological media were used. Nutrient agar and Nutrient broth were products of FlukaChemie, CH 9471 Buchs) while Deoxyribonuclease agar, Mueller Hinton agar, MacConkey Agar, were obtained from Basingstoke, UK. Others from Himedia laboratories India were Triple Sugar Iron Agar and Simmons Citrate Agar

3.4.2 Equipment

- Autoclave, model EC2P2ER, Gallenkamp Co. Ltd England
- Incubator, Ambient, EC2h3, Gallenkamp Co. Ltd England
- Refrigerator, (Thermocool)
- Freezer (5^0C) ,(Thermocool)
- Binocular Microscope (Gallenkamp Co. Ltd England Olympus)
- Hot air oven, model ACM-22O66-I Technocracy Co. Ltd India
- Water bath, model Gallenkamp Co. Ltd England

3.4.3 Chemicals & Reagents

- Barium chloride ($Bacl_2$) (Mubi chemicals Ltd, India)
- Hydrochloric acid, concentrated(Vardhmanchemi –sol industries, India)
- Sulphuric acid, concentrated (Sai chemicals, India)
- Sodium hydroxide(Manas chemicals Mumbai, India)
- Acetone(Triveni Inter chem., India)
- Hydrogen peroxide 3% (Aditya chemicals, India)
- Kovacs reagent(Apollo Scientific Ltd, England)
- 1% tetramethyl-p-phenylenediaminedihydrochloride } Laboratory stock
- Gram staining reagents

3.4.5 Plasma

Undiluted, pooled human plasma was collected from the blood bank of Ahmadu Bello University Teaching Hospital, Zaria, Nigeria and stored in the freezer until required.

3.4.6 Antibiotic discs

All the antibiotic sensitivity discs used in this study were obtained from Oxoid, Basingstoke, UK. Ampicillin (AMP) (10 µg), Amoxicillin (AML) (25 µg), Amoxicillin-Clavulanic acid (AMC) (30 µg), Ceftriaxone (CRO) (30 µg), Chloramphenicol (C) (30 µg), Ciprofloxacin (CIP) (5 µg), Cloxacillin (CX) (5 µg),), Erythromycin (ERY) (5 µg), Gentamicin (CN) (10 µg), Methicillin (MET) (5 µg),), Nalidixic acid (NA) (30µg), Nitrofurantoin (FM) (200 µg), Norfloxacine (NOR) (10 µg) Tetracycline (TTC) (25 µg), Trimethoprim-sulphamethoxazole (SXT) (25µg).

3.5 METHODS

3.5.1 Retrospective study of nosocomial infections

Retrospective study was carried out by assessing the medical records of patients kept in the medical records department of the Teaching Hospital. Records of patients operated upon (January 2009 – December 2010) were reviewed. The following information were obtained from the folders; *Patients hospital numbers, names, age, sex, date of admission, diagnoses on admission, type of operation, specimen sent to the microbiology laboratory and results, type of organism(s) isolated, susceptibility of the isolates to the antibiotics tested, second diagnoses if any with dates and interval between the first and second diagnosis* For patients whose information about their specimen microbiology test results were not available in the folders, visits were made to the microbiology laboratory to retrieve the needed data. Attempts were also made to verify the microbiological test results in the folders by matching them with the records kept in the microbiology laboratory. The folders were arranged year by year and sorted out ward by ward.

3.5.2 Determination of Rates of infections

Within the study period rates of infection was determined by dividing total number of patients infected by total number of patients discharged multiply by 100, as described by Jones and Bartlett **(**1983).

$$\text{Infection rate} = \frac{\text{No of patients infected}}{\text{Total Number of patient discharged}} \times 100$$

3.5.3 Prospective Study of Nosocomial Infections

a. Media preparation

All media used were prepared according to manufacturer's specification, sterilized at 121^0C for 15 minutes and stored at 4^0C until required.

b. Bacteriological study of operated surgical sites

Surgical operations were monitored by the medical team between January –June 2011 in the theatre. The time taken to complete each surgical operation cycle was also recorded.Due to the sensitivity of the study, the laboratory scientist took samples from the patient's surgical sites under the supervision of the medical team after 30 days of surgery after observing signs and symptoms of surgical site infections.

c. Detection of Surgical Site Nosocomial Infections (SSI)

The operated patients in the wards were visited on daily bases, and the sites of operations inspected for signs of infection by the medical team. The presence of surgical sites nosocomial infections was classified as positive according to WHO/CDC (2002) guideline which states that "SSI is an infection that occurs within 30 days after operative procedure". The patient is deemed to have developed SSI when at least one of the followings is noticed in the patient.

a. Purulent drainage from the superficial incision.

b. Organism is isolated from an aseptically obtained culture of fluid or tissue from superficial incision.

c. At least one of the following symptoms or signs occurs: pain, tenderness, or heat and superficial incision deliberately opened by surgeon unless incision is culture negative.

Surgical wound was inspected at the time of the first dressing and weekly thereafter for 30 days.Whenever any of the signs or symptoms indicated above were seen at the incision sites, the siteswere then swabbed with a sterile swab stick and inoculated unto MacConkey agar plates and blood agar plates which were incubated at 37^0C for another 18-24hrs. Pure

colonies were isolated unto nutrient agar slants, incubated at 37^0C for another 18-24hrs before storage in the refrigerator for biochemical analysis.

d. Follow-up study & Method of sampling

These study was conducted on patients that stayed back at the hospital for a period of time after surgery.Data collection forms for surgical site infection surveillance were used to collect information on surgical site infections fromone hundred and fifty patients between January and June 2011 after thirty days of surgery when symptoms or signs of surgical site infections occurred.

Information collated in the data collection form were *gender, ward ,age, Patients hospital numbers, date of admission, date of discharge, diagnoses on admission, date and type of operation, the wound class, American Society of Anesthesia score, antibiotics given, surgical site infections and the microorganism isolated.*

To classify an infection to be nosocomial, the following criteria, as specified by WHO/CDC (2002) were used:

- Time interval between the first and second diagnosis is not less than 48 hours
- Positive culture results in the first and second diagnosis
- Isolated organism in the second diagnosis is different from the first isolated pathogen.

e. Air Sampling

The bacterial load of the air was studied using settling plate method. Plates containing Nutrient agar and MacConkey agar were exposed and kept at strategic points in the Female surgical wards (FSW) and Male surgical wards (MSW) once every week for an hour as reported by Russel et al,(1984). In the operating theatre, plates were left exposed from the start of the operation until the operation was completed. Thereafter, they were covered and

taken for incubation. The duration for each operation was recorded. The Nutrient and MacConkey agar plates were incubated at 37^0C for 24 hours.

f. Characterisation of the bacteria isolates

All the isolated bacteria already subcultured onto Nutrient agar slants were characterized based on their cultural, Morphological and biochemical features as described byCheesebrough, (2002).

i. Cultural Characterization

Cultural characterization of the isolates was based on their colonial morphology and microscopy following growth on bacteriological media.

ii. Gram Staining

Gram staining was carried out as described by Cheesebrough (2002) and examined under a binocular microscope. Isolates were classified as Gram positive or negative cocci, cocco bacilli or rods.

iii. Motility Test

Motility test was performed by stabbing the motility medium with a sterile wire loop of the culture of the organism to a depth of 1-2cm short of the bottom of the bijou bottle; incubate at 37^0 C for 24 to 48hrs. A positive result is indicated by a cloudy medium and non distinct line of inoculation while negative result is indicated by a growth restricted to the line of inoculation, which becomes sharply defined as described byCheesebrough, (2002).

iv. Biochemical Characterization of isolates

All isolates were reactivated in 0.1% peptone water and incubated at 37^0C for 18 hours in an incubator. Thereafter, several biochemical tests were carried out according to Cheesebrough, (2002).

- **Triple Sugar Iron Test (TSI)**

Triple Iron agar slants were prepared in constricted test tubes. No carbohydrate fermentation shows the butt and slant becoming yellow (K/K). No Glucose, lactose and sucrose fermentation is indicated by the slant becoming yellow and the butt becoming red (K/A) but if the slant and butt becomes red it shows that all the sugar was fermented (A/A) as described byCheesebrough, (2002).

- **Gas formation Test**

The development or appearance of one or several bubbles in the butt in Triple sugar iron agar is indicative of gas formation. Attention was also paid to occurrence of pushing and the Cracks in the butt, which is also indicative of gas formation as described byCheesebrough, (2002).

- **H_2S formation Test**

Formation of H_2S was determined by the blackening of the whole butt or a streak or ring of blackening at the slant butt junction in TSI.

- **Citrate Utilization Test**

Simmons citrate agar medium was used in this test, as stated by Cheesebrough (2002). The development of a deep blue colour indicates a positive reaction.

- **Indole Test**

This test is part of the IMViCtests and is helpful in differentiating the Enterobacteriacea**.** It was performed by adding Kovac's reagent on an overnight peptone water culture of the organism. A positive result is indicated by formation of a red color in the layer above the broth as described byCheesebrough, (2002).

- **Catalase Test**

A drop of 3% hydrogen peroxide solution was placed on a glass slide. A bit of growth was then removed from the solid medium with a wire loop and emulsified in the hydrogen peroxide. A positive test is indicated by bubbling and frothing within 10 secs. The test was performed on Staphylococcus spp as described byCheesebrough, (2002).

- **Coagulase slide Test**

The glass slide method was adopted, using human serum. A drop of physiological saline was dropped on a clean glass slide and a colony picked from the solid medium was emulsified in the saline. A loopful of citrated human plasma was added to the bacterial suspension and mixed using the wire loop. The slide was then held up and tilted back and forth for one minute. A positive test is indicated by clumping of cells in the mixed suspension. The test was performed on Staphylococcus spp. as described byCheesebrough, (2002).

