Surveillance of Surgical Site Infections at The Aga Khan University Hospital, Nairobi

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

I dedicate this work to my family for their tireless support in terms of time, resources and advice throughout the course of the Master of Science degree.

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ABBREVIATIONS

AKUH-N	Aga Khan University Hospital-Nairobi
API	Analytical profile Index
ASA	American Society of Anaesthetists
ATCC	American Type Culture collection
BMI	Body Mass index
CDC	Centre of Disease Control and Prevention
CLSI	Clinical and Laboratory standards Institute
CSSD	Central Sterilization Supplies Department
ET intubation	Endotracheal intubation
HAI	Hospital Acquired Infection
MRSA	Methicillin Resistant *Staphylococcus aureus*
NINSS	Nosocomial Infection National Surveillance Service
NNIS	National Nosocomial Infection Surveillance
ORSA	Oxacillin Resistant *Staphylococcus aureus*
ORSE	Oxacillin Resistant *Staphylococcus epidermidis*
OR	Operating Theatre
SENIC	Study on the Efficacy of Nosocomial Infection Control study
VRE	Vncomycin Resistant *Enterococcus*
SSI	Surgical Site Infection

ABSTRACT

Surgical site infections (SSI) remain a major clinical problem contributing to significantly high morbidity, mortality, and patient hospital costs. Post-operative infections have always been a feature of human life and sepsis in modern surgery continues to be a significant problem for healthcare practitioners across the globe. Patients that are undergoing surgery or surgical procedures are at risk of acquiring infection at the site of incision as result of the same procedure. SSIs are real risks associated with any surgical procedure and represent a significant burden contributing to morbidity and mortality, and increased cost to health services around the world. Despite Surgical site infection being a relatively serious problem in our health institution, there are scanty published reports on the bacterial pathogens (especially their antibiograms or molecular epidemiology) that are involved in SSIs in our local hospitals. The sporadic reports from the public sector hospitals are mainly from the Microbiology laboratory records which may not show the complete clinical picture. These reports from the records have been used to estimate or predict this predicament. This study aimed at determining the occurrence of SSI, pathogens associated with SSI, the antibiograms of the causative pathogens and specific risk factors associated with SSI at Aga Khan University Hospital, Nairobi (AKUH-N). It was a prospective observational study with patient follow-up until the 30^{th} postoperative day, carried out at AKUH-N. The study recruited 175 respondents (patients) admitted for general surgical procedures from March 2008 to December 2008 at the hospital and were eligible

to take part in the study. To eligible respondents, questionnaires were administered; preoperative and intra-operative samples were obtained for culture. After surgery patients were observed for symptoms of infection. Reviews were done through the consulting clinics, breast clinic and casualty dressing clinic. In cases of infection, pus swabs were obtained for culture. All the samples were transported to the laboratory for culture. Cultures were done using standard bacteriological procedures. The samples were cultured in Blood agar, MacConkey and Chocolate agar. Sensitivity was done on Mueller Hinton Agar medium. Disc diffusion was used to determine the antimicrobial susceptibility patterns to a panel of commonly available drugs against the pathogens implicated in the infection. Patients' data were managed using EPI-INFO statistical program and analyzed using SPSS version 17, mean, median, frequencies and cross tabs were used to interpret the data. The findings were presented in tables and pie chart. The study found out that the SSI incidence rate was 6.8%. Pathogens isolated from SSI included *S. aureus* (30%), Coagulase negative *Staphylococcus* (16%), *Klyuvera spp. (13%), E. coli (13%), P. aeruginosa (13%), Klebsiella spp. (9%)* and other Gram negative. *S. aureus* was the most prevalent pathogen isolated from infected surgical site with 10% ORSA rate. Vancomycin was potent on Gram positive bacteria. Preoperative stay $\geq$ 2days ($p=0.002$) and wound class ($p=0.003$) at $p< 0.05$ (95% confidence interval) were the risk factors associated with SSI among patients admitted for general surgical procedure at the hospital during the study period. From the findings of this study, it can be concluded that incidence rate of

SSI of 6.8% is relatively lower than documented SSI incidence rates in other studies in the Kenya. *S. aureus* (30%) is the most prevalent pathogens associated with SSI at AKUH-N, similar to findings from other studies done in the region. Ampicillin and Cotrimoxazole are not potent against pathogens associated with SSI in AKUH-N. Prolonged hospital stay and dirty wounds are the main risk associated with post surgical sepsis at the AKUH-N.

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CHAPTER ONE

1.1 INTRODUCTION

Post-operative infections have always been a feature of human life and sepsis in modern surgery continues to be a significant problem for healthcare practitioners across the globe. Patients that are undergoing surgery or surgical procedures are at risk of acquiring infection at the site of incision as result of the same procedure. When such a phenomenon occurs, it is referred to as surgical site infection (SSI). Surgical site infections (SSIs) are real risks associated with any surgical procedure and represent a significant burden contributing to morbidity and mortality, and increased cost to health services around the world (National Audit Office, 2000). A multitude of risk factors influence the development of SSIs and awareness of these could facilitate the promotion of effective preventive strategies. Infections of the surgical site account for approximately 10% of all Hospital Acquired Infections (HAI) and are estimated to double the cost of care and result in an additional average of 6.5 days of hospital stay (Emmerson *et al.,* 1996; Haley, 1986 *et al.,*; Plowman *et al.,* 1999).

Surgical care is an integral part of health care throughout the world, with an estimated 234 million operations performed annually. 2008 yearly surgical procedures volume exceeded that of childbirth (Haynes *et al.,* 2009). Surgery is performed in every community: wealthy and poor, rural and urban, and in all regions. The World Bank reported that in 2002, an estimated 164 million

disability-adjusted life-years, representing 11% of the entire disease burden, were attributable to surgically treatable conditions (Haynes *et al.,* 2009).

SSI as Hospital-acquired infections add to functional disability and emotional stress of the patient and in some cases leads to disabling conditions that reduce the quality of life. The economic costs are considerable. The increased length of stay for infected patients is the greatest contributor to cost (Ducel *et al.,* 2002). One study reported by Ducel *et al.* (2002) showed that the overall increase in the duration of hospitalization for patients with surgical wound infections was 8.2 days, ranging from 3 days for gynecology to 9.9 for general surgery and 19.8 for orthopedic surgery. Prolonged stay not only increases direct costs to patients or payers but also indirect costs due to lost work. The increased use of drugs, the need for isolation, and the use of additional laboratory and other diagnostic studies also contribute to costs. Hospital-acquired infections add to the imbalance between resource allocation for primary and secondary health care by diverting scarce resources to the management of potentially preventable conditions (Ducel *et al.,* 2002).

1.2 Statement of the Problem

SSI remains one of the most important problems in post operative complication, contributing approximately 38% of all cases (Kirkland *et al.*, 2000). There is no doubt that SSIs substantially contribute to prolongation of hospital stay and increase costs. However, it has been difficult to establish the extent SSI contributes

to attributable mortality. Kirkland *et al.* (2000) found that the likelihood of death for patients with SSI is twice that for patients without SSI.

Although the situation of SSI in the region or locally is scantily documented, few reports indicate that the situation is not any better to (Abdalla *et al.*, 1998; Fehr *et al.*, 2006; Koigi-Kamau *et al.,* 2005; Kotisso *et al.*, 1998; Onche, 2004; and Ussiri *et al.*, 2005). Reports from studies done in Nigerian, Ethiopian, Sudan, Tanzanian and some of the Kenyan hospitals are in harmony that the situation warrants more attention. Despite other overwhelming and relatively severe conditions burdening the patients in resource strained countries like the ones mentioned above it is evidently clear that SSI is a problem and needs to be attended to (Abdalla *et al.*, 1998; Fehr *et al.*, 2006; Koigi-Kamau *et al.*, 2005; Kotisso *et al.*, 1998; (Onche and Adedeji, 2004; and Ussiri *et al.*, 2005).

From these few studies documented none of them have featured clearly the economic burden (cost) of the SSI and the susceptibility patterns of commonly used antibiotics in these countries (resource strained) and therefore it is high time some studies and documentation on the current situation of the subject (Abdalla *et al.*, 1998; Fehr *et al.*, 2006; Koigi-Kamau *et al.,* 2005; Kotisso *et al.*, 1998; (Onche and Adedeji, 2004; and Ussiri *et al.*, 2005).

1.3 Justification for the Study

Despite Surgical site infection being a relatively serious problem in our health institution, there are scanty published reports on the bacterial pathogens (especially their antibiograms or molecular epidemiology) that are involved in SSIs in our local hospitals. The sporadic reports from the public sector hospitals are mainly from the Microbiology laboratory records which may not show the complete clinical picture. These reports from the records have been used to estimate or predict this predicament.

Paucity of published data on the risk factors involved in SSIs has impacted negatively on management of patients particularly in the resource strained set up. This study sought to determine specific risk factors that are associated with surgical site infection in a resource limited set up.

Various past attempts made by the Infection Control Unit in resource strained settings (AKUH-N included) at having a methodical surveillance of SSIs failed due to lack of concerted protocol and resources. A well designed prospective study would certainly help to get accurate information on the situation. Data from this study could be used by policy makers to make informed decision on issues of infection control pertaining to surgical wound sepsis.

1.4 Research Questions

1. What is the incidence of SSI among the patients undergoing general surgical procedure at AKUH-N?
2. What are/is the specific risk factor(s) associated with SSI development among the patients undergoing general surgical procedure at AKUH-N?
3. What are the pathogens associated with SSIs from the patients undergoing general surgical procedure at AKUH-N?

1.5 Objectives

1.5.1 General objective

To determine incidence of pathogens, their antimicrobial susceptibility patterns and the risk factors associated with surgical site infections (SSIs) among patients undergoing surgery at the AKUH-N.

1.4.2 Specific objectives

1. Document the incidence of postoperative wound infections among the patients undergoing general surgical procedure at AKUH-N.
2. Determine specific risk factors that predispose to postoperative wound infections.
3. Isolate and identify the pathogens associated with SSIs from the patients undergoing general surgical procedure at The Aga Khan University Hospital Nairobi (AKUH-N).
4. Determine antibiotic susceptibility patterns of these pathogens

CHAPTER TWO

2.1 LITERATURE REVIEW

2.2 Surgical Site Infection (SSI)

Infection may be defined as invasion and multiplication of microorganisms in body tissues, which may be clinically unapparent or result in local cellular injury because of competitive metabolism, toxins, intracellular replication, or antigen-antibody response (Oluwatosin, 2005). These series of events lead to progressive tissue destruction and eventual death of the host if wounds are left unchecked (Oluwatosin, 2005).