- **Methyl Red Test (MR)**

As described byCheesebrough, (2002), Four (4) drops of 0.04% methyl red was dropped in a dextrose phosphate broth culture of the organism.A positive result was indicated by a red color. The test was performed to differentiate the Enterobacteriaceae family.

- **VogesProskauer Test (VP)**

1ml of 10% potassium hydroxide was dropped in a dextrose phosphate broth culture of the organism .A positive test is indicated by a pink color. The test was performed on the family of Enterobacteriaceae. As described byCheesebrough, (2002).

- **Oxidase Test**

This test is used for identifying *Ps.aeruginosa*. 2 drops of 1% freshly prepared oxidase reagent (phenylenediamine) was placed on a filter paper in a clean Petri dish. The test organism was smeared on it with a glass rod. A positive result shows deep purple colour appearing within 5-30secs. The absence of deep purple colour indicates a negative result as described byCheesebrough, (2002).

- **Urease Test**

This test is helpful in differentiating the Enterobacteriaceae **.**Christensen's medium was prepared according to the manufacturer's instructions and was inoculated**.** The slant was incubated at 37°C for 24 hours. The development of a deep red colour with ammonia fumes indicates a positive reaction as described byCheesebrough, (2002).

- **Gluconate oxidation Test**

This test is used for identifying *Ps.aeruginosa*. The organisms were grown in 5ml gluconate broth for 24hours to 48hours, after which1ml of Benedict's solution was added and the mixture was put in boiling waterfor about 10-15minutes. A positive test is indicated by the formation of an orangePrecipitate which develops within 10 minutes as described byCheesebrough, (2002).

- **Malonate utilization Test**

The test is used in differentiating among the Enterobacteriaceae, especially Klebsiella spp. Malonate phenylalanine broth was prepared and inoculated with the reactivated -isolates.

This was incubated at 37°C for 24hours. The formation of a blue color is indicative of a positive test as described byCheesebrough, (2002).

- **Phenylalanine deaminase Test**

Phenylalanine broth was prepared and inoculated with the reactivated isolates. This was incubated at 35℃ for 24 hours. The broth was then acidified with 2-3 drops of 10% HC1until a yellow color results and then l0 drops of $FeCl_3$ was added. The development of a dirty green precipitate indicates a positive reaction as described byCheesebrough, (2002),

- **Dnase Test**

This test differentiates *S.aureus* from *S. epidermidis*. Dnase agar plates are used and the cultures were inoculated and incubated overnight at 37^0C. The plates were then flooded with N/1HCL which precipitates the DNA, A clear zone around the colonies indicates a positive result as described byCheesebrough, (2002).

- **Eijkman Test**

This test differentiates *E.coli*from other Enterobacteriaceae. From an overnight peptone water culture of the organism under test, 5ml of the MacConkey single strength broth was inoculated and incubated in a water bath at 44^0C.Production of acid and gas indicates a positive test as described byCheesebrough, (2002).

3.6 DETERMINATION OF ANTIBIOTICS SUSCEPTIBILITY PROFILE OF THE ISOLATES

Antimicrobial susceptibility testing was performed for all isolates according to the criteria of Bauer et al (1966) using the disk diffusion method.

From a pure culture, 3-5 colonies of bacteria were taken and transferred to tubes containing 5 ml of nutrient broth and mixed gently, to obtain a homogenous suspension and incubated at

37^{o}C for 24 hours until the turbidity of the suspension became adjusted to 0.5 McFarland standards.

A sterile cotton swab was used and the excess suspension was removed by gentle rotation of the swab against the surface of the tube. The swab was then used to distribute the bacteria evenly over the entire surface of Mueller-Hinton agar .The inoculated plates were left at room temperature to dry for 3-5 minutes and a set of 6-8 antibiotic discs (Oxoid) were then delivered on the surface of a Muller-Hinton plate. The drugs for disc diffusion testing were in the following concentrations:

For Gram negative bacteria; ampicillin (AMP) (10 µg), amoxicillin-clavulanic acid (AMC) (30 µg), chloramphenicol (C) (30 µg), gentamicin (CN) (10 µg), erythromycin (ERY) (5 µg), nalidixic acid (NA) (30µg), nitrofurantoin (FM) (200 µg), amoxicillin (AML) (25 µg), tetracycline (TTC) (25 µg), cotrimoxazole (COT) (25µg), ceftriaxone (CRO) (30 µg), norfloxacine (NOR) (10 µg) and ciprofloxacin (CIP) (5 µg).

For Gram positive bacteria; ampicillin (AMP) (10 µg), amoxicillin-clavulanic acid (AMC) (30 µg), chloramphenicol (C) (30 µg), gentamicin (CN) (10 µg), erythromycin (ERY) (5 µg),), methicillin (MET) (5 µg), streptomycin(10ug), amoxicillin (AML) (25 µg), tetracycline (TTC) (30 µg), cotrimoxazole (COT) (25µg), ceftriaxone (CRO) (30 µg), norfloxacine (NOR) (10 µg) and ciprofloxacin (CIP) (5 µg).

The plates were incubated at 37^{o}C for 24-48 hours. Diameters of the zone of inhibition around the disc were measured to the nearest millimeter and the isolates were classified as sensitive, intermediate, and resistant according to the standardized table of the Clinical Laboratory Standards Institute (CLSI, 2006) and Fluka zone interpretative chart in accordance with WHO requirements (www.eurnotes.sial.com). High, intermediate and low

level of resistance is defined when the percentage of resistance is >80%, 60-80% and < 60%, respectively.

- **Reference Strains**

Standard reference strain for *S. aureus*(ATCC-25923), *E. coli*(ATCC-25922) and *P.aeruginosa*(ATCC-27853) were used as a quality control throughout the study for culture and antimicrobial susceptibility testing.

3.7 DETERMINATION OF MULTIPLE ANTIBIOTIC RESISTANCE (MAR) INDEX

The Multiple Antibiotic Resistance (MAR) index was determined for each isolate by dividing the number of antibiotics to which the organisms is resistant by the total number of antibiotics tested as described by Krumperman (1983).

3.8 DATA ENTRY & ANALYSIS

The entry and analysis was done using Statistics Package for the Social Sciences (SPSS) version 17.0. The data obtained from the patients that have undergone surgery and the samplings of the surgical wards were reduced into tabular forms. Comparisons were made using Chi-square .The prevalence and incidence rates of organisms isolated were calculated and expressed in percentages.

CHAPTER FOUR

4.0 RESULTS

4.1 ANALYSIS OF RETROSPECTIVE DATA ON SURGICAL SITE NOSOCOMIAL INFECTIONS IN AHMADU BELLO UNIVERSITY TEACHING HOSPITAL ZARIA.

The results of the retrospective data on incidence of surgical site nosocomial infections in ABUTH Zaria showed that the infection rate in 2009, (10.5%) was significantly higher than the value in 2010 (8.3%) although higher numbers of patients were discharged in 2010 (Table 4.1). Monthly infection rates showed that the infection rates varied from one month to another. The result also showed that in 2009, surgical site nosocomial infection were highest in the months of January and March with infection rates of 16.3 and 16.8%, respectively, while in 2010, surgical site nosocomial infections were highest in the months of March and May with infection rates of 12.0% and 12.3%, respectively.

The result further showed that surgical site nosocomial infection rates in ABUTH were lowest in the months of November (4.7%) and July (5.1%), in the year 2009 and 2010, respectively.

However, monthly incidence of nosocomial infections showed that there was a significant association in the rates of nosocomial infections between monthsand years 2009at $p<0.05$.There was no significant difference for the year 2010.

The infection rates also differ between the two surgical wards (Table 4.2). In each of the two years, male surgical ward had higher infection rates .The level of significance was determined using chi square; there was no significant difference between the incidence of

nosocomial infection and the gender of the patient in the wards in 2009 and 2010 ($p = 0.5557$ and $p = 0.6786$, respectively).

Analysis of data based on type of surgical sites as presented in (Table 4.3) clearly showed that superficial sites were more frequently infected compared with other sites. Generally, organ/space surgical site were associated with low infection rates.

Table 4.1 Monthly surgical site infection rates in male and female surgical wards of Ahmadu Bello University Teaching Hospital in year 2009-2010

	Monthly incidences of nosocomial infections in			
Month	**2009**		**2010**	
No Discharged	**Infection Rate (%)**	**No Discharged**	**Infection Rate (%)**	
January	110	16.3	77	7.8
February	46	6.5	75	5.6
March	125	16.8	117	12.0
April	51	7.8	163	7.4
May	73	10.9	130	12.3
June	62	8.0	90	5.6
July	57	7.0	39	5.1
August	41	12.2	134	10.4
September	34	8.8	129	6.2
October	58	5.1	92	6.5
November	42	4.7	73	6.8
December	58	6.8	94	9.5
Total / Mean	**757**	**10.5**	**1213**	**8.3**

Table 4.2 Surgical site nosocomial infection rates in male and female surgical wards of Ahmadu Bello University Teaching Hospital in 2009-2010

Prevalence of surgical site infections in the wards in year				
Ward	**2009**		**2010**	
	No Discharged	**Infection Rates (%)**	**No Discharged**	**Infection Rates (%)**
Male Surgical	391	(11.3)	648	(8.6)
Female Surgical	366	(9.8)	565	(7.9)
Total	**757**	**(10.5)**	**1213**	**(8.3)**

Table 4.3 Prevalence of nosocomial infections at different surgical sites in male and female surgical wards of Ahmadu Bello University Teaching Hospital in 2009-2010.

Wound Infection sites	**Nosocomial infection rates at different Infection Sites in year**			
	2009		**2010**	
	No discharged	**(n =80)**	**No discharged**	**(n=101)**
Superficial site infection	356	66.3	587	77.2
Deep incisional	235	30.0	262	16.8
Organ/Space	166	3.8	364	5.9
Total	**757**	**1213**		

Distribution of organisms isolated from the infected surgical site in the patients in the two wards is presented in Table 4.4. Gram positive bacteria comprise of *S.aureusand S. epidermidis*accounting for 38.8% in 2009 and 42.6% in 2010 respectively. *S.aureus* was the most predominant isolate followed by *S. epidermidis* for the two years. Among the Gram negative bacteria, *E.coli*was the predominant organism, constituting 23.8% and 23.7%of the Gram negative isolate in 2009 and 2010 respectively. *Kl. pneumoniae* and Proteus spp were least frequently isolated nosocomial pathogens.

The Antibiogram of the isolates in 2009 is presented in Table 4.5 with high resistance seen to chloramphenicol, tetracycline and cotrimoxazole, while ciprofloxacin and ceftriazone were themost active. Table 4.6 shows the MAR index of isolates in 2009, with all the isolates being multidrug resistant. The antibiogram of isolates in 2010 as presented in Table 4.7 shows high resistance to gentamicin, tetracycline and chloramphenicol, while all the isolates were susceptible to ciprofloxacin. Table 4.8 which shows the MAR index of isolates in 2010 which indicated that all the isolates have high multiple antibiotic resistance indices.

Table 4.4 Prevalence of nosocomial pathogens in surgical sites of Ahmadu Bello University Teaching Hospital in 2009-2010

Pathogens	Percentage occurrence of nosocomial pathogens in year 2009 (n=80)	year 2010 (n=101)
S.aureus	38.8	42.6
S.epidermidis	11.3	18.8
Kl. pneumoniae	5.0	2.0
E.coli	23.8	23.7
Ps aeruginosa	12.5	7.9
Pr.vulgaris	8.8	5.0

Table 4.5 Antibiotic resistance profile of isolated nosocomial pathogens at Ahmadu Bello University Teaching Hospital in 2009

Antibiotics	*S.aureus* (n=31)	*S.epidermidis* (n=9)	*E. coli* (n=19)	*Ps.aeruginosa* (n=12)	*Pr.vulgaris* (n=7)	*Kl.Pneumoniae* (n=4)
Ampicillin	61.2	11.1	52.6	91.6	71.4	75.0
Ceftriaxone	61.2	0.0	21.0	16.7	28.5	75.0
Ciprofloxacin	0.0	0.0	0.0	16.7	0.0	0.0
Cotrimoxazole	96.7	55.6	73.6	50.0	85.7	100
Chloramphenicol	83.8	11.1	57.8	75.0	71.4	25.0
Erythromycin	54.8	11.1	52.6	66.7	42.8	25.0
Gentamicin	70.9	11.1	68.4	58.3	57.1	75.0
Tetracycline	90.3	44.4	84.2	83.3	85.7	75.0

Table 4.6 Multiple Antibiotics Resistance Index of nosocomia pathogens isolated in Ahmadu Bello University Teaching Hospital in 2009

Organisms	**% with MAR Index ≥ 0.2**
S.aureus (n =31)	100.0
S.epidermidis (n =9)	66.7
E. coli (n=19)	94.7
Ps. aeruginosa (n =12)	91.7
Pr.vulgaris (n =7)	85.7
Kl. pneumoniae (n =4)	75.0

Table 4.7 Antibiotic resistance profile of isolated nosocomia pathogens at Ahmadu Bello University Teaching Hospital in 2010

Antibiotics	*S.aureus* (n=43)	*S.epidermidis* (n=19)	*E. coli* (n=24)	*Ps. aeruginosa* (n=8)	*Pr. vulgaris* (n=5)	*Kl.Pneumoniae* (n=2)
Ampicillin	70.0	42.1	46.8	62.5	20.0	100
Cotrimoxazole	81.3	68.4	100	87.5	100	100
Chloramphenicol	88.3	47.3	62.5	62.5	20.0	100
Ciprofloxacin	0.0	0.0	0.0	50.0	0.0	0.0
Erythromycin	72.0	47.0	50.0	62.5	40.0	100
Gentamicin	84.0	47.3	58.3	50.0	100	50.0
Tetracycline	93.0	58.0	100	87.5	100	100

Table 4.8: Multiple Antibiotics Resistance Index of nosocomial pathogens isolated in Ahmadu Bello University Teaching Hospital in 2010

Organisms	% with MAR Index ≥ 0.2
S.aureus (n =43)	95.3
S.epidermidis (n =19)	78.9
E.coli(n=24)	95.8
Ps.aeruginosa (n =8)	87.5
Pr.vulgaris(n =5)	100.0
Kl. pneumoniae (n =2)	100.0

4.2 PROSPECTIVE STUDIES ON SURGICAL SITE NOSOCOMIAL SURGICAL SITE INFECTIONS IN AHMADU BELLO UNIVERSITY TEACHING HOSPITAL, ZARIA.

The age distribution of 239 patients admitted for surgical site infection from January 2011 to June 2011 is presented in Table 4.9. The highest number of cases were in the age group of greater than 60 (43.7%) followed by age group of less than 20 (42.3%). There was no significant difference between age of the patients and infection rates ($P>0.05$).

As shown in Table 4.10, the incidence of surgical site differs according to the gender distribution Male surgical wards had higher infection rates compared to the female surgical wards with rates of 62.0% and 38.0%.There was significant difference between gender of the patients and infection rates ($P<0.05$).

Table 4.11 shows the distributionof incidences of nosocomial surgical site infection among the various types of surgical operations performed from Jan- June 2011. Highest infection rates were observed among patients that underwent plastic surgery and Debridement of contractures (41% and 40.6%) respectively. Infection rate was much lower among mastectomy patients. The total number of patients who developed surgical site infection was found to be 79 with overall incidence of 33.0%.

Further analysis showed that there were differences in the monthly incidence rate of nosocomial surgical site infections from Jan - June, 2011 (Table 4.12). Highest infection rate of 49.2% was observed in the month of March while no incidence of nosocomial infection was recorded in the month of June, 2011.

As shown in Table 4.13, the incidence of infection of surgical sites differs according to the nature of wounds. Clean andContaminated wounds were associated with lower infection rates as compared with levels in Clean contaminated and dirty wounds. These differences were

significant particularly between clean contaminated on one sideand dirty on the other side.There was significant difference between class of wound and infection rates (P<0.001).

Table 4.14 shows that a total of 106 pathogens were isolated from surgical sites in patients that underwent surgical operations in ABUTH from Jan-June, 2011. *S. aureus*was the most predominant accounting for 33%, followed by *S. epidermidis* (19.8%) and *Ps. aeruginosa* (17.9%).

As shown inTable 4.15, *S. aureus* and *S. epidermidis* isolates from wounds were highly resistant tocotrimoxazole, moderately resistant to the other antibiotics and very sensitive to ciprofloxacin and nitrofurantoin. *Ps. aeruginosa*, *E.coli*,*Pr.vulgaris* and *Kl. pneumoniae* isolated from wounds were highly resistant to the panel of antibiotics, except for ciprofloxacin and nitrofurantoin which had the least percentage resistance as presented in Table 4.16. Data presented in Table 4.17 shows that over 68% of the wound isolates were multidrug resistant.

Data of surgical site infections with their risk factors were evaluated by chi square (X^2 statistical test, $p \leq 0.05$ was considered to be significant).

Table 4.9: Age distribution of patients with surgical site infections in ABUTH Zaria between January - June 2011

Age group (years)	Total number of cases	Number with Surgical site infections	Infection rate(%)
< 20	26	11	42.3
21-30	64	26	40.6
31-40	55	17	31.0
41-50	51	9	17.6
51-60	27	9	33.3
> 60	16	7	43.7
Total	239	79	33.0

Table 4.10: Gender distribution of patients with surgical site infections in ABUTH Zaria between January - June 2011

Gender	Number Of Total Cases	Number With Surgical Site Infection	Infection rate %
Male surgical ward	149	49	62.0
Female surgical ward	90	30	38.0
Total	239	79	33.0

Table 4.11: Incidence of surgical site nosocomial infections in Ahmadu Bello University Teaching Hospital in 2011 (Jan-June)

Type of Operation	No of Operations	No infected	Infection Rate
Appendicectomy	29	10	34.5
Exploratory Laparatomy	82	27	33.0
Heniorrhaphy	21	07	33.3
Simple Mastectomy	20	03	15.0
Thyroidectomy	12	03	25.0
Debridement of contracture	32	13	40.6
Plastic surgery	39	16	41.0
Total	239	79	33.0

Table 4.12: Monthly frequency of nosocomial infection in surgical sites of Ahmadu Bello University Teaching Hospital in 2011 (Jan-June)

Month	Total patient operated	No infected	Infection Rate (%)
January	63	11	17.5
February	62	22	35.4
March	71	35	49.2
April	29	09	31.0
May	09	02	22.2
June	05	0	0.0

Table 4:13 Distribution of nosocomial infection according to nature of site of surgery of surgical patients in ABUTH, Zaria from January to June, 2011.