Documentary evidence suggests that the historical background of wound infection may be traced as far back as the1st century AD when a Roman physician, Cornelius Celsus described the four principal signs of inflammation (Oluwatosin, 2005). Claudius Galen (130-200AD), another Roman physician had such an influence on the management of wounds that he is still thought of by many today as the 'father of surgery'. He and some of his followers instigated the 'laudable pus' theory, which incorrectly considered the development of pus in a wound as a positive part of the healing process. This continued until the 16th century when Ambroise Pare "encouraged wounds to suppurate" (Oluwatosin, 2005). The 19th century witnessed the acceptance of the germ theory of disease and introduction of antisepsis through works of Semmelweiss (1818-1865), Pasteur (1822-1895) and

Lister (1827-1912). Mary Ayton, a Nursing officer, defined terminologies like; wound contamination, wound colonization and wound infection, which are currently used in most literature (Oluwatosin, 2005). Vincent Falanga, in 1994 identified the concept of 'critical colonization' with fresh insights into chronic wound healing and non-healing wounds (Oluwatosin, 2005).

The Centers for Disease Control and Prevention (CDC) in 1992 developed criteria for defining SSIs, which have become the international standard and are widely used by surveillance and surgical personnel (Whitehouse *et al.*, 2007). These criteria defined SSIs as infections related to the operative procedure that occurs at or near the surgical incision within 30 days of an operative procedure or within one year if an implant is left in place (Whitehouse *et al.*, 2007).

The clinical criteria used to define an SSI included any of the following:

- A purulent exudate draining from a surgical site.
- A positive fluid culture obtained from a surgical site that was closed primarily.
- The surgeon's diagnosis of infection.
- A surgical site that requires reopening.

2.3 Surgical Wound Classification

A widely accepted wound classification system was developed over 45 years ago (Altemmeier *et al.*, 1998). This wound classification scheme, developed by the

National Academy of Sciences and the National Research Council, was based upon the degree of expected microbial contamination during surgery. It stratified wounds as clean, clean-contaminated, contaminated, or dirty using the following definitions:

2.3.1 Class I/Clean

An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tract is not entered (Mangram *et al.*, 1999). In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow non penetrating (blunt) trauma should be included in this category if they meet the criteria (Mangram *et al.*, 1999).

2.3.2 Class II/Clean-Contaminated

An operative wound in which the respiratory, alimentary, genital or urinary tracts are entered under controlled conditions and without unusual contamination ((Horan *et al.*, 1992). Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered (Horan *et al.*, 1992).

2.3.3 Class III/Contaminated

This class of wounds includes open, fresh and accidental wounds (Mangram *et al.*, 1999). The operations may involve major breaks in sterile technique (e.g., open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in

which acute, non purulent inflammation is encountered are included in this category.

2.3.4 Class IV/ Dirty-Infected

Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera are included in this group (Horan *et al.,* 1992).This definition suggests that the organisms causing postoperative infection were present in the operative field before the operation (Horan *et al.,* 1992).

2.4 Classification of Surgical Site Infection (SSI)

SSIs are classified as incisional or organ/space. Incisional SSIs are further divided into superficial (i.e., those involving only the skin or subcutaneous tissue) or deep (ie, those involving deep soft tissues of an incision). An organ/space SSI may involve any part of the anatomy (other than the incision) that was opened or manipulated during the operative procedure (e.g. meningitis following an elective neurological procedure or mediastinitis following coronary artery bypass surgery). Although organ/space SSIs account for only one-third of all SSIs, they are associated with 93% of deaths related to SSIs. Organ/space SSIs are also vastly more costly to treat and manage than incisional SSIs (Altemeier *et al.,* 1984).

2.5 Surveillance of Surgical Site Infection

The milestones of SSI surveillance are traced back to the development of the National Nosocomial Infections Surveillance (NNIS) system in the early 1970s to

monitor the incidence of healthcare-associated (nosocomial) infections (HAIs) and their associated risk factors and pathogens (Masud, 2008). NNIS has been the national system for tracking healthcare-associated (nosocomial) infections (Masud, 2008).

Study on the efficacy of nosocomial infection control (SENIC) a study conducted to by the CDC in 1974 to evaluate the efficacy of common nosocomial infection prevention programs (including surveillance) in reducing the rate of infection in 4 important infections (Masud, 2008): -

- Surgical site infection.
- Urinary tract infection.
- Pneumonia.
- Bacteremia. (Source: Masud, 2008)

SSI Surveillance is a dynamic process of assembling, managing, analyzing and reporting data on events that occur in a specified surgical population. An efficient SSI surveillance program is a critical part of surgical wound infection prevention. Surveillance provides data that enable the epidemiology staff to determine baseline rates of nosocomial infections or other adverse events, detect changes in the rates or the distribution of these events, investigate significantly increased rates, institute control measures and determine whether the interventions were effective (Masud, 2008).

Surveillance can readily identify epidemiologic foci of surgical wound infection (It can also provide accurate analysis of pathogens and their antibiograms. Analysis of surveillance data could be made more resourceful when surgeons are involved. Comprehensive surgical wound surveillance of infection rates and action by individual surgeons can result in sustained reductions in infection rates over time (Mitchell *et al.*, 1999; Stockley *et al.*, 2001).

2.6 Epidemiology of Surgical Site Infection

Rates of SSIs for individual procedures vary widely depending upon the patient population, size of hospital, experience of the surgeon, and methods used for surveillance (Whitehouse *et al,* 2007). Tertiary hospitals generally have the lowest rates of SSI compared to small (<500 beds) or large (>500 beds) teaching hospitals (4.6 versus 6.4 and 8.2 percent, respectively) (Whitehouse *et al.,* 2007).

Studies conducted by Cruse, noted an increased risk of SSI in patients with cancer who undergo surgical procedures (Cruse *et al*., 1980). The type of procedure is also associated with different rates of SSIs. The highest rates occur after abdominal surgery: small bowel surgery (5.3 -10.6%), colon surgery (4.3 -10.5%), gastric surgery (2.8-12.3 %), liver/pancreas surgery (2.8-10.2 %), exploratory laparotomy (1.9-6.9 %), and appendectomy (1.3 to 3.1 percent). High volume surgeries associated with higher rates of SSI and therefore more common infections include: coronary bypass surgery (3.3 -3.7 %), caesarean section (3.4 to

4.4 percent), vascular surgery (1.3 -5.2 %), joint prosthesis (0.7 - 1.7 %), and spinal fusion (1.3- 3.1 %). Eye surgery is associated with an extremely low rate of SSI (0.14%) (Whitehouse *et al.*, 2007).

2.7 Pathogenesis and Microbiology of SSI

Most SSIs are acquired at the time of surgery. The most common source is believed to be direct inoculation of endogenous patient flora at the time of the surgery. For clean procedures, the most common pathogens causing SSIs are normal skin flora including the staphylococcal species, *Staphylococcus aureus* and Coagulase Negative *Staphylococci* (CNS). When the surgical procedure involves opening a viscous region, the pathogens causing SSIs reflect the endogenous flora of the viscous or nearby mucosal surface. Such infections are typically polymicrobial (Jarvis, 1995; Schaberg, 1994).

The species of microorganisms isolated from surgical site infections have not changed markedly during the last decade, but the percentage of SSIs that are caused by antibiotic-resistant pathogens has increased (e.g. Methicillin-resistant *S. aureus* (MRSA), Methicillin-resistant *S. epidermidis* (MRSE), and Vancomycin-resistant *Enterococci* (VRE) (Schaberg, 1994). In addition, fungi, particularly *Candida albicans*, have been isolated from an increasing proportion of SSIs (Schaberg, 1994). This trend of increasing proportion of resistant organisms and *Candida* species probably is due to the widespread use of prophylactic and empiric

antibiotics, increased severity of illness, and greater numbers of immunocompromised patients undergoing surgical procedures (Schaberg, 1994).

While most SSIs are due to normal endogenous flora, there are also exogenous sources of infection (Pottinger *et al.,* 1989). These include contamination of the surgical site by flora from the operating room environment or personnel. Anal, vaginal, or nasopharyngeal carriage of group A streptococci by operating room personnel has been implicated as a cause of several SSI outbreaks (Pottinger *et al.*, 1989). Carriage of Gram-negative organisms on the hands has been shown to be greater among surgical personnel with artificial nails. Rarely, outbreaks or clusters of surgical site infections caused by unusual pathogens have been traced to contaminated dressings, bandages, irrigants, or disinfection solutions (Pottinger *et al.,* 1989).

2.8 Surgical Site Infection Risk Factors

Mangram *et al.* (1999), refers to risk factor as a variable that has a significant, independent association with the development of SSI after a specific operation. These factors include patient or operation features which, although associated with SSI development, and are not necessarily independent predictors. These risk factors as has been documented in Western studies are either patients or procedure related as shown in the Table 2.1

Table 2.1: The Risk factors of SSI

Patient characteristics	**Operative Characteristics**	
Co morbid – Diabetes.	**Preoperative Issues**	Preoperative antiseptic showering
Nicotine use		Preoperative hair removal
Steroid use		Patient skin preparation in the operating room
Malnutrition		Preoperative hand/forearm antisepsis
Prolonged preoperative hospital stay		Management of infected or colonized surgical personnel
Perioperative transfusion		Antimicrobial prophylaxis
Preoperative nares colonization with *Staphylococcus aureus*		Preoperative antiseptic showering
	Intra-operative issues	Operating room environment
		Surgical attire and drapes
		Asepsis and surgical technique
	Postoperative issues	Incision care
		Discharge planning

2.9 SSI Risk Indices

SSI risk indices are different systems developed to stratify and predict SSI (Soleto *et al.*, 2003). Surgical wound classification was the only variable used to predict SSIs. Previous studies conducted Center for Disease Prevention and Control on SSI risk indices generated two systems which are currently used as landmark in prediction of SSI. The systems include, Study on the Efficacy of Nosocomial Infection Control study (SENIC) and the National Nosocomial Infections Surveillance (NNIS). These systems came up with predictor variables into which

Surgical Sites Infection (SSI) can be predicted. The ideal risk index is a simple additive scale that is calculated at the end of surgery and used to predict the patients who are at a high risk of SSIs (Roy *et al.,* 1997). Patients who do not meet any of these criteria are not expected to be at risk for getting wound infections (Anvikar *et al.*, 1999; Mangram *et al.*, 1999; Roy *et al*, 1997; Smyth *et al* 2000; Soleto *et al.*, 2003).

2.9.1 American Society of Anesthetists (ASA) Scores

In 1963, American Society of Anesthesiologists (ASA) adopted a five category physical status classification system for assessing a patient before surgery. A sixth category was later added. If the surgery is an emergency, the physical status score is followed by “E” (for emergency) for example “3E”. Category 5 is always an emergency so should not be written without "E" (Horan *et al.,* 1992).

Table 2.2: Variables for ASA scores

ASA Score	Variables
1	A normal healthy patient.
2	A patient with mild systemic disease.
3	A patient with severe systemic disease.
4	A patient with severe systemic disease that is a constant threat to life.
5	A moribund patient who is not expected to survive without the operation.
6	A declared brain-dead patient whose organs are being removed for donor purposes.