WOUND CLASS	NUMBER OF CASES SCREENED	INFECTION RATE %
CLEAN	147	30.0
CLEAN-CONTAMINATED	74	39.2
CONTAMINATED	11	27.3
DIRTY	7	43.0
TOTAL	239	33.0

Table 4.14: Distribution of pathogens in the surgical site at Ahmadu Bello University Teaching Hospital in 2011 (Jan-June)

Isolated pathogen	Occurrence	% frequency
S. aureus	35	33.0
S. epidermidis	21	19.8
Ps. Aeruginosa	19	17.9
E. coli	13	12.3
Pr. Vulgaris	10	9.4
Kl. Pneumonia	8	7.5
Total	106	100

Table 4.15: Antibiotic resistance profiles of *S. aureus* and *S. epidermidis*isolated from wounds to different Antibiotics

Antibiotics	No of Resistant isolate (%)	
	***S. aureus* (n =35)**	***S. epidermidis*(n=21)**
Ampicillin	17.1	100
Chloramphenicol	37.1	52.3
Gentamicin	40.0	28.5
Tetracycline	51.4	52.3
Cotrimoxazole	91.4	90.4
Erythromycin	57.1	33.3
Ceftriazone	40.0	57.1
Ciprofloxacin	0.0	0.0
Nitrofurantoin	2.8	19.0

Table 4.16: Antibiotic resistance profiles of *Ps. aeruginosa, E. coli, Pr. vulgaris*and *Kl. pneumoniae*isolated from wound to different antibiotics

Antibiotics	No of Resistant isolate (%)			
	Ps. aeruginosa **(n =19)**	***E.coli*** **(n =13)**	***Pr. vulgaris*** **(n=10)**	***Kl. pneumoniae*** **(n = 8)**
Ampicillin	89.4	92.3	100	62.5
Chloramphenicol	89.4	53.8	80.0	62.5
Gentamicin	94.7	23.0	100	50.0
Tetracycline	100	61.5	100	75.0
Cotrimoxazole	100	100	100	100
Erythromycin	100	84.6	100	100
Ceftriazone	21.0	7.6	10.0	37.5
Ciprofloxacin	63.1	0.0	0.0	12.5
Nitrofurantoin	68.4	15.3	0.0	37.5

Table 4.17: Multiple antibiotics resistance index of nosocomial wound pathogens isolatedin Ahmadu Bello University Teaching Hospital in 2011

Organisms	% with MAR Index ≥ 0.2
S. aureus(n =35)68.6	
S. epidermidis(n =21)	100.0
Ps. aeruginosa(n =19)	94.7
E. coli (n =13)92.3	
Proteus Spp(n =10)	100.0
Kl. pneumoniae(n =8)	87.5

4.3 FOLLOW- UP STUDIES ON SURGICAL SITE NOSOCOMIAL INFECTIONS IN AHMADU BELLO UNIVERSITY TEACHING HOSPITAL, ZARIA.

Of the 239 patients operated upon within the period of study (Jan – June, 2011) follow- up study was conducted on 150 (63%) patients who had elective surgery and stayed back at the hospital for 30 days after surgery. Assessment of the patients after operation revealed surgical site infections in 63 patients with incidence rate of 42.0%.The results revealed that duration of hospitalization, health status of the patients as well as duration of surgery have effect on the level of surgical site nosocomial infection.

As depicted in Fig 4.1 the longer the hospitalization of patients before surgery, the greater the likelihood of the patient presenting surgical site nosocomial infection. Patients that stayed for a maximum of one month and four months had relatively low infection rate of 7.9%during the period of hospitalization, compared with 62.0% and 22.2% in patients with 2-3months hospitalization. Data on post surgery surveillance also showed that longer hospitalization is likely to lead to a higher incidence of nosocomial infection in surgical sites (Figure 4.2).

The result presented in Fig 4.3 shows the distribution of the patients according to the ASA (American society of anesthesiologist) score. Although, higher numbers of patients were admitted as normal and healthy, a low percentage of the patient had incidence of surgical site infection 40.1% compared with 60.0% and 66.7% in mild systemic disease and severe systemic disease categories respectively).

Data presented in Fig 4.4 shows the effect of duration of surgical operation on patients with surgical site infections. Those with one hour and 4 hours surgical operation duration had least SSI rate (12.7% and 6.3), compared with much higher figures of 49.2% and 31.8% of 2-3 hours duration of surgical operation.

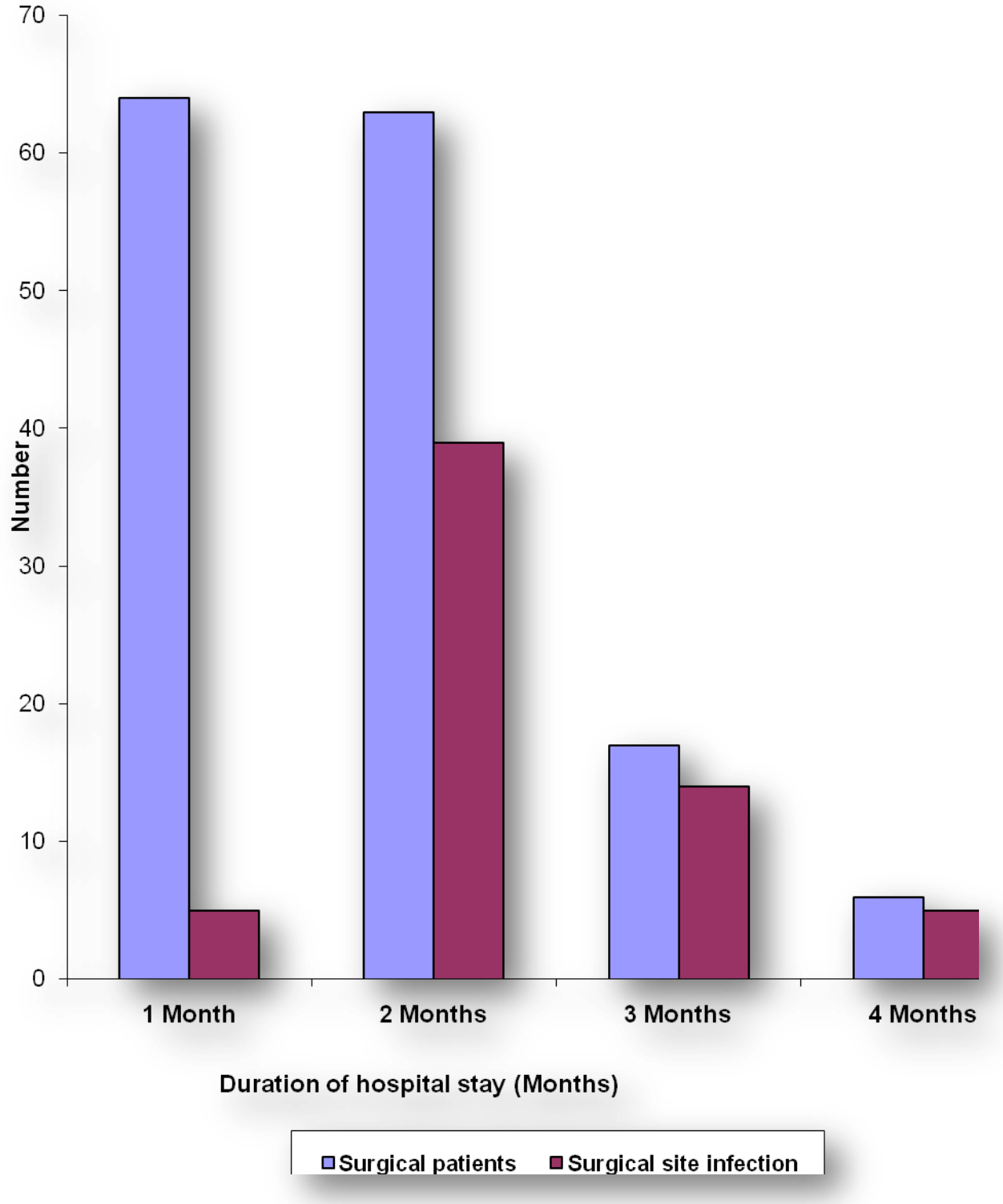


Figure 4.1: **Effect ofduration of hospital stay on the incidences of nosocomial surgical site infections at ABUTH, Zaria from January to June 2011.**

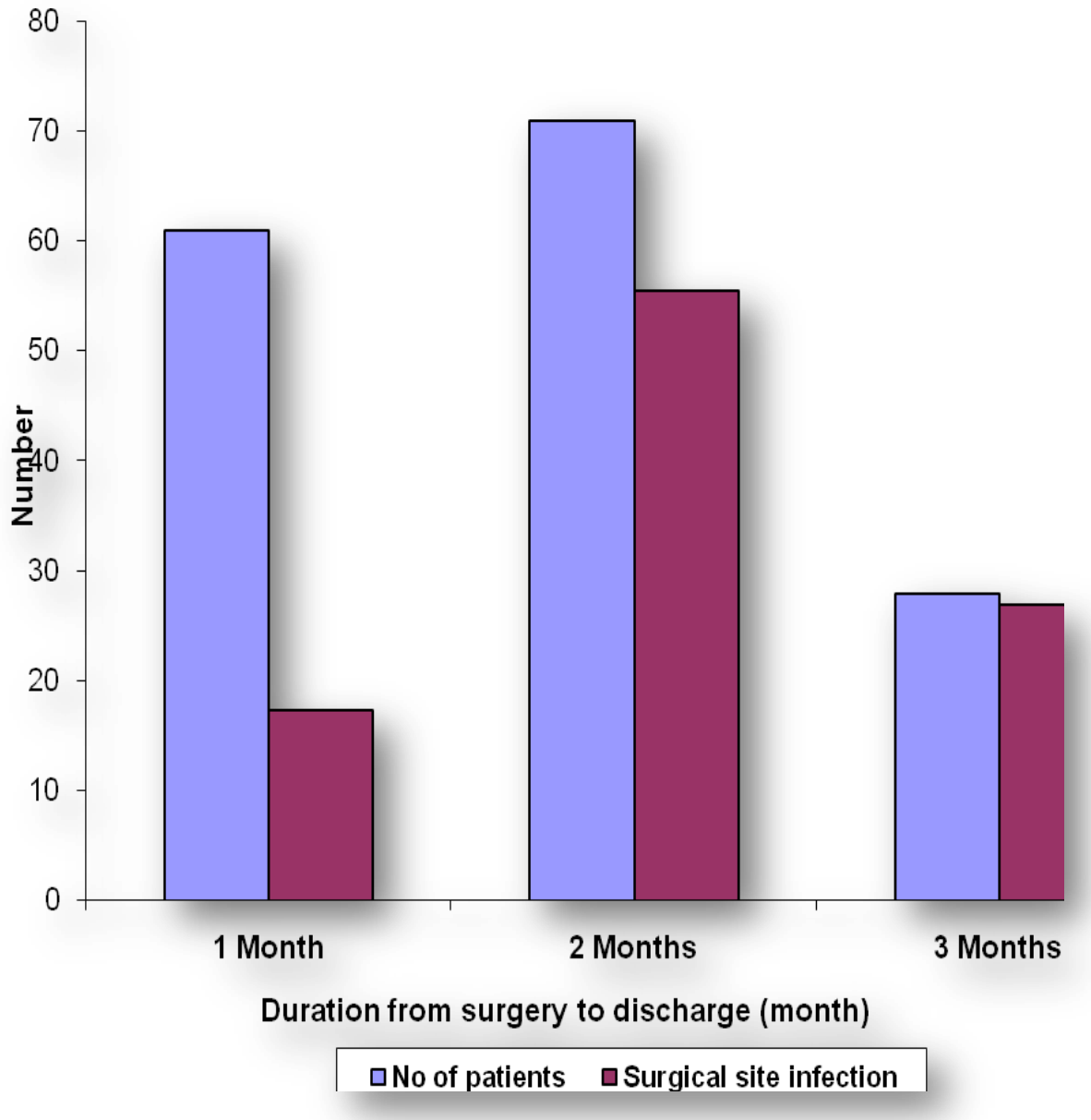


Figure 4.2: Effect of duration of hospital stay (from surgery to discharge) on the incidence of nosocomial infection in surgical patients in ABUTH, Zaria from January to June 2011.

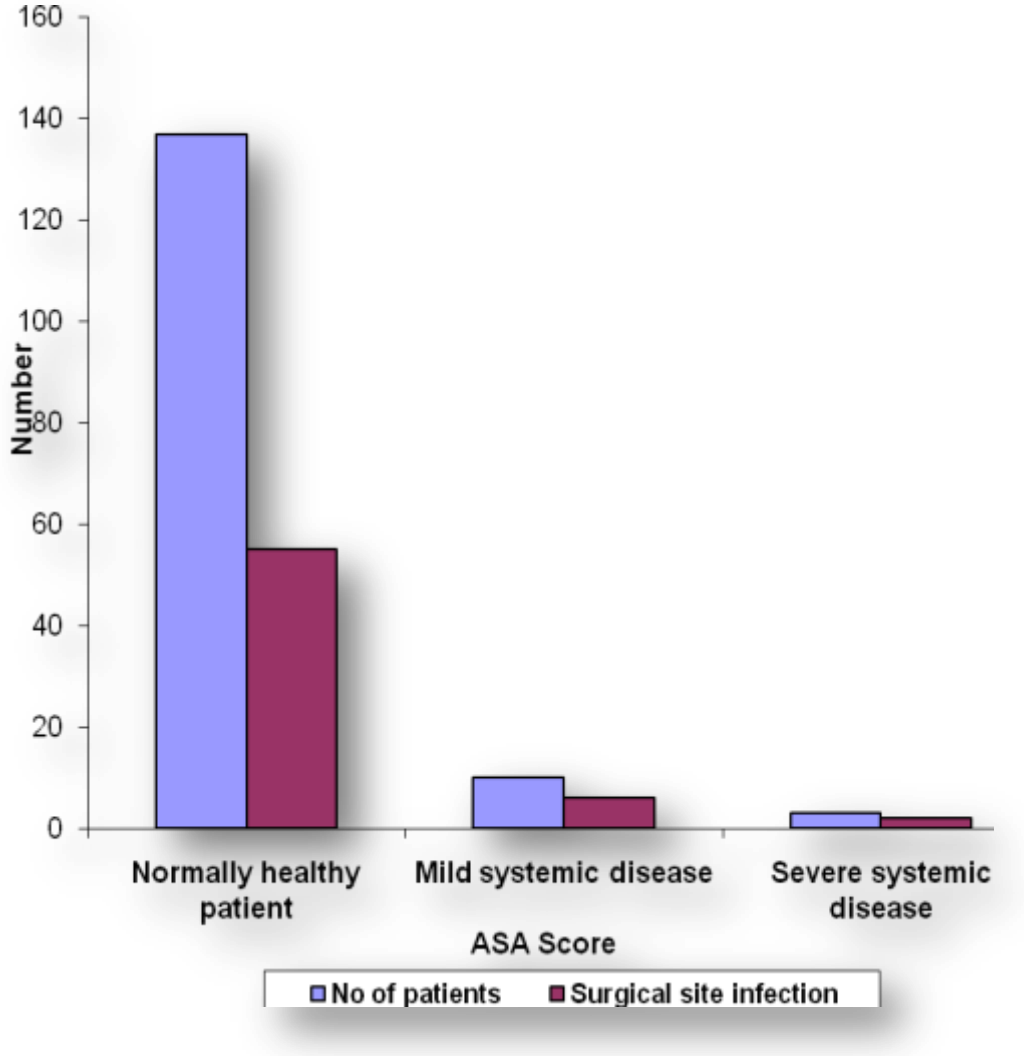


Figure 4.3: **American Society of Anesthesia score of surgical patients as regards the incidence of surgical site nosocomial infection in ABUTH, Zaria from January to June, 2011**

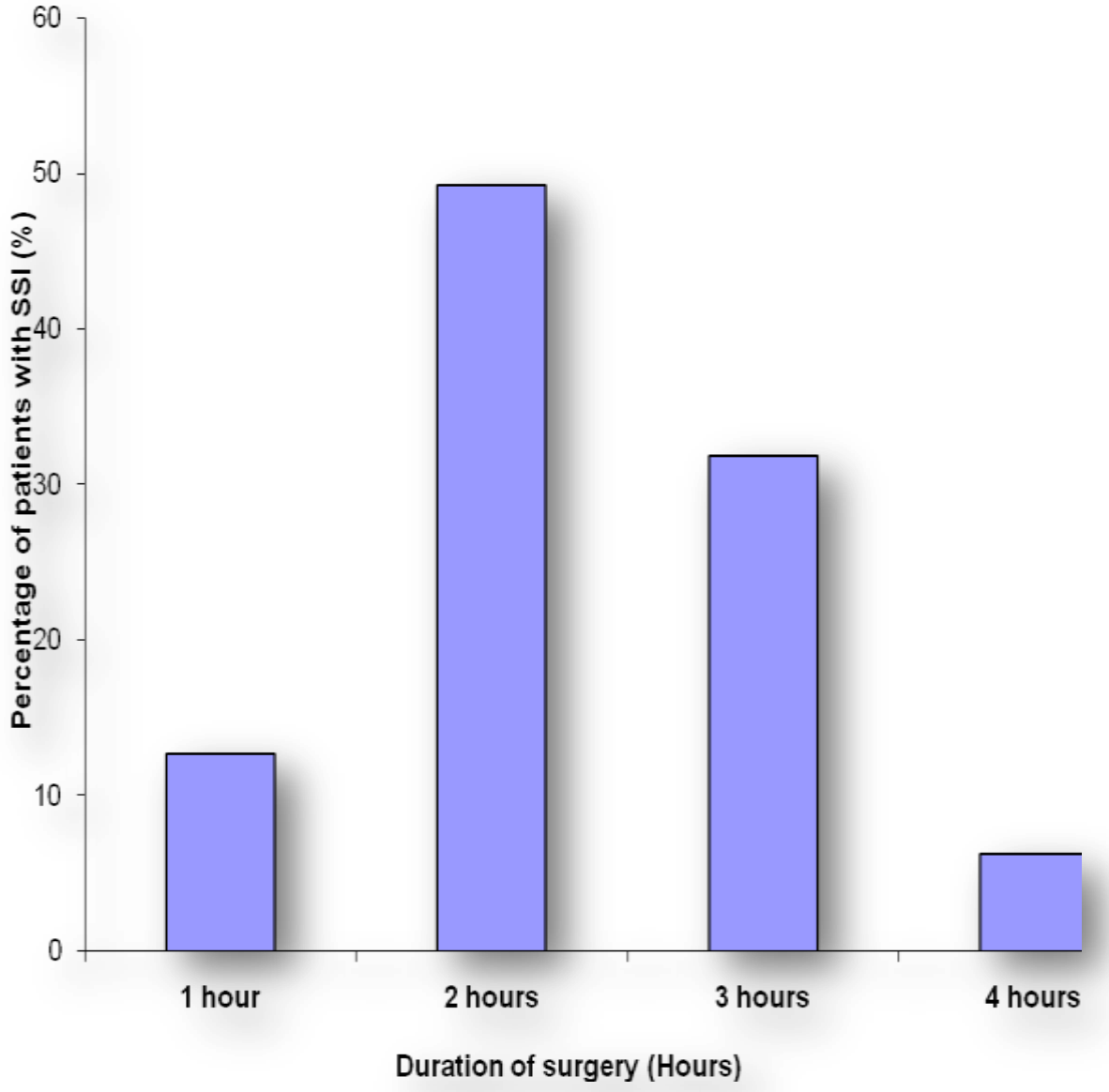


Figure 4.4: **Incidence of nosocomial surgical site infections and duration of surgery for patients operated in ABUTH, Zaria from January to June, 2011**

4.4 BACTERIOLOGICAL STUDIES OF HOSPITAL ENVIRONMENTS

The result presented in Table 4.18 showed that a total of 24 bacteria were isolated from the air in the two surgical wards and operating theatre of the hospital with *S. aureus, Ps. aeruginosa* and *E. coli* accounting for 33.3%, 20.8% and 20.8% respectively. Proteus and Bacillus spp were also isolated but at lower frequencies.

Data presented in Table 4.19 showed that the months of February, March and May of 2011 recorded the high microbial counts in the surgical ward. Air microbial levels were relatively low in the other three months (January, April and June).The theater air was relatively free of organisms.