2.10 Global SSI Problem

Surgical site infection still remains a major concern globally among health care practitioners not only in terms of increased trauma to the patient but also in view of it's burden on financial resources and the increasing requirement for cost-effective management within the health care system as documented by Alexander, (1994). Several attempts to understand the prevailing burden of the SSI has evolved with time in different regions globally.

In USA, a surveillance study done by Gaynes *et al.,* (2001), showed that of 738,398 NNIS operative procedures performed during January 1992 through June 1998, 19,267 subsequent SSIs (about 2.6%), as was reported from 225 NNIS hospitals. Despite relative low incidence of SSI as revealed by Gaynes study findings, the occurrence of sepsis post surgery is a public health concern among the patients undergoing through the procedure. Therefore preventive measures are necessary to curb the situation.

Brown *et al.* (2007) in a prospective, multicenter, observational cohort study, in seven surgical departments at 3 urban academic hospitals in St. Petersburg, Russian Federation, assessed the risk-adjusted incidence and predictors of surgical site infections (SSIs) and found out that 138 patients out of 1,453 (9.5%) developed SSI, with male sex (1.54), ASA classifications of 3 or 4, longer duration of surgery, and wound classes of 3 or 4 were associated with increased SSI risk in

multivariate analysis. Endoscopic surgery was associated with a lower risk of SSI. Antibiotic prophylaxis was used in 0%-33% of operations, and 69% of uninfected patients received antibiotics after the operation.

The Russian study still reveals clearly that SSI is a public health problem and further documents on some of the predisposing factors to the development of SSI. This called for improved knowledge on the subject, to assist understands the problem and devise strategies and measures to reduce if not eradicate SSI problem.

Mitchell *et al.* (1999) did a study to evaluate two methods of post-discharge surgical wound surveillance and to compare the incidence and outcomes of wound infections that develop prior to patients' discharge with those that develop after hospital discharge. One thousand, three hundred and sixty (1360) inpatients that underwent major elective surgery in an 800-bed teaching hospital in Australia, Western Sydney between 1996 and 1997 were followed prospectively.

Overall, 138 wound infections were diagnosed (incidence 10.1%), of which less than one-third (44) were diagnosed before discharge (average 10.4 days postoperatively) and the remainder (94) after discharge (average 20.6 days postoperatively). Seven hundred and eighty-two (57.5%) post-discharge survey forms were returned by patients and 680 (50.0%) by surgeons (Mitchell *et al.*, 1999).

Findings of this Australian study indicates that every ten patients that undergo surgical procedure one get infected (SSI), although scanty information has been provided about the total surgery done in Australia but this indicates that SSI play a important role in terms morbidity and possibly mortality amongst this group (surgical patients).

A prospective study done between July 1998 and June 1999 in a general surgical ward of a public hospital in Santa Cruz, Bolivia with patient follow-up until the 30th postoperative day, aimed at estimating the frequency of and risk factors for surgical-site infections (SSIs), and to study the performance of the National Nosocomial Infections Surveillance (NNIS) System risk index in a developing country (Soleto *et al.*, 2003).

Follow-up was complete for 91.5% of 376 surgical procedures. The overall SSI rate was 12%. Thirty-four (75.6%) of the 45 SSIs were culture positive. A logistic regression model analysis asserts ASA score of more than 1; not-clean wound class (Clean contaminated, contaminated and dirty wound class), procedure duration of more than 1 hour, and drain as independent risk factors for SSI (Soleto *et al.*, 2003).

From Soleto's study findings in Bolivia, the problem of SSI is further complicated by other factors related to the patients themselves. This calls for better

understanding of SSI and the risk factors associated with wound infections, therefore, there is need to critical initiate studies in this direction.

A Prospective cohort study done at Cho Ray Hospital, Ho Chi Minh City, Vietnam, to determine the pathogens associated with surgical site infections (SSIs) and describe patterns of antimicrobial use and resistance in orthopedic and neurosurgical patients in a large university hospital in Vietnam found that of 702 surgical patients, 80 (11.4%) developed an SSI. The incidence of SSI among orthopedic patients was 15.2% (48 of 315), and among neurosurgical patients it was 8.3% (32 of 387) (Thu *et al.,* 2006).

Postoperative bacterial cultures of samples from the surgical sites were performed for 55 (68.8%) of the 80 patients with SSI; 68 wound swab specimens and 10 cerebrospinal fluid samples were cultured. Of these 78 cultures, 60 (76.9%) were positive for a pathogen, and 15 (25%) of those 60 cultures yielded multiple pathogens. The 3 most frequently isolated pathogens were *Pseudomonas aeruginosa* (29.5% of isolates), *Staphylococcus aureus* (11.5% of isolates), and *Escherichia coli* (10.3% of isolates). Ninety percent of *Staphylococcus aureus* isolates were Methicillin resistant, 91% of *Pseudomonas aeruginosa* isolates were Ceftazidime resistant, and 38% of *E. coli* isolates were Cefotaxime resistant (Thu *et al.,* 2006).

The Vietnamese study by Thu *et al.* (2006), gives the other part of SSI in terms of emergence antibiotic resistance amongst the pathogens implicated. Many of the infections and complications have been brought about by the current emergence of multi drug resistance pathogens. Therefore, need to have deeper understating of the current situation of the SSI problem in our setup is fundamental.

Petrosillo, *et al,* (2008), conducted a one prospective national multicenter surveillance study in the General and the Gynecological units of 48 Italian hospitals to asses the incidence of both in- hospital and post discharge SSI and associated risk factors. SSI occurred in 241 (5.2%) of 4,665 patients, of which 148 (61 .4%) occurred during in-hospital, and 93 (38.6%) during postdischarge period. Higher SSI incidence rates were observed in colon surgery (18.9%), gastric surgery (13.6%), and appendectomy (8.6%).

The risk factors associated with SSI, at multivariate analysis were found to be emergency interventions; NNIS risk score, preoperative hospital stay, and uses of drains. Moreover, risk factors for total SSI were also associated to in-hospital SSI. Additionally, only NNIS, pre-operative hospital stay, use of drains, and antibiotic prophylaxis were associated with postdischarge SSI.

Italian analysis of the SSI incidence reveals that some of the risk factors associated with sepsis after surgery if addressed can further assist scale down the rate

occurrence of SSI among the surgical patients. Global trends of SSI occurrences clearly show that, some tangible efforts to look into the problem could bring solution to the SSI problem.

2.11 SSI Problem in Africa

Despite the difference in regions, the epidemiology of SSI and implicated bacteria seem not be very different except in the prevalence rates and this could be attributed to different factors like the resources, facility setups, population dynamics etc.

Oguntibeju and Nwobu, (2004) at Lagos University Teaching Hospital, Idi-Araba, Lagos, Nigeria conducted a study to determine the prevalence of *Pseudomonas aeruginosa* in Post-Operative Wound Infection, found out that out of the 60 bacterial isolates found in post-operative wound infection, 20 (33.3%) were *Pseudomonas aeruginosa*, followed by *Staphylococcus aureus* 13 (21.7%), *Klebsiella* species 10 (16.7%), *Escherichia coli* 7 (11.7%), Atypical coliform 4 (6.7%), *Proteus* species 4 (6.7%), *Streptococcus pyogenes* 1 (1.7%) and *Enterococcus faecalis* 1 (1.7%) in that order.

A prospective study carried out at the National Orthopedics Hospital, Lagos, Nigeria, between August 1998 and July 2000 by Onche and adedeji. Two hundred and fifty-four patients who had Open reduction and internal fixation (ORIF) with

implants and prosthesis were recruited in the study and followed-up for twelve weeks. Aerobic and anaerobic cultures were carried out on each specimen (Onche and Adedeji, 2004).

Two hundred and fifty-four patients were recruited and 19 had post-operative wound infection (Onche and Adedeji, 2004). The infection rate was 7.5%. Plates and screws were the commonest implant. Thirty-six bacterial isolates were recovered. *Staphylococcus aureus* was the commonest in 16 cases (44%), *Bacteroides fragilis* 4(11%), *Escherichia coli* 4(11%), *Proteus spp*. 4 (1l %). Others were *Pseudomonas spp, Klebsiella spp*. and *Peptostreptococcus*. Cephalosporins were found to be the most potent against *Staphylococcus aureus* while the anaerobes responded favorably to Flagyl (Metronidazole) (Onche and Adedeji, 2004).

In Tanzania, two surveillance studies on surgical site infection have been documented by Ussiri *et al.,* (2005); Fehr *et al.,* (2006).. One was done at Muhimbili National Hospital which set out to determine the prevalence of surgical wound infection and dehiscence and mortality following laparotomy for clean-contaminated and contaminated abdominal operations (Ussiri *et al.,* 2005).The study revealed that surgical wound infection was the commonest complication accounting for 15.6%. Other complications include mortality rate of 8.9% and wound dehiscence1.1%.

The other study was performed in the 82-bed department of general surgery conducted by Fehr *et al.*, (2006) included gynecology and obstetrics at St. Francis Designated District Hospital, a 371-bed hospital in Ifakara, Southern Tanzania between November 2003 and March 2004, all consecutive adult patients admitted for surgery were enrolled.

Six hundred thirteen (99.2%) of 618 eligible patients were included in the study. One hundred forty-four (23.5%) of the 613 patients developed an SSI, 55 (38.2%) of the patients had a superficial SSI, 67 (46.5%) had a deep SSI, and 22 (15.3%) had an organ/space SSI. Thirteen patients (2.1%) died, and 2 of these deaths were directly attributable to SSI. For 30 patients (21%), the SSI was identified after discharge from the hospital; 9 of these 30 were readmitted because of SSIs (Fehr *et al.*, 2006).

In Sudan, Abdalla *et al.*, (1998) carried out a study at Soba University Hospital, Khartoum, Four hundred and fourteen patients who underwent elective surgery during the study period were enrolled. Each of them had a nasal swab for *Staphylococcus aureus* taken on the first day of admission. After surgery, patients were monitored for 4 weeks for the development of SSI. In addition, 82 people on the surgical staff, which is a large majority of the people working in this

department, were screened for nasal *Staphylococcus aureus* carriage every 2 weeks during the same period (Abdalla *et al.*, 1998).

The 414 patients who underwent elective surgery, ninety eight patients (23.9%) had *Staphylococcus aureus*-positive nasal cultures preoperatively (Abdalla *et al.*, 1998). Fifty-seven patients (13.8%) developed SSI; in 24 (5.8%) *Staphylococcus aureus* was the primary pathogen. The incidence of SSI was not significantly different for nasal *S. aureus* carriers (6 of 98 patients; 6.0%) compared to non carriers (18 of 316 patients; 5.7%) (Abdalla *et al.*, 1998).