As shown in Table 4.20 all the isolated organisms with the exception of *S. aureus*were absent in the air of the theater while in the air of the surgical wards, all of them except *S.epidermidis*and *Kl. pneumoniae*were present. Table further showed that, swabs taken from wound sites in the surgical wards yielded positive cultures for the different isolates.

The antibiotic resistance profile of the isolates from the air in the theater and surgical wards are presented in Table 4.21 and Table 4.22.Most of the *Bacillus*spp isolated from the air in the wards and theatres were 100% resistant to all the antibiotics and sensitive to only two (ciprofloxacin and nitrofurantoin) of the test antibiotics. The *S. aureus* isolates were generally very sensitive to all the test antibiotics. The result further showed that *Ps. aeruginosaE.coli and Proteus spp*were resistant to cotrimoxazole, erythromycin and chloramphenicol and moderately sensitive to ceftriazone and ciprofloxacin. Data presented in Table 23 shows that all the isolates were multidrug resistant.

Table 4.18: Air bacterial isolates in the surgical wards of Ahmadu Bello University Teaching Hospital, Zaria (January 2011-June 2011)

Isolate	% Occurrence
S. aureus (n =8)	33.3
Ps. aeruginosa (n=5)	20.8
E.coli (n = 5)	20.8
Pr. spp (n = 4)	16.0
Bacillus spp (n = 2)	8.3

Table 4.19: Monthly microbial levels of air in operating theater, and surgical wards of Ahmadu Bello University Teaching Hospital (Jan-June2011).

	Microbial Count of Air (Cfu/m^3)	
Month	**Theater**	**surgical wards**
January	-	2
February	1	8
March	-	5
April	-	-
May	1	5
June	1	1
Total	**3**	**21**

Table 4.20: Bacterial species isolated (Jan-June 2011) from air and patients surgical wounds sites in the theater and ward.

Isolate	**Theatre**		**Ward**	
	Air	AirWound		
S. aureus	+	+	+	
S. epidermidis	_	_	+	
Ps. aeruginosa	_	+	+	
E .coli	_	+	+	
Proteus spp	_	+	+	
Kl. pneumoniae	_	_	+	
Bacillus spp	_	+	_	

Table 4.21: Antibiotic resistance profiles of *S. aureus* and *Bacillus spp*isolated from air todifferent Antibiotics

Antibiotics	*S. aureus* (n =8)	*Bacillus spp* (n =2)
Ampicillin	0.0	100
Chloramphenicol	25.0	100
Gentamicin	0.0	100
Tetracycline	25.0	100
Cotrimoxazole	12.5	100
Erythromycin	0.0	100
Ceftriazone	0.0	100
Ciprofloxacin	0.0	0.0
Nitrofurantoin	25.0	0.0

Table 4.22: Antibiotic resistance profiles of *Ps. aeruginosa, E. coli* and *Pr. vulgaris* isolated from air to different antibiotics

Antibiotics	**Frequency**		
	Ps.aeruginosa **(n=5)**	***E.coli*** **(n =5)**	***Proteus spp*** **(n = 4)**
Ampicillin	100	0.00	25.0
Chloramphenicol	100	80.0	100
Gentamicin	0.0	0.0	100
Tetracycline	100	20.0	100
Cotrimoxazole	100	100	100
Erythromycin	100	100	100
Ceftriazone	0.0	20.0	100
Ciprofloxacin	0.0	0.0	0.0
Nitrofurantoin	40.0	0.0	0.0

Table 4.23: Multiple Antibiotics Resistance Index of nosocomial air pathogens isolated in Ahmadu Bello University Teaching Hospital in 2011

Organisms	% with MAR Index ≥ 0.2
S .aureus (n =8)0.00	
Ps. aeruginosa (n =5)	100.0
E.coli (n=5)	80.0
Pr vulgaris (n =4)	100.0
Bacillus Sp(n =2)	100.0

CHAPTER FIVE

5.0 DISCUSSION

Nosocomial infections (NIs) constitute an important health problem throughout the world, and account for high morbidity and mortality, prolonged hospital stays, greater use of antibiotics, and increased costs (Horan, *et al*., 2008). Hospitals worldwide are continuing to face the crisis of the upsurge and dissemination of antimicrobial-resistant bacteria, particularly those causing nosocomial infections in intensive care unit patients (Mangram*et al.*, 2009).

The results of the retrospective study in Ahmadu Bello University Teaching Hospital (ABUTH), Zaria showed that the surgical site infection rate in 2009 (10.5%) was found to be significantly higher than the values in 2010 (8.3%) . This may be due to under reporting of infections in the hospital. It was observed during collection of data that some of the folders contained specimens that might not be appropriate for detecting these infections and also some of the culture positive test results were not reflected in the folders and hence these patientswere part of those not analyzed.

Monthly incidence of surgical site nosocomial infections rates showed that the infection rates were highest for the months of March for the two years of study which might be due to the weather conditions. There was a significant difference between months and years for 2009 at $p<0.05$.The rates varied from one month to another which indicated that the incidence was mostly affected by seasonal changes. But no significant difference was seen between months and the surgical site nosocomial infection in 2010.

The result also revealed that the incidence of surgical site nosocomial infections was relatively higher in the male surgical wards in the 2 years of study as more number of male patients was operated than female. However, there was no significant difference between the incidence of the infection and gender of the patients in the two wards for the 2 years.

Similarly, a study conducted in a Peruvian Hospital in 2005 by Hernandez *et al*. reported 65.6% males and 34.4% females among the surgical site infection patients.

Classification of the nosocomial infections into different surgical sites also showed that, superficial surgical site infections were the highest for the two years of study. This is because organisms associated with superficial surgical site infections are part of the endogenous flora of the patient's skin, mucous membrane and the hollow viscera. It shows further that in the order of infection rate; superficial site infection was highest, followed by deep incisional and then organ/space. This agrees with the CDC, NNIS system surveillance criteria for defining surgical site infections (Horan *et al*., 1992).

Analysis of causative agents of surgical site nosocomial infections in ABUTH for the two years of study indicated that most of the organisms were with monobacterial growth. Giacometti *et al.* (2000) reported monomicrobial and polymicrobial wound infections, respectively.

In the prospective study, the overall incidence rate of surgical site nosocomial infections in Ahmadu Bello University Teaching Hospital was (33.0%); several studies have also reported high incidence rates of nosocomial surgical site infections. Ige*et al.*, (2011) reported as high as 48.3% of surgical site infections from the surgical wards. From ObafemiAwolowo University, Ife Onipede*et al* (2004) reported anincidence rate of 38.3% while 27.9 % was reported from the University College Hospital Ibadan by Oni *et al* (2006). 26.1% was reported by Atata*et al*. (2010) in University of Ilorin Teaching Hospital, Nigeria. He also reported a lower figure of about 1.27% for average nosocomial infection rates for 3 years beside the figure for surgical cases.

Surgical site infection rates assessed in Canadian and Irish hospitals over a prolonged period of 10 -16 years showed a rate of only 4.7% and 4.5% respectively.A study by Creamer et al. (2002), and Cruse and Ford (1980). The observations indicate that larger groups studied over

a longer duration may give a better assessment of surgical site infection rates. Reports from other developed countries by Gebubbels*et al*. (2000) and Saito *et al*. (2005) also showed a lower incidence of infection of 3.1% in the UK (2000), 4.3% in the Netherlands and 7.6% in Japan. A lower infective rate in developed countries as compared to developing countries indicates a better implementation of infection control practices along with availability of a proper surveillance system (Lilani*et al.,* 2005). The observed higher incidence rate of surgical site infections in this hospital could be due to the fact all the patients were exposed for surgical procedures withincrease risk of getting an infection in the hospital by direct invasion of the patient's body, thus allowing bacteria in to normal sterile parts of the body. Infection can also be acquired from contaminated surgical equipment or from health care workers (Dumpis*et al.,* 2011).

There was no statistical relationship between age and incidence of surgical site nosocomial infection .The observation that the age groups <20 and >60 had highest nosocomial infection rates is in disagreement with the reports of some other workers (Gaynes*et al*., 2001; WHO, 2002; Sohn*et al*., 2002). WHO reported that the incidence were highest in the very young and elderly.

As the data showed, there was a significant difference between gender and incidence rates of infections in male and female surgical wards in six months of study in ABUTH.

The patients selected had various surgical procedures including appendicectomy, exploratory laparatomy, heniorrhaphy, mastectomy, plastic surgery and debridement of contractures. The highest infection rates were observed among patients that hadplastic surgery and debridement of contractures (41% and 40.6%), respectively and lowest among mastectomy patients. Similarly, in a study by Anvikar et al on 3280 surgical wounds the commonest surgery performed was plastic surgery followed by laparatomy. Analysis of the monthly distribution of nosocomial infections showed that highest infection rates were observed in the month of

March while no incidence was recorded in the month of June. The differences of nosocomial infection rates were due to the number of patients admitted for surgery.

Surgical wound classification has been established as an important predictor of the post operative site infections. In this study SSI rate for clean surgery 30.0%, clean contaminated surgery 39.2%, contaminated surgery 27.3% and dirty surgery 43% respectively. High infection rates for these wound class may be due to endogenous flora of the patient present at the sites and the airborne exogenous organisms(Ducel*et al.*, 2002). There was significant difference between wound class and infection rates ($P<0.05$).

The distribution of pathogens in the surgical sites showed that the most common bacterial isolates in this study were *S.aureus, S.epidermidis, E.coli, and Ps.aeruginosa* which agreed with the results of other workers (Shittu, *et al*., 2002; Nwobu and Oguntibeju, 2004; Esposito and Leone, 2007; Chikere*et al*., 2008; Zhanel*et al.*, 2008).