Kotisso *et al.*, (1998) carried a surveillance study of surgical wound infection at a teaching hospital in Gondar, northwest Ethiopia, where patients were prospectively followed up over a one year period revealed that, out of 129 abdominal surgical wounds from 129 patients, 50 (38.7%) yielded pathogenic organisms on culture. The wound infection rate was 21% on clinical grounds alone. Wound infection was significantly associated with class of wound; with the highest rate being 61.4% for contaminated or dirty wound. There was no difference in infection rate between emergency and elective operations (Kotisso *et al.*, 1998). *Staphylococcus aureus* and *Escherichia coli* were the leading etiological agents with rates of 28.8% and 27.1% of pathogenic isolates respectively. Surgical wound infection accounted for delays in the discharge in 14.7% of the patients (Kotisso *et al.*, 1998)

From the documented studies from the Africa continent, it is glaring that SSI is a public health concerned that urgently needs to be tackled with seriousness. It is also well understood that African countries still battle with other problems due to limited resources. Despite exhaustive understanding of SSI is necessary to address the problem adequately (Abdalla *et al.,* 1998; Fehr *et al.,* 2006; Kotisso *et al.*, 1998; Oguntibeju and Nwobu, 2004; (Onche and Adedeji, 2004; Ussiri *et al.*, 2005).

2.12 SSI Problem in Kenya

In Kenya, SSI surveillance studies are not adequately documented. The few studies documented included the one carried out in Central province (Colombo and Ferrari, 1990; Koigi-Kamau *et al.* 2005). Colombo and Ferrari letter to the editor of Tropical Doctor Journal published in England in1990 revealed that the 11% of 372 consecutive caesareans sections were complicated by infection at North Kinangop Hospital, Nyandarua District Hospital.

Koigi-Kamau *et al.* (2005) in prospective descriptive study carried out at Maternity unit of Kiambu District Hospital in Central Province of Kenya, among women undergoing caesarean delivery. During the study period in the hospital, found out that the overall post-caesarean wound infection rate was at 10%.

Infection Control Unit at AKUHN has been putting a lot of efforts to a prevent occurrence of hospital acquired infections over many years of its existence. Amongst the infections of concern has been surgical site infection. It has been very difficult to come up accurate information about the prevalence of SSI in the institution. The staff in charge of the Unit distributed questionnaires to the operating surgeons, and then surgeons filled the questionnaires and returned them to the unit. Near 50% were received back at the unit for analysis. From data extracted from the questionnaires it was reported that the rate of SSI was below 2% (data not published). No specific risk factor was pin pointed to be associated with SSI at the hospital.

Reports from the Microbiology section of The Aga Khan University Hospital indicated that several pathogens have been isolated from patients with history of post operative sepsis but no study had been done to associate the pathogens isolated with the patients from whom the samples were obtained. No concerted study had been conducted at the AKUHN before that clearly looks into the occurrence of SSI, pathogens involved in SSI, susceptibility patterns of the pathogens involved and risk factor that could be associated with the SSI occurrence if there are any.

CHAPTER THREE

3.1 MATERALS AND METHODS

3.2 Study Design

This was an observational prospective study carried out at Aga Khan University Hospital, Nairobi between March and December 2008, with patient follow-up until the 30th postoperative day.

3.3 Study site

The study was carried out at Aga Khan University Hospital-Nairobi (AKUH-N) in the Division of Microbiology, Department of Pathology, in collaboration with the Departments of Surgery, Infection Control and Nursing after the ethical committee of AKUH-N approved the study protocol. The hospital serves a wide range of patients from within and outside Kenya. It is one of the largest private, tertiary healthcare facilities in Kenya and receives referrals from all over the Eastern and Central African region. Besides being a health facility, AKUH-N is also a centre of learning and training for mid-career health personnel to highly specialized professionals. It has a bed capacity of 254. The hospital provides general medical services, specialist clinics and state of the art diagnostic services. A mean of 250 surgical interventions are performed per month in the 5 operating rooms (OR). Three OR are located in the Main Theatre and two in the Day care theatre.

3.4 Study population

Adult patients admitted for general surgical procedures were enrolled between March and December 2008 and 175 patients were recruited, he determination of the minimum sample size was determined using modified Fischer's formula for sample size determination, 10% prevalence was used from Koigi-Kamau *et al.* (2005) study carried out at Maternity unit of Kiambu District Hospital.

Where $\mathbf{N} \geq \{Z^2_{1-\alpha/2} \text{ x } P \text{ x } (1-P)\}/d^2$

Confidence interval at 95%

Incidence rate of 10%

Where, N= minimum sample size

Z= 1.96(2-tailed standard normal deviation set at 95% confidence interval)

P= 10% (0.1) incidence rate

d= 0.05 (5% level of significance).

The minimum sample size would be 139 patients

Because of follow up it will be modified by addition of 10% of the total.

This gives a minimum sample size of 154 patients.

3.5 Criteria for Inclusion of Subject

The patient who satisfied the following inclusions were recruited to participate in the study

- Patient admitted at the AKUH-N for general surgical procedure during the study period.
- Consented to participate in the study or whose guardians/parents consented and also assented to participate in the study.

- Patients who had not had another operation within 1 month before admission
- Patient who were 15 years and above.

3.6 Criteria for Exclusion of Subject

The following were excluded from the study

- Patients admitted to AKUH-N for reasons other than general surgical procedure
- Patients admitted for general surgery but who do not consent to participate in the study
- Patients who had another operation within 1 month before admission.
- Patient below 15 years.

The following surgical procedures were also excluded from the surveillance study:-

Procedures that are done in the wards and not necessarily taken to theatre e.g. episiotomy done in maternity delivery rooms were not included in the study. Diagnostic procedures performed in the operating theatre, e.g. biopsy, bronchoscopy, gastroscopy, aspiration, injection, or catheterization.

3.7 Sampling procedure

Consecutive patients admitted to the hospital for elective or emergency surgery during study period and were eligible according to the inclusion criteria were

recruited to the study. Preoperative and patient related factors, intraoperative and surgery related factors and postoperative and management related factors were recorded in detail on a structured questionnaire (See Appendix II and III) prepared according to the CDC guidelines (NNIS, 1996). Antibiotic prophylaxes were administered according to the institutional policy. Where only dirty and clean contaminated surgical wounds operations were covered with antibiotic prophylaxis, the antibiotics prophylaxis used were Cefuroxime and Ceftriaxone depending on the operating surgeon.

3.8 Ethical considerations

The study was approved by the ethics committee of Aga Khan University Hospital, Nairobi. Written informed consent and assent was obtained from every patient participating in the study (Appendix I).

3.9 Surveillance of SSI

The surgical sites were examined on the 2nd postoperative day and then daily for pain, redness, warmth, and swelling and purulent drainage. SSIs were diagnosed and defined by the surgeon according to the CDC definition (Mangram *et al.*, 1999). All patients' charts, including laboratory reports were reviewed six times a week. Post discharge examination of the surgical site was performed for all patients in the out patient clinic for any evidence of SSIs. For day care patients a phone call was made on the second day to ascertain the condition of the patient. Cases where infection was suspected the patient was requested to come to the

hospital for consultation with resident doctor in the department of surgery for SSI diagnosis and management.

To all patients, re-attendance clinics after seven days after discharge and other subsequent re-attendance at the consulting, breast clinics and casualty dressing clinic were used in the surveillance of SSIs. The surveillance was extended up to 30 days after surgery in order to detect SSIs that may have appeared after discharge.

3.10 Specimen Collection and Culture

Three types of specimens were collected namely:

1. Preoperative swabs from the carrier sites

   (Nasal cavity; Axilla region; Groin region; Perianal region)
2. Intraoperative swab from the incision site
3. Infected Surgical site, pus swab

Tip of sterile cotton swab (Aptaca) was moistened in sterile normal saline, the moistened tip was rolled on the carrier sites (both nasal, both axilla, both groins and perianal regions) 360^0 three times applying equal pressure in preoperative sampling. Intraoperative samples were collected by scrub nurse by rolling the sterile swab on the incision site before the surgeon stitched up the incision site. In cases of infection a pus swab was collected. The swabs were then transported to

the laboratory in Stuart's transport (Oxoid, Hampshire, England) medium well labeled for culture.

Culture was done using standard bacteriological procedures, on Blood agar (Oxoid, Hampshire, England), chocolate blood agar (Oxoid, Hampshire, England) and MacConkey agar (Oxoid, Hampshire, England). Cultures on chocolate blood agar were incubated at 35- 37^0C) in 5% Carbon dioxide (CO_2) (Sanyo MCO-20AIC CO_2 incubator), while blood agar and MacConkey agar were incubated at 35-37^0C in ambient air (Jouan IG 150 incubator) for 18 to 24 hours.

3.11 Identification of the Bacterial Isolates

3.11.1 Morphological Characteristics

Analysis of the colonies through their morphologies for colonies in terms of form, elevation, margins, opacity and Chromogenesis was performed.

3.11.1.1 Form

Basic shape of the colonies was analyzed, for example, circular, filamentous, irregular, rhizoid etc. Sizes (diameter) of the representative colony and tiny (punctiform) ones were noted. Texture/ consistency of the colonies were described as dry, moist, mucoid, brittle, viscous, butyrous (buttery).

3.11.1.2 Elevation

Cross sectional shape or side view of the colony was analyzed to aid in the identification i.e. flat, raised, convex, umbonate etc.

3.11.1.3 Margin

Magnified shape of the edge of the colony was observed i.e. undulate, entire, lobate, curled, filiform etc.

3.11.1.4 Surface

The surface of the colony appearance was observed i.e. Smooth, glistening, rough, dull (opposite of glistening), rugose (wrinkled), etc

3.11.1.5 Opacity

Colonies were observed, transparent (clear), opaque, translucent (almost clear, but distorted vision, like looking through frosted glass), iridescent (changing colors in reflected light), etc.

3.11.1.6 Chromogenesis

Colonies pigmentation were observed i.e. white, buff, red, purple, etc.

3.11.2 Gram Stain Morphology and Reaction

Gram stain was performed on distinct colonies, Gram stain morphology and reaction was used to categorize the isolates. The categories included;

- Gram positive cocci (GPC),
- Gram positive bacilli (GPB)
- Gram negative cocci (GNC)
- Gram negative bacilli (GNB).

Sequential identification was done as shown in the flow chats in Appendices VI, VII, VIII and IX

3.11.3 Biochemical Identification of the Bacterial isolates

3.11.3.1 Catalase test

Catalase test was performed only on Gram positive cocci. One distinct colony was emulsified in 3% Hydrogen peroxide on a clean glass slide using a sterile wooden stick. Active bubbling was interpreted as positive while no release of bubbles was negative. This test was performed to differentiate *Staphylococcus spp* from *Streptococcus spp* (Cheesebrough, 2000).

3.11.3.2 Oxidase test

Oxidase test was performed by smearing a colony of test organism on to moistened oxidase filter paper. Blue - purple color appearance on the paper within 10 seconds indicated oxidase positive and no color indicated negative test. The test was performed to identify bacteria that are capable of producing cytochrome C oxidases.

3.11.3.3 Bacitracin test

Bacitracin test was done by placing a Bacitracin disk (BD BBL, Bennex Ltd, County clare, USA 0.4units) on to the streak of the test organism done on 10% blood agar plate. Then the plate was incubated at 35-37^{0}C in 5% carbon dioxide overnight. Inhibition zone of $\geq$ 10 Millimeters was considered positive. Bacitracin

test performed to identify *S. pyogenes* and differentiate it from other β hemolytic *Streptococcus spp.* (Cheesebrough, 2000).

3.11.3.4 CAMP test

The test was performed by streaking a known *Staphylococcus aureus* across 10% sheep blood agar plate and then inoculated the test organism at right angle to it, without touching Staphylococcal inoculum. *Enterocccus spp* was inoculated as negative control. The plate was incubated overnight at 35-37^{0}C. Hemolysin shown by an arrow-head shape of hemolysis indicated positive test. The test was performed to identify *S. agalactiae* presumptively from other *Streptococcus spp.* (Cheesebrough, 2000).

3.11.3.5 Optochin test

Optochin test was done by placing an optochin disk (BD BBL, Bennex Ltd, County clare, USA 5.0 units) on to the streak of the test organism done on blood agar plate. Then the plate was incubated at 35-37^{0}C in 5% carbon dioxide overnight. Inhibition zone of ≥ 14 Millimeters was considered positive; this test was used to identify *S. pneumoniae* presumptively from other alpha hemolytic *Streptococcus spp.* (Cheesebrough, 2000).

3.11.3.6 Esculine test

Esculine test was performed by inoculating the test organism by stabbing it into the bile esculine agar medium (Oxoid, Hampshire, England) severally (approx 5 times); then incubated at 35-37^{0}C aerobically for 24 h. Positive test showed

diffused black precipitate, negative test showed no change, the test was performed to identify *Enterococcus spp.* (Cheesebrough, 2000).

3.11.3.7 Coagulase test

Coagulase test was performed only on Gram positive cocci which were also catalase positive. Two loopful of pure test organism was emulsified into 0.5 ml of dilute plasma in a test tube, mixed well and incubated at 35-37^{0}C for one to three hours, then examined the mixture in the tube for clots. If no clots appeared, further incubation was done overnight. Clotting indicated the presence of *Staphylococcus aureus*. No clots indicated presence of Coagulase Negative *Staphylococcus.* The test was set together with both positive control and negative controls. The test is used to differentiate *Staphylococcus aureus* from Coagulase Negative *Staphylococcus* (Cheesebrough, 2000).

3.11.3.8 Analytical Profile Index Testing (API 20E test and API 20NE)

API 20E is a standardized identification system for *Enterobacterieae* and other non fastidious, Gram negative bacilli which uses miniaturized biochemical tests and database. These tests were inoculated with a bacterial suspension onto the API 20 E strip which consist of 20 microtubes (capsules) containing dehydrated substrates and incubated at 37^{0}C aerobically for 24 hours. During incubation, metabolism produces color changes that are either spontaneous or revealed by the addition of reagents. The reactions were read according to the Reading Table and

the identification is obtained by referring to the Analytical Profile Index or identification software.

API 20NE is a standardized identification system for non fastidious, non enteric, Gram negative bacilli, combining 8 conventional tests, 12 assimilation tests and a database. API 20 NE strip which consist of 20 microtubes (capsules) containing dehydrated substrates are inoculated with bacterial suspension and incubated as in API 20E. During incubation, metabolism produces color changes that are either spontaneous or revealed by the addition of reagents. The reactions were read according to the Reading Table and the identification is obtained by referring to the Analytical Profile Index or identification software.

3.12 Antimicrobial susceptibility testing (Disk diffusion)

Antimicrobial susceptibility tests for the commonly available antimicrobials were carried out on SSI isolates suspected of nosocomial origin by Kirby Bauer disk diffusion technique (see appendix IV and V) (Lalitha *et al.*, 1997). Fresh colonies of the isolates were emulsified in peptone water to conform to 0.5 McFarland turbidity standards. A sterile cotton swab was dipped into the emulsified isolates, squeezed on the sides of the bottle or tubes to remove excess broth and the test organisms were spread uniformly onto Mueller Hinton Agar (Oxoid, Hampshire, England) plate using the sterile swab.

The plates were allowed to dry for 15 minutes and then antimicrobial disk placed aseptically using dispenser (Becton Dickson (BD), Germany). The plates were then incubated at 35-37^{0}C (Jouan IG 150) for 24 hours, the diameters of the inhibition zone of the tests and the controls were measured using a graduated ruler with millimeters (mm) measurement. Control organisms used in this test were *Escherichia Coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853 and *Staphylococcus aureus* ATCC 25923. Susceptibility results of the organisms were interpreted as sensitive or resistant according to Clinical and Laboratory Standards Institute manual (CLSI, 2008).

3.13 Data Storage and Statistical Analysis

The data collected were entered and kept in a research workbooks, computer Microsoft Word and Excel/Access software. Hard copies of data collection forms and consent forms were stored in files safely and privately. The data was organize, and managed using computer software EPI INFO version 3.4.3. Analysis was done using SPSS version 17.0. Descriptive statistics was used to show simple frequencies and means. Cross tabs and Chi squares were done to determine the relationship between the dependent and the independent variables, at 0.05 level of significance. The findings were presented in tables and pie charts.

3.14 Validity and reliability

Standard operating procedure (SOPs) for sample collection, transport, culture and susceptibility testing for isolated organisms were used to ensure quality of the

procedures. *Escherichia Coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, *Staphylococcus aureus* ATCC 25923 and *Enterococcus faecalis* ATCC 29212 were used as control organisms in the antimicrobial susceptibility testing (CLSI, 2008).

CHAPTER FOUR

4.1 RESULTS

4.1.1 Age Distribution and Gender of study subject

One hundred and seventy five (175) respondents were enrolled, 173 (98.9%), were followed to one month, two were lost during follow up. The respondents had a mean age of 38yrs, median age of 37yrs and modal age of 45yrs. One hundred and twenty three were females (70.3%) and fifty two males (29.7%).

4.1.2 Incidence Rates of Surgical Site Infections

The Cumulative occurrence rate (all cases) amongst the respondents was 13.1% (23); adjusted occurrence rate was 6.8% (10) (Clean and Clean contaminated). Sepsis development due to surgery in this study was analyzed in various categories (Table 4.1). It was observed that, there were more infections in dirty wound 54.5% (14) than in clean wound 3.9% (5), the incidence rate among men 17.3% (9) was higher than their female counterparts 11.4% (14). It was noted that there were more thoracic surgical infections 12.1% (7); more infections were also observed among African Kenyan urban population (17) than Asian Kenya urban population (3) and African Kenyan rural population (3). It was also noted that the incidence rate of SSI increased with increasing deviation from normal Body Mass Index (BMI). More infections were noted with prolonged stay in the hospital before surgery. Patients of ASA grade score of 1, 13.7% (20) had more infection than in other ASA grade scores. Higher incidence rate of SSI among patients who

received antibiotic prophylaxis (intraoperative prophylaxis) 18% (9) than those who did receive 11.2% (14)

Table 4.1: Summary of selected incidence rates of Surgical Site Infection

Incidence rates of Surgical Site Infection

		Frequency	Incidence
Overall	Cumulative/ crude	23	13.1%
	Adjusted	10	6.8%
Wound class	Clean wound surgery	5	3.9%
	Clean contaminated wound surgery	5	23.8%
	Dirty wound surgery	13	54.5%
	Contaminated wound surgery	0	0%
Sex	Male	9	17.3%
	Female	14	11.4%
Race	African Immigrants	0	0%
	African Kenyan Rural	3	6.8%
	African Kenyan Urban	17	14.2%
	Asian Kenyan Urban	3	60%
	Others	0	0%
Operation Sites	Abdominal	4	8.5%
	Neck	2	10.0%
	Thorax	7	12.1%
	Head	0	0%
	Perineum	4	20.0%
	Upper Limbs	1	5.3%
	Lower Limbs	5	26.3%
BMI	<18.4	1	11.1%
	18.5-24.9	8	10.3%
	>25	14	15.9%
Preoperative operative stay	Less than a day	1	7.6%
	1 day	7	7.9%
	2 days	2	33.3%
	3 days	1	25%
	4 days	1	100%
	5 days	1	100%
	7 days	1	50%
	> 7days	9	25%
ASA Grade scores	1	20	13.7%
	2	3	11.5%
	3	0	0%
Invasive Device used in the procedure	None	3	11.1%
	E.T intubation	16	11.9%
	Urinary catheter, E.T intubation	3	25%
	Urinary catheter, Central vein line, E.T intubation	1	100%
Intraoperative Prophylaxis	No	14	11.2%
	Yes	9	18%

4.I.3 Risk Factors to development of SSI

This study grouped SSI risk factors into three main categories namely demographic related factors, preoperative factors and intraoperative factors. Chi squared analysis demonstrated that among the risk factors measured in this study only preoperative stay beyond 2 days (preoperative factor) and wound class above 2 (intraoperative factor) were associated with development of wound sepsis, Table 4.2

Table 4.2: Risk factors associated with SSI at AKUHN, among the patient who underwent general surgery.

Risk factors associated with SSI development

Risk factor	($p< 0.05$)
Preoperative stay over 2 days	0.002
Wound class IV	0.003

4.1.4 Bacterial Isolates

Three hundred and eighty nine isolates were obtained from respondents admitted for general surgical procedures. Three hundred and fifty three were isolated from the carrier sites, four isolates from intra operative sites and thirty two isolates from the pus swabs sampled from infected surgical sites. Coagulase negative *Staphylococcus* was the most prevalent isolate from the carrier sites; *Escherechia coli* was the most prevalent in intraoperative sites, whilst *Staphylococcus aureus* was the most prevalent isolate from infected surgical wounds.

Of the thirty two (32) bacteria species isolated from the infected surgical sites, seventeen isolates (52%) were Gram negative bacteria. *Staphylococcus aureus* 10 (30%) was the most prevalent causative agent of isolated from infected surgical sites, see Table 4.3

Table 4.3: Bacterial species isolated from the study subjects.

Organisms	**Nasal**	**Axilla**	**Groin**	**Perianal**	**Intra-operative**	**Post-operative**	**Total**	**%**
Coagulase negative *Staphylococcus*	94	62	20	0	1	5	**182**	**47**
E. coli	0	0	8	58	2	4	**72**	**19**
S. aureus	34	27	0	0	1	10	**72**	**19**
Klebsiella spp	1	0	2	10	0	3	**16**	**4**
Klyuvera spp	0	0	5	8	0	4	**17**	**4.1**
Citrobacter frendii	0	3	2	0	0	0	**5**	**1**
Enterococcus spp.	0	0	8	5	0	0	**13**	**3**
P. aeruginosa	0	0	1	0	0	4	**5**	**1**
Proteus	0	0	0	4	0	0	**4**	**1**
Acinetobacter spp	0	0	0	1	0	0	**1**	**0.3**
E. cloacae	0	0	0	0	0	1	**1**	**0.3**
Serratia marscence	0	0	0	0	0	1	**1**	**0.3**
Total	**129**	**92**	**46**	**86**	**4**	**32**	**389**	**100**

4.1.5 Antimicrobial Susceptibility Profiles of Pathogens Isolated from SSI

4.1.5.1 *Staphylococcus spp*

Vancomycin, Novobiocin and Netilmicin showed 100% susceptibility amongst other antimicrobial agents with varied sensitivity. One strain of S*taphylococcus aureus* and one strain of Coagulase negative *Staphylococcus* were resistant to Oxacillin disk. Table 4.3 shows complete range of antimicrobial susceptibility testing to *Staphylococcus spp*. isolated from infected surgical sites. The zone diameter was used to determine susceptibility of the bacteria to the available antibiotic in this profile. Break points used to categorize the susceptibility of the bacteria as susceptible (S) or resistant (R) to antibiotics was adopted from CLSI, 2008 manual, see Appendix V. Table 4.4 summaries information in Table 4.3 in percentage susceptibility.

Table 4.4: Antibiotic Susceptibility Testing to *Staphylococcus spp*

		Ampicillin		Doxycycline		Azithromycin		Augmentin		Cefuroxime		Ciprofloxacin		Chloramphenicol		Oxacillin		Novobiocin		Netilm
		(10µg/mL)		(30µg/mL)		(15µg/mL)		(30µg/mL)		(30µg/mL)		(5µg/mL)		(30µg/mL)		(1µg/mL)		(5µg/mL)		(30µg
rganism	Lab No	Zone (mm)	I	Zone (mm)	I	Zone (mm)	I	Zone (mm)	I	Zone (mm)	I	Zone (mm)	I	Zone (mm)	I	Zone (mm)	I	Zone (mm)	I	Zone (mm)
. *aureus*	*S4*	30	S	25	S	18	R	32	S	28	S	18	R	21	S	20	S	18	S	24
. *aureus*	*S14*	20	R	22	S	22	S	25	R	30	S	25	S	25	S	18	S	20	S	27
. *aureus*	*S15*	15	R	27	S	25	S	14	R	35	S	23	S	26	S	22	S	19	S	26
. *aureus*	*S26*	29	S	24	S	12	R	35	S	29	S	28	S	24	S	20	S	22	S	22
. *aureus*	*S28*	22	R	20	R	24	S	26	R	27	S	20	R	15	R	12	R	19	S	23
. *aureus*	*S67*	30	S	23	S	23	S	30	S	29	S	24	R	17	R	21	S	19	S	25
. *aureus*	*S78*	10	R	15	R	20	R	30	S	32	S	15	R	20	S	19	S	20	S	23
. *aureus*	*S91*	12	R	17	R	21	S	28	S	27	S	27	S	14	R	18	S	22	S	26
. *aureus*	*S122*	21	R	25	S	22	S	16	R	20	R	24	S	20	S	20	S	22	S	22
. *aureus*	*S171*	27	S	24	S	24	S	28	S	32	S	15	R	24	S	20	S	18	S	27
oagulase g. Staph.	*S16*	20	R	26	S	19	R	27	S	30	S	25	S	25	S	21	S	18	S	29

oagulase g. Staph.	*S52*	28	S	20	R	22	S	32	S	28	S	24	S	15	R	18	S	19	S	23
oagulase g. Staph.	*S88*	19	R	26	S	20	R	30	S	17	R	12	R	22	S	19	S	24	S	22
oagulase g. Staph.	*S91*	20	R	24	S	21	S	25	R	20	R	26	S	10	R	22	S	20	S	22
oagulase g. Staph.	*S123*	12	R	18	R	17	R	15	R	14	R	27	S	22	S	12	R	23	S	25

Table 4.5: Summary of antibiotic susceptibility testing to *Staphylococcus spp*

Antibiotic Tested	**% Susceptibility of *S. aureus***	**% Susceptibility of CN *Staphylococcus***
Ampicillin	**40**	**20**
Doxycycline	**60**	**40**
Azithromycin	**70**	**40**
Augmentin	**60**	**60**
Cefuroxime	**90**	**40**
Ciprofloxacin	**50**	**80**
Chloramphenicol	**80**	**60**
Oxacillin	**90**	**90**
Novobiocin	**100**	**100**
Netilmicin	**100**	**100**
Vancomycin	**100**	**100**

4.1.5.2 Gram Negative isolates (first line)

Cefuroxime, Ciprofloxacin and Chloramphenicol showed sensitivity of 50% and above in all the groups of pathogens in this cluster. Cotrimoxazole showed sensitivity of less than 33% against the groups of pathogens tested. Other antibiotics showed varied sensitivity these pathogens. Table 4.5 is a complete antimicrobial susceptibility testing to Gram negative bacteria; interpretation was as shown in Appendix V, Table 4.6 summarizes percentage susceptibility of the Gram negative bacteria to the tested antibiotics in this profile

Table 4.6: Antibiotics susceptibility testing for Gram negative bacteria (first line panel)

		CL (30µg/mL)		AMC (30µg/mL)		CXM (30µg/mL)		D (30µg/mL)		SXT (25µg/mL)		CIP (5µg/mL)		GM (10µg/mL)		CTX (30µg/mL)	
Organism	**Lab No**	**Zone (mm)**	**I**	**Zone (mm)**	**I**	**Zone (mm)**	**I**	**Zone (mm)**	**I**	**Zone (mm)**	**I**	**Zone (mm)**	**I**	**Zone (mm)**	**I**	**Zone (mm)**	**I**
Klyuvera spp.	*S13*	25	S	10	R	12	R	15	S	12	R	20	R	20	S	20	R
Klyuvera spp.	*S16*	30	S	15	R	22	S	12	R	10	R	36	S	22	S	30	S
Klyuvera spp.	*S52*	19	R	20	S	23	S	16	R	17	R	32	S	14	R	32	S
Klyuvera spp.	*S169*	22	S	12	S	20	S	14	R	18	R	30	S	19	S	20	R
E. coli	*S15*	28	S	12	R	16	R	10	R	20	R	30	S	17	R	22	R
E. coli	*S24*	15	R	20	S	17	R	12	R	25	S	12	R	16	R	32	S
E. coli	*S26*	27	S	14	R	26	S	26	S	13	R	31	S	20	S	29	S
E. coli	*S39*	18	R	15	R	22	S	10	R	6	R	16	R	28	S	34	S
Klebsiella spp.	*S13*	21	S	17	R	24	S	28	S	6	R	32	S	22	S	38	S
Klebsiella spp.	*S24*	13	R	19	S	20	S	11	R	26	S	30	S	15	R	20	R
Klebsiella spp.	*S123*	23	S	12	R	22	S	22	S	14	R	31	S	10	R	31	S
Enterobacter cloacae	*S139*	26	S	6	R	21	S	20	R	30	S	30	S	20	S	32	S
S. marcescens	*S35*	22	S	10	R	18	R	8	R	6	R	6	R	30	S	19	R

Key:

D	Doxycycline	**SXT**	Cotrimoxazole	**CIP**	Ciprofloxacin
GM	Gentamycin	**CTX**	Cefotaxime	**S**	Susceptible
I	Interpretation	**R**	Resistant	**C**	Chloramphenicol
AMC	Augmentin	**CXM**	Cefuroxime		

Table 4.7: Summary of susceptibility test for Gram Negative bacteria (first line panel)

Antibiotics	**% susceptibility of *Klyuvera spp.***	**% susceptibility of *E. coli***	**% susceptibility of *Klebsiella spp.***
Cotrimoxazole	**0**	**25**	**33**
Doxycycline	**25**	**25**	**67**
Augmentin	**50**	**25**	**33**
Cefotaxime	**50**	**75**	**33**
Chloramphenicol	**75**	**50**	**67**
Cefuroxime	**75**	**50**	**100**
Ciprofloxacin	**75**	**50**	**100**
Gentamycin	**75**	**50**	**33**

Enterobacter cloacae and *Serratia marcescens* were not included in the summary because of their less count isolated from the infected surgical sites.

4.1.5.3 *Pseudomonas aeruginosa* (Second line)

Amikacin and Ceftriaxone showed 75% susceptibility, Cefepeme, Ceftazidime, Gentamycin, Imipenem, and Piperacillin showed 50% susceptibility while Ciprofloxacin and Tazobactam showed 25% susceptibility. One of the strains was of *Pseudomonas aeruginosa* was resistant to all antimicrobial agents (MDR). Table 4.7 is a complete antimicrobial susceptibility testing to *Pseudomonas aeruginosa*; interpretation was as shown in Appendix V, Table 4.8 summarizes % susceptibility of the *Pseudomonas aeruginosa* to the tested antibiotics in this profile.

Table 4.8: Antibiotics susceptibility testing for *Pseudomonas aeruginosa*

	Organism	*P. aeruginosa*		*P. aeruginosa*		*P. aeruginosa*		*P. aeruginosa*	
	lab No.	S35		S54		S39		S169	
Antibiotics		**Zone (mm)**	**I**	**Zone (mm)**	**I**	**Zone (mm)**	**I**	**Zone (mm)**	**I**
Imipenem	(10µg/mL)	26	S	14	R	12	R	22	S
Tazobactam	(100µg/mL)	12	R	18	R	24	S	10	R
Ceftriaxone	(30µg/mL)	25	S	12	R	26	S	24	S
Piperacillin	(10µg/mL)	24	S	6	R	10	R	25	S
Amikacin	(30µg/mL)	24	S	10	R	19	S	20	S
Cefepeme	(30µg/mL)	28	S	6	R	12	R	25	S
Ciprofloxacin	(5µg/mL)	30	S	8	R	10	R	12	R
Ceftazidime	(30µg/mL)	26	S	6	R	22	S	24	S
Gentamicin	(10µg/mL)	22	S	6	R	17	S	19	S

Key

I Interpretation: '**R'** Resistant: ' **S'** Susceptible

Table 4.9: Summary Antibiotics susceptibility testing for *Pseudomonas aeruginosa*

Antibiotics	**% Susceptibility of *P. aeruginosa***
Ciprofloxacin	**25**
Tazobactam	**25**
Cefepeme	**50**
Ceftazidime	**50**
Gentamycin	**50**
Imipenem	**50**
Piperacillin	**50**
Ceftriaxone	**75**

CHAPTER FIVE

5.1 DISCUSSION

5.1.1 Incidence Rate of SSI

The current study observed that the incidence rate of SSI at The Aga Khan University Hospital was 6.80%. Earlier reported rates of SSI at this institution by the Infection Control Unit (not published), indicated that the incidence rate of SSI was below 2% (internal audit report). The Unit sent out SSI surveillance forms to the operating surgeons to be filled and returned to the unit. Less than 60% of the forms were returned and from this an incidence rate of less than 2% was deduced, the difference in incidence rate in the two reports may have occurred due to poor follow up of the patients and biased judgment by the surgeons when submitting their reports back to the unit. In this study biased judgment of the surgeon was eliminated by consultative discussion of all SSI cases by the Consultant surgeon, operating surgeon, the resident surgeon doctor and the investigator.

The findings of this study on SSI incidence rate are comparable to other findings of other studies; Petrosillo *et al.* 2008, reported the SSI incidence rate of 5.2% in Italy. A Nigerian study on SSI surveillance at the National Orthopedics Hospital by Onche and Adedeji, (2004) Lagos reported a 7.5% incidence rate.

These findings on SSI incidence were noted to be relatively lower compared to other studies; Brown *et al.* (2007) reported a 9.5% incidence rate in 3 urban

academic hospitals in St. Petersburg, Russian Federation. Mitchell *et al*. 1999 in Australia reported 10% incidence rate. Soleto *et al.* 2003 in Santa Cruz, Bolivia, got an incidence rate of 12%. In Sudan at Soba University Hospital, Khartoum, Abdalla *et al.* 1998 reported 13.80% SSI incidence rate. Ussiri *et al.* 2005, at Muhimbili National Hospital, Tanzania, documented incidence rate of SSI of 15.6%.

Some of the documented studies in Kenya, reported SSI incidence rate at North Kinangop Hospital, Nyandarua District Hospital at 11%, as revealed in Colombo and Ferrari's letter to the editor of the Journal of Tropical Doctor in 1990. Koigi-Kamau *et al.* 2005 reported 10% incidence rate of SSI occurrence at Maternity unit of Kiambu District Hospital in Central Province of Kenya, among women undergoing caesarean delivery.

The relative lower incidence rate of SSI observed at AKUH-N compared to other studies done Kenya may have been for the reason of the stringent protocols in the way cases of nosocomial infection are handled in the hospital. These measures that may have contributed to lower incidence may include:

- The hospital has functional Infection control Unit which is always on alert for any eventful occurrence of Nosocomial infection which has been in place in the institution for several years.

- AKUH-N has a well established and managed central sterilization supplies department with clearly outlined policies on sterilization, distribution and management of theatre supplies and waste.
- The hospital commands highly trained surgeons and other theatre users that consume the theatre services.
- The Department of Surgery in AKUH-N has clear policies on surgical patient management in terms of antibiotic prophylaxis and management.
- The housekeeping Department in the hospital maintains and adheres to high standards of hygiene.
- The Pathology Department (Microbiology Section) maintains high standards of laboratory services that have been able to predict possible outbreaks of the Nosocomial infections.

Above all, the class of clientele that are able to access and afford the surgical services at this institution are above average in terms of economic status.

Variable occurrence rates were observed in different groups in this study. Incidence rate among females was observed to be lower in than males. From this study it was very difficult to establish the reason for the variation, although this observation was also reported from a Russian study (Brown *et al.*, 2007). Perhaps the cause of high incidence rate amongst men could be as it has always been speculated that men do not keep high standards of hygiene.

It was observed in this study that the SSI rate was higher in dirty wounds class than in any other class, these findings showed that the dirtier the wound was, the higher the chances of infection, this finding agrees with other finding from other studies (Cruse *et al,* 1980; Culver *et al.,* 1991; Haley *et al.,* 1985; Olson *et al.,* 1984). Several studies found a moderate correlation between the wound class and the SSI rate (Cruse *et al,* 1980; Culver *et al.,* 1991; Haley *et al.,* 1985; Olson *et al.,* 1984). The higher incidence rate in dirty wounds is because of the obvious reason that the wounds were already infected before the procedure.

In the study, it was noted that a higher frequency of SSI occurred in the African Kenyan Urban group, than in other groups under study. This may be because of the accessibility and affordability of the services offered at the facility to this set of population. Since this group represents the majority of the patients in this hospital it could be the reason for the high frequency. Other noted finding was Asian Kenyan urban population SSI occurrence rate, whose incidence rate was higher than all other groups in this study. Since the Asian Kenyan Urban population can equally access and afford the services as the African Kenyan urban group, it is possible that the higher incidence rate may have been attributed to the lifestyle, culture and possibly belief like the in breeding in the Caucasians group.

5.1.2 Risk Factors associated with SSI Development

This study found out that, only wound class IV and preoperative stay ≥2 days were the risk factors associated with SSI at the Aga Khan University hospital.

Different studies in the world have associated SSIs to different risk factors in varied settings. At St. Francis Designated District Hospital, Ifakara, Tanzania, Fehr *et al.*, (2006) reported several risk factors for the SSI that occurred during the study period. These Factors included ASA score of 2 or higher, duration of surgery greater than 75th percentile of the duration for the relevant type surgical procedure, type of intervention, and wound class. The Russian study by Brown, *et al.*, (2007) reported that emergency operation, male sex, ASA classification greater than 2, wound class greater than 2 and excessive operation duration were significant predictors of SSI. In Bolivia, Santa Cruz in 2003 it was reported that ASA scores, wound class, Procedure duration and presence of drains were significantly associated with SSI (Brown, *et al.*, 2007; Fehr *et al.*, 2006; Soleto *et al.*, 2003). The above findings from different studies and settings show wound class as a common risk factor associated with SSI which is similar to the findings of this study.

Prolonged preoperative hospital stay is frequently suggested as a patient characteristic associated with increased SSI risk. However, length of preoperative stay is likely a surrogate for severity of illness and co-morbid conditions requiring inpatient work up and/or therapy before operation (Conte, 2002).

5.1.3 Bacterial Isolates from the SSI

This study found out that the pathogens that were involved in SSI at the Aga Khan University Hospital Nairobi included *S. aureus* (30%), *Coagulase negative*

Staphylococcus (16%), Pseudomonas aeruginosa (13%), Klyuvera spp. (13%), E. coli (13%), *Klebsiella pneumoniae* (9%), *Serratia marcescens* (3 %) and *Enterobacter cloacae* (3%).

A report (Internal audit Report) from Aga Khan University Hospital Nairobi, Microbiology section agrees with the findings of this study in that the most prevalent pathogen isolated from the pus swabs from patients with post operative history is *Staphylococcus aureus.*

Other surveillance studies are in harmony with the findings of this study as per the distribution of the organism isolated from SSI. Onche and Adedeji (2004) in Nigeria at the National Orthopedics Hospital, Lagos reported *S.aureus* (44%) from infected surgical site among other pathogens recovered in that study. A Tanzanian study conducted by Ussiri *et al.* (2001) at Muhimbili hospital agrees with the findings of this study. It reported *Staphylococcus aureus* (36.1%) as the most prevalent pathogen amongst others. Similar findings were reported in Sudan and Ethiopia (Abdalla *et al., 1998;* Kotisso *et al.,* 1998).

Contrary to the finding of this study, other studies done in Nigeria and Vietnam have reported *Pseudomonas aeruginosa* as the most prevalent pathogen recovered from SSI among microorganisms (Oguntibeju and Nwobu, 2004; Thu *et al.,* 2006).

Both studies *Pseudomonas aeruginosa* was reported as the most prevalent pathogen causing sepsis post surgery followed closely by *Staphylococcus aureus.*

The high prevalence of *Staphylococcus aureus* in SSI may be attributed to the skin and nasal carriage of the organism by the patients themselves and contaminating the surgical wounds. The same organism (*Staphylococcus aureus)* could be transmitted by the medical personnel during the procedure or dressing post surgery as had been report by Abdalla *et al*., (1998).

5.1.3 Antimicrobial Susceptibility Profiles

Antimicrobial susceptibility testing was divided into three main categories. Each category had different cluster of antimicrobial agents tested against particular group of bacteria. For this study the categories were as follows: *Staphylococcus spp.* antimicrobial susceptibility testing; Gram negative isolates antimicrobial Susceptibility Testing (First line) and *Pseudomonas aeruginosa* antimicrobial Susceptibility Testing (Second line).

5.1.3.1 *Staphylococcus spp.* Antimicrobial Susceptibility Testing

Susceptibility patterns for *Staphylococcus aureus* and Coagulase Negative *Staphylococcus* were comparable in certain particular antimicrobial agents. Vancomycin, Netilmicin and Novobiocin were 100% sensitive. Ampicillin was less 50% sensitive to the two groups of pathogens. A strain of *Staphylococcus aureus* (ORSA) (10%) and Coagulase Negative *Staphylococcus* (20%) were

resistant to Oxacillin. The ORSA prevalence in this study is comparatively low compared to the Russian and Vietnamese studies (Brown *et al.,* 2007; Thu *et al.,* 2006). The low prevalence of ORSA from SSI pathogen in this study may be because of low prevalence of MRSA in the population in question.

5.1.3.2 Gram Negative Isolates Antimicrobial Susceptibility Testing (first line).

Organisms in this cluster showed a susceptibility of 50% and above to Cefuroxime, Ciprofloxacin and Chloramphenicol. To other antimicrobial agents, percentage susceptibilities were varied while Cotrimoxazole showed lowest susceptibility. The increased resistance of Cotrimoxazole in this cluster of pathogens could be for the reason of over use of the antibiotic on this population and the pathogens have devised methods in their folate metabolism, thus developing resistance against the drug.

5.1.3.3 *Pseudomonas aeruginosa* Antimicrobial Susceptibility Testing (second line)

One strain of *Pseudomonas aeruginosa* (S54) was resistant to all the antibiotics tested on this panel (multi drug resistant). Amikacin, Ceftriaxone, Cefepeme, Ceftazidime, Gentamicin, Imipenem and Piperacillin showed susceptibility of 50% and above while Tazobactam and Ciprofloxacin showed susceptibility below 50% to the *Pseudomonas aeruginosa* isolated from the SSI.

The basis for development of multi drug resistant state in the case of *Pseudomonas aeruginosa* (high intrinsic resistance of this organism) may be as a result of low outer-membrane permeability of these species, coupled with secondary resistance mechanisms such as an inducible cephalosporinase or antibiotic efflux pumps, which take advantage of low outer-membrane permeability acquired as result of previous exposure to the antibiotics.

Few studies have documented the sensitivity patterns of bacteria isolated from SSI; a Nigerian study reported Cephalosporins (Cefuroxime or Cephalexin) to be the most potent antimicrobial agents against *Staphylococcus aureus* (58.8% sensitive). Gram negative aerobic rods (*Pseudomonas, Escherichia coli*, *Proteus* and *Klebsiella spp.*) were found to be sensitive to Gentamicin while resistant to Cephalosporins (Onche *et al.*, 2004).

CONCLUSIONS

Based on the findings of this study the following conclusions were drawn:-

(i) The incidence of postoperative wound infections among the patients undergoing general surgery at AKUH-N following surgical procedures was 6.8%.

(ii) *S. aureus,* Coagulase negative *Staphylococcus, Pseudomonas aeruginosa, Klyuvera spp., E. coli, Klebsiella pneumoniae, Serratia marscence,* and *Enterobacter cloacae* were the pathogens associated to surgical wound sepsis in that order from highest to lowest. *S. aureus* was the most commonly isolated pathogen from SSIs from the patients undergoing general surgical procedure at AKUH-N.

(iii) Vancomycin was effective against resistant Gram positive bacteria. Amikacin, Cefuroxime and Ciprofloxacin were the potent antimicrobial agents against Gram negative bacteria isolated from infected wounds at AKUH-N.

(iv) Wound class IV and preoperative stay ≥2 days, were the risk factors associated with SSI at the AKUH-N.

RECOMMENDATIONS

(i) Aga Khan University Hospital, Nairobi Infection control Unit and Research Support to facilitate more studies, to establish transmission routes and high prevalence *S. aureus*.

(ii) Aga Khan University Hospital, Nairobi Departments of Surgery and Internal Medicine to withdraw Ampicillin and Cotrimoxazole in Management of patients with SSI

(iii) Aga Khan University Hospital, Nairobi Departments of Surgery to devise better and improved strategies to minimize prolonged preoperative hospital stay.

(iv) Aga Khan University Hospital, Nairobi Department of Surgery in collaboration with Department of pathology (Microbiology) to evaluate effective antibiotic prophylaxis to surgical patients with wound class IV

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APPENDICES

Appendix I: Consent form

Surveillance of Surgical Site Infection at the Aga Khan University Hospital Nairobi (AKUH-N)

I, Victor Dinda a Master student at the Jomo Kenyatta University of Agriculture and Technology (JKUAT), carrying out a study on surgical wound infection in collaboration with the AKUH-N departments of Surgery and Pathology. The aim of this study is to determine the pathogens associated with surgical site infections (SSIs) and their antimicrobial patterns at AKUH-N.

This study involves collection of samples before and after operation. The samples will be analyzed in the laboratory free of charge, and may be used by your doctor in your clinical management should any infections be detected.

When you agree to participate, we will collect swabs from your skin before operation and after the operation in case sepsis develop in the site of incision. You will also be expected to answer some questions that I will ask you and to give information about the condition of the operated site after discharge. There will be minimal discomfort during the collection of samples.

Participant

I ……(Name)……do voluntarily agree to take part in the above named study. The nature of the study has been explained to me and will involve filling in a standard questionnaire and having wound/skin swabs taken. While the results will remain the confidential property of the investigator, significant findings that may influence further management of any clinical condition detected will be made available to me.

My questions concerning this study have been answered by Victor Dinda.

I also understand that I am free to withdraw from the study at any time without giving a reason and without it affecting my normal care and management at the hospital.

Participant Name ……Signature…… Date……

Researcher:

Your signature certifies that you have explained the objectives and procedures for this study to the participant and that you have answered all the questions that the participant had about the study and that the participant has voluntarily agreed to take part in the research.

Signature: …… Date: ……

If you have any concerns or questions about this research study, please contact the investigator:

Mr. Victor Dinda
Department of Pathology, Microbiology Division AKUH N
Extension 2235
Phone: +254 720 893468
Email: vicuek2006@yahoo.com

Appendix II: Questionnaire

SURVEILLANCE OF SURGICAL SITE INFECTION IN AKUH

A) DEMOGRAPHIC DETAILS

1. Study patient No _____
2. Date _____
3. Name _____
4. Residence _____
5. Age _____
6. Registration No. _____
7. Address_____
8. Phone Number _____
9. Occupation _____
10. Weight(Kg) _____
11. Height(M)

12. Sex

Male	1	
Female	2	

13. What is the highest level of education completed?

None	1	
Primary	2	
Secondary	3	
Tertiary	4	

14. What is the BMI of the patient?

<18.4	1	
18.5-24.9	2	
>25	3	

15. What is the patients' diagnosis (es)?

1 _____

2 _____

16. State the operative procedure to be done:_____

17. State type of the admission

Emergency	1	
Elective	2	
Day care	1	
Private wing	2	
Ground floor	3	
First floor	4	
Second floor	5	
third floor	6	
Nursery	7	
Neonate	8	
HDU	9	
Renal	10	
ICU	11	
Children	12	
Pavilion	13	

B) PREOPERATIVE DATA

19. How long has the patient stayed in the ward before surgery?

1 day	1	
2 days	2	
3 days	3	
4 days	4	
5 days	5	
6 days	6	
7 days	7	
> 7 days	8	

20 How often do you smoke?

Always(2 or more cigars/week)	1	
seldom(<2 cigars/wk)	2	
None	3	

21. How often do you take alcohol?

Always (2 or more bottles/week)	1	
seldom (<2 bottles/wk)	2	
None	3	

22. Are you suffering from any of the following diseases?

a) Diabetes Mellitus

Yes	1	
No	2	
Don't Know	3	

b) Liver disease

Yes	1	
No	2	
Don't Know	3	

c) Chronic renal disease

Yes	1	
No	2	
Don't Know	3	

d) Cardiac disease

Yes	1	
No	2	
Don't Know	3	

e) HIV

Yes	1	
No	2	
Don't Know	3	

C) PREOPERATIVE PERIOD

23. Did the patient take bath before surgery?

Yes	1	
No	2	
Don't know	3	

24. If the response to question 23 above is yes, was it with antiseptic?

Yes	1	
No	2	
Don't know	3	

25. Was the site to be operated shaved?

Yes	1	
No	2	
Don't know	3	

26. If the response to question 26 above is yes how long before surgery?

<15 min	1	
16-30 min	2	
31-45 min	3	
46-60min	4	
>60 min	5	

27. Was the preoperative gut preparation done?

Yes	1	
No	2	
Don't know	3	

28. If the response to question 27 above is yes, how was it done?

Mechanical	1	
Antibiotic	2	
Both Mechanical & Antibiotic	3	
Others	4	

If others, specify: _____

D.) INTRAOPERATIVE PERIOD

29a. What is the number of the case on the O.T table for that day?

1	1	
2	2	
3	3	
4	4	
5	5	
6	6	
7	7	
8	8	
> 8	9	

29b. Which type is this surgical procedure?

Clean	1	
Clean contaminated	2	
Contaminated	3	
Dirty	4	
Don't know	5	

30a. What is the number of the surgery done on the table before this case?

1	1	
2	2	
3	3	
4	4	
5	5	
6	6	
7	7	
8	8	
>8	9	

30b. Which type surgical procedure preceded this case?

Clean	1	
Clean contaminated	2	
Contaminated	3	
Dirty	4	
Don't know	5	

31. Where was the operation site in this procedure?

Head	1	
Neck	2	
Thorax	3	
Abdomen	4	
Perineum	5	
Upper limbs	6	
Lower limbs	7	

32. What is the ASA grade of the procedure?

1	1	
2	2	
3	3	
4	4	
5	5	

33. State the names of the operation team involved with the procedure

Surgeon _____

Ass surgeon I _____

Ass surgeon II _____

Scrub Nurse _____

Anesthetist

34. Which antiseptic did the surgeon used for hand scrubbing?

Iodine	1	
Hibiscrub	2	
Iodo/hibscrub	3	
None	4	

35. Which antiseptic was used in patient skin preparation?

Betadine	1	
Hibt spirit	2	
Hibt H_2O	3	
HibtH_2O/spirit/Betadine	4	
Hibt H_2O /Betadine	5	
Hibt spirit/ Betadine	6	
Saline	7	
Water	8	

36. Did the patient receive blood transfusion during intraoperative period?

Yes	1	
No	2	
Don't know	3	

37. If the response to question 36 above is yes, how much?

1 unit	1	
2 unit	2	
3 unit	3	
>3 unit	4	

38. Any major intraoperative event that occurred during the procedure?

Hemorrhage	1	
Shock	2	
Major contamination	3	
Glover puncture	4	
None	5	
Others	6	

If others, specify: _____

39. Insertion devices used during this procedure?

Drains	1	
Mesh	2	
Implants	3	
None	4	
Others	5	

If others, specify: _____

40. Invasive devices used in the procedure?

Urinary catheter	1	
Central vein line	2	
arterial Line	3	
E.T intubation	4	
None	5	
Others	6	

If others, specify: _____

41. How long did the surgery last?

15 mins or less	1	
16-30 mins	2	
31-60 mins	3	
61-120mins	4	
> 120 mins	5	

E) POST OPERATIVE PERIOD

42. Which type of dressing is/was used on the surgical site?

Gauze	1	
Gauze& saline	2	
Gauze&povidine	3	
Open	4	
None	5	
Others	6	

If others, specify: _____

43. How frequent is the dressing done?

after 8hours	1	
After 12 hours	2	
After 24 hours	3	
After 48 hours	4	
Weekly	5	
None	6	
Others	7	

If others, specify: _____

F) POST OPERATIVE SEPSIS AND COMPLICATION

44a. Did the patient get wound sepsis?

Yes	1	
No	2	

44b. If the response to 44a. Above is yes, when did the sepsis appear after surgery

After 1 day	1	
After 2 day	2	
After 3 day	3	
After 4 day	4	
After 5 day	5	
After 6 day	6	
After 1 week	7	
After 2 week	8	
After 3 week	9	
After 4 week	10	

45. Other infection sites involved?

Effusions	1	
Septicemia	2	
Ventilator related pneumonia	3	
UTI	4	
Catheter related sepsis	5	
None	6	
Others	7	

If others, specify: _____

Appendix III: Post discharge follow up form

Surveillance Of Surgical Site Infection In Akuh
Post Discharge Follow Up Form

Study patient No.		Sex	
Name		Address	
Age		Phone No.	
IP No.		Date.	

1. What is the status of the wound?

			OFFICE USE	
Healthy	1			
Not Healthy	2			
Don't know	3		**1**	

2. How is the cardiac and other system?

Normal	1			
Abnormal	2			
Don't know	3		**2**	

3. How is the activity of the patient?

Normal	1			
Abnormal	2			
Don't know	3		**3**	

4. Is the patient on any medication(s)?

Yes	1			
No	2			
Don't know	3		**4**	

5. If the response in the question 4 above is yes, specify.....

6. Did the patient develop sepsis?

			OFFICEUSE	
Yes	1			
No	2			
Don't know	3		**6**	

7. Did the patient die due to sepsis following the surgery?

Yes	1			
No	2			
Don't know	3		**7**	

Appendix IV: Susceptibility Testing (Disc Diffusion)

a) Inoculum Preparation

The growth method is performed as follows

1. Five well-isolated colonies of the same morphological type were selected from an agar plate culture. The top of each colony is touched with a loop, and the growth is transferred into a tube containing 5 ml of peptone water.
2. The broth culture is incubated at 37^0C until it achieved or exceeds the turbidity of the 0.5 McFarland standards (usually 2 to 6 hours)
3. The turbidity of the actively growing broth culture was adjusted with sterile saline to obtain turbidity optically comparable to that of the 0.5 McFarland standards. (Lalitha *et al.*, 1997).

b) Inoculation of Test Plates

1. A sterile cotton swab was dipped into the adjusted suspension, the swab was rotated several times and pressed firmly on the inside wall of the tube above the fluid level. This removed excess inoculum from the swab.
2. The dried surface of a Müeller-Hinton/ agar plate was inoculated by streaking the swab over the entire sterile agar surface. This procedure was repeated by streaking two more times, rotating the plate approximately 60^0 each time to ensure an even distribution of inoculum. As a final step, the rim of the agar was swabbed