Although *S.aureus*, Ps. *aeruginosa*and*E.coli*were the three most frequently isolated pathogens in surgical site infections, most of the organisms isolated vary with the type of procedure and the anatomic location of the operation. For most superficial surgical site infections, the organisms were usually aerobic Gram –positive coccie.g Staphylococci and(Coagulase negative staphylococci). When gastrointestinal organ is opened during an operation, the sources of pathogens were Gram –negative bacilli (e.g*E.coli*), and sometimes anaerobes (e.g., Bacillus spp) (Mangram*et al*., 2009).

The findings of higher prevalence rate of surgical site nosocomial infections, 42% obtained in the follow up surveillance study could be due to unregulated entry of visitors into the wards of the hospitals which may increase the rate of nosocomial infections and contribute to the microbial bioload of the wards, thus, increasing the rate of nosocomial infections. Also patients that have undergone surgical operation and were not discharged were available in the

surgical wards therefore incidences of these infections are more likely to be seen and reported. As a result of the high incidence of surgical site nosocomial infection, more than 40% of the operated patients had to spend longer than one month in the hospital. A large proportion of these categories of patients were those associated with superficial site and deep incisional surgical site infections.

The finding that length of hospitalization and duration of stay was significantly associated with surgical site infection is not surprising. A prolonged hospital stay is associated with exposure to hospital environment and its ubiquitous diagnostic procedures, therapies and micro-flora and these have been shown to increase the rate of surgical site infection. Similarly, in this study, the incidence of infection was higher with a prolonged hospital stay of two months (62.0%). According to Anvikar, *et al.*, 1999, longer post-operative stay also resulted in prolonged exposure to the potentially infective hospital environment, microbes and consequently higher infection rate. Similarly, in this follow up study, the incidence of infection was high with a post operative hospital stay of two months (55.6%).

The ASA score is an important predictor of surgical site infection and this finding was confirmed by this study. Its relationship with the development of infection in surgical ward in this study is in line with findings from other countries (Soleto*et al.*, 2003 and Hernandez *et al*., 2005).

In this study, the incidence of surgical site infection was found to be influenced by the duration of surgery. The incidence was lower in surgeries of duration less than 1 hour (12.7%) and higher with surgeries lasting more than 2 hours (49.2%). A similar trend was found in studies by Anvikar*et al* (2009) and Kasatpibal*et al (*2006) which reported low infection rates in surgeries of duration less than 1 hour and higher rates of infections after 2 hours of surgery. This is also in line with Cruse and Ford, 1980.

The results of bacteriological sampling of the air for both the surgical wards and theater showed that the bacterial count for the surgical wards were high compared to the theater. This is a confirmation of the unsatisfactory hygienic conditions in these surgical wards. It also implies that the effectiveness of the daily disinfection process is questionable. It was observed that some of the hospital cleaners use only detergent for cleaning and when disinfectants are used, they were only diluted which could contribute to the contamination process. Unregulated entry into the wards of the hospitals by visitors may also be a contributing factor. Visitors enter the wards severally at almost all times of the day contributing to microbial bioload of the wards and thus increasing the rate of nosocomial infections. Garibaldi *et al.* (1988) had reported that even low microbial levels in the environment could cause wound contamination and eventual infection, in certain surgical cases. Low monthly bacterial levels in the operating theater showed that the level of hygiene in the theater is better compared to the wards. The detection of *S. aureus*,*Ps*. *aeruginosa*and *E. coli* in both the air and wounds of the patients in the wards points to the possible relationship between air contaminants and wound infection. Staphylococci organisms have continued to be the most frequently isolated nosocomial pathogens in the wards. This was followed closely by *Staphylococcus epidermidis*. These observed bacterial distribution have high tendency to cause serious wound infections in the patient, if the right dose of these organism are available or if the patient immune system is depressed or compromised (CDC, 2002). The reason for this may be because of the fact that staphylococci are members of the body flora of both asymptomatic carriers and sick persons. These organisms can be spread by the hands, expelled from the respiratory tract or transmitted by animate or inanimate objects (Pelczar*et al.*, 1993). Though strains of *S. epidermidis* are known to be non pathogenic on the skin, but when they harbor antimicrobial resistance, they can constitute serious health hazard. Recently, Methicillin –resistant S. epidermidis strains and other Coagulase negative

Staphylococci have emerged as common nosocomial pathogens affecting immunocompromised patients carrying medical devices (Kainer*et al.,* 2007). These pathogens have been severally implicated as major causative agents of nosocomial infections of surgical sites and wounds in Nigeria by several workers (Chikere*et al*., 2008; Shittu*et al*., 2002; Nwobu and Oguntibeju, 2004; CDC, 1999). Among the total bacteria isolated from the wounds and air, Gram-positive bacteria accounted for 50.7%, while Gram-negative bacteria constitute 49.3%. Similar findings have been observed by Chikere*et al*. (2008) and Zhanel*et al.* (2008) in their survey of antimicrobial resistant pathogens in intensive care units in Nigeria and Canada. They reported that Gram positive cocci were among the most common isolates recovered respectively from 80% of all clinical specimen collected.

In this study, both Gram-positive and Gram-negative bacteria isolates showed high resistance level to various antibiotics such as ampicillin, chloramphenicol, tetracycline and trimethoprim-sulphamethoxazole.This is perhaps so because these agents are misused and abused. The result also indicated that these isolates were susceptible to ciprofloxacin, nitrofurantoin and ceftriaxone.A number of studies in the literature indicated a gradual increase in the emergence of antibiotic resistant microorganism in patients undergoing surgery (Cruse and ford 1980, Shittu, *et al*., 2002; Nwobu and Oguntibeju 2004; Chikere*et al.*, 2008).

Currently many micro organisms have become resistant to different antimicrobial agents and in some cases, to nearly all agents. Resistance to antimicrobial agents is a problem in health care facilities, but in hospitals, transmission of bacteria is amplified because of the highly susceptible population (WHO, 2002). The antibiotic sensitivity results confirmed the alarming percentage of resistance exhibited by pathogens to the common antibiotics in use.

The antibiotic resistant profiles of bacteria isolated from the surgical ward, theatre and wounds of patients in ABUTH in the period under study revealed that there were multiple antibiotics resistant. Multiple antibiotics resistance (MAR) index is a tool that reveals the spread of bacteria resistance in a given population. MAR index greater than 0.2 often implies that the strains of such bacteria originated from an environment where several antibiotics are in use (Ehinmidu, 2003). The MAR indices obtained in this study is a possible indication that a very large proportion of the bacteria isolates have been exposed to several antibiotics.

The high prevalence of antibiotic resistance among the bacteria isolates might be due to the widespread use of antimicrobial agent in the hospital, the ease of availability and indiscriminate use of these drugs outside the hospitals, as many of the antibiotics are available over the counter for self-medication. These problems, coupled with the increase chance of cross infection among inpatients, are known to account for circulating resistant strains. The implications are that:

- Most of the commonly used antibiotics will not be useful in the management of wounds and surgical site infections.
- Infected wounds are likely to take longer to heal
- Patients will have to stay longer in the hospital environment
- There will be increased cost of drugs, test and medical bills.
- There is higher likelihood of transmission of such pathogens to other patients.

It is important therefore, that the hospital management adopt suitable policies to avoid epidemic outbreak of drug resistant organisms in its environment.

As part of measures to combat nosocomial infections, the following suggestions had been put forward:

- The WHO recommends that hospitals should have an Antimicrobial Use Committees to be charged with evolving a “simple, flexible and regularly updated antibiotic-

prescribing policy on a disease specific basis, relying whenever possible on knowledge of prevailing antibiotic-sensitivity patterns and controlled use of reserve antibiotics (WHO, 2002).

- The hospital microbiology laboratory an important chain in controlling antibiotic resistance, should test for susceptibility, work with the Antimicrobial Use Committee, monitor and report trends in the prevalence of bacterial resistance to antimicrobial agents, and notify infection control of any unusual patterns of bacterial resistance. Antimicrobial use in healthcare facilities must be monitored, usually by the Pharmacy Department(WHO, 2002*)*.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 SUMMARY

This study has looked into the incidence and prevalence rates of surgical site nosocomial infections in Male and Female surgical wards of Ahmadu Bello University Teaching Hospital Shika, Nigeria.

The result of the retrospective study of nosocomial infection in surgical wards of Ahmadu Bello University Teaching Hospital, Zaria showed incidence of surgical site nosocomial infections, with prevalence rates of 10.5 % and 8.3% respectively for the two years. Superficial surgical sites were more frequently infected compared with other sites with prevalence rates of 66.3% and 77.2% in 2009 and 2010 respectively. The leading causative agents of surgical site nosocomial infections in the retrospective study were *S. aureus, E.coli, S.epidermidis, and Ps. aeruginosa* in the two years of study. Antibiotic susceptibility tests showed that all the bacterial isolates were multiple antibiotics resistant (MAR) with more than 65% of the isolates having MAR index > 0.2 in the two years of study indicative of exposure to many antibiotics in the hospital.

The result of the prospective study on surgical site nosocomial infections in surgical wards of ABUTH, Zaria showed thata total of 106 bacterial isolates were isolated from nosocomial infection (n=79) cases. *Staphylococcus aureus*accounted for (33.0%) of the total isolates followed by Coagulase negativestaphylococcus (19.8%), *Pseudomonas aeruginosa*(17.9%), *Escherichia coli* (12.3%), *Proteus vulgaris (*9.4%) and *Klebsiellapneumonia* (7.5%). Morethan one bacteria etiologic agent was isolated from 22/79(27.8%) the patients withnosocomial infection. The Gram-positive and negative bacteria accountedfor and 56/106 (52.8%) and 50/106(47.2%) respectively.

The incidence of surgical site nosocomial infections was found to be 33.0%. *Staphylococcus aureus*was the most commonly isolated organism followed by *S.epidermidis*. The results of the follow-up study for patients that had under gone surgery in the hospital showed that risk factors like age and gender, type of operation and duration of surgery played a significant role in causing surgical site infection. Bacteriological study of air in ABUTH showed that a total of twenty four bacterial species were isolated which were *Staphylococcus aureus (33.3%)*, *Pseudomonas aeruginosa*(20.8%), *Escherichia coli* (20.8%), *and Proteus vulgaris (*16.0%) from both wards and in the theatre.

The results have demonstrated that the antibiotic susceptibility profile of the Gram positive isolates from air have high rates of resistance (>80%) to the commonly used antibiotics such as ampicillin, chloramphenicol, gentamicin, and cotrimoxazole; and low level of resistance (< 60%) was observed against ciprofloxacin, ceftriaxone, norfloxacin, nitrofurantoin, gentamicin and nalidixic acid. All Gram negative bacteria isolated from air showed high level of resistance to ampicillin, chloramphenicol, gentamicin, tetracycline and trimethoprim-sulphamethoxazole. All the bacteria isolated from the air were multiple antibiotics resistant (MAR) with the air isolates having 100% of the MAR index of >0.2.

The result of antibiotic susceptibility profile of the Gram positive isolates from wounds showed high level of resistance to ampicillin and cotrimoxazole and low level of resistance to ciprofloxacin while for the susceptibility profiles of the Gram negative isolate from wounds showed high level of resistance to ampicillin, gentamicin, erythromycin, and tetracycline and low level of resistance to ciprofloxacin, ceftriaxone, and nitrofurantoin. Most of the bacteria isolated from wounds were multiple antibiotics resistant (MAR) with over 75% of the wound pathogen having an MAR index of > 0.2.

6.2 CONCLUSION.

Result of the study of nosocomial infections obtained from Ahmadu Bello University Teaching Hospital showed that

- Retrospective analysis indicated that surgical site nosocomial infection in 2009-2010 ranged between 8.32% and 10.5% compared to 33.0% in the prospective study in 2011.
- A prolonged preoperative stay and also a long post-operative stay is associated with higher nosocomial infection rate among surgical patients.
- The major nosocomial surgical site infection pathogens in the surgical wards of ABUTH are *S. aureus, S. epidermidis, Ps. aeruginosa* and *E. coli*.
- *S. aureus* and *S. epidermidis* which are often associated with personal hygiene were the major bacteria contaminants in these wards.
- The surgical wards, in particular harbor high level of bacterial contaminants, which are potentially pathogenic
- The bacteria isolated in the wards were similar to those found as the causative organism of the surgical wound infections..
- Most of the nosocomial pathogens are not only resistant to the commonly used antibiotics, they are multi drug resistant.

6.2 RECOMMENDATIONS

Based on these findings, it was evident during the course of this study that there is a high prevalence of nosocomial infection among surgical patients in ABUTH, Zaria. The following remedies are therefore recommended: -

- More studies on the incidence of surgical site nosocomial infections in other wards and infection sites should be carried out in Ahmadu Bello University

Teaching hospital, to enable assessment of the overall prevalence rate in the hospital

- Empirical treatment of surgical site nosocomial infections which provoke drug resistance should be avoided.
- Evidence based treatment of surgical site nosocomial infections should be based on the result of culture and sensitivity. In order to achieve this, the capacity of microbiology laboratory should be strengthened with trained manpower, improved finance and laboratory equipments.
- There is a need for a continuous surveillance for resistant bacteria to provide the basis of alternative treatment.
- This type of study should be conducted in other teaching hospitals across the country.
- The hospital should put in place, measures that will regulate human traffic in the wards housing surgical patients.
- The hospital should establish nosocomial infection surveillance and control committee to draw out policies and implement measure that will lead to a substantial reduction in the current rate of prevalent surgical site nosocomial infections.
- There is need for awareness campaign for the hospital staff on the prevalent level of nosocomial infections in the hospital, the implications and consequences.

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POSTGRADUATE OFFICE

FACULTY OF MEDICINE

AHMADU BELLO UNIVERSITY TEACHING HOSPITAL

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Your Ref: _____

ABUTH/PGO/COMM 9

Our Ref: _____

31st December, 2010

Date: _____

Bello Elizabeth Adenike
Dept of Pharmaceutical Microbiology and Pharmaceutics
A B U. Zaria

ETHICAL CERTIFICATE

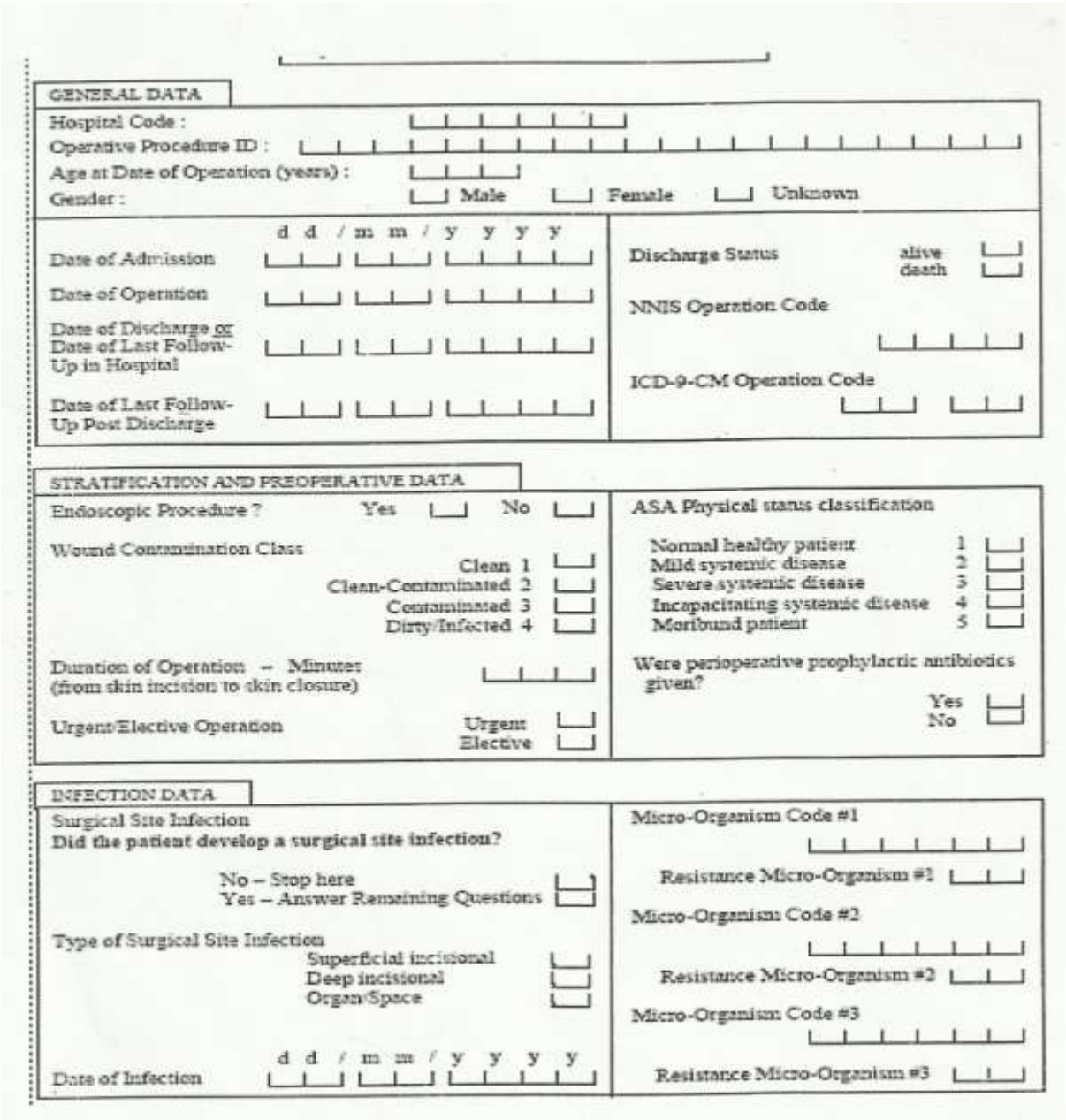
Your application for ethical certification for the research study titled "**INCIDENCE OF NOSOCOMIAL INFECTION IN FEMALE SURGICAL WARD OF AHMADU BELLO UNIVERSITY TEACHING HOSPITAL, ZARIA**" refers.
This is to convey the scientific and ethical committee approval for your research. You are expected to up date the committee on the progress of the work.

Thank you.

Yours sincerely

.....

DR. A. J. RANDAWA - FWACS
Coordinator Residency and ethics



GENERAL DATA

Hospital Code :

Operative Procedure ID :

Age at Date of Operation (years) :

Gender : Male Female Unknown

Date of Admission (d d / m m / y y y y)

Date of Operation

Date of Discharge or Date of Last Follow-Up in Hospital

Date of Last Follow-Up Post Discharge

Discharge Status: alive / death

NNIS Operation Code

ICD-9-CM Operation Code

STRATIFICATION AND PREOPERATIVE DATA

Endoscopic Procedure ? Yes No

Wound Contamination Class

Clean 1

Clean-Contaminated 2

Contaminated 3

Dirty/Infected 4

Duration of Operation – Minutes (from skin incision to skin closure)

Urgent/Elective Operation: Urgent / Elective

ASA Physical status classification

Normal healthy patient 1

Mild systemic disease 2

Severe systemic disease 3

Incapacitating systemic disease 4

Moribund patient 5

Were perioperative prophylactic antibiotics given? Yes / No

INFECTION DATA

Surgical Site Infection

Did the patient develop a surgical site infection?

No – Stop here

Yes – Answer Remaining Questions

Type of Surgical Site Infection

Superficial incisional

Deep incisional

Organ/Space

Date of Infection (d d / m m / y y y y)

Micro-Organism Code #1

Resistance Micro-Organism #1

Micro-Organism Code #2

Resistance Micro-Organism #2

Micro-Organism Code #3

Resistance Micro-Organism #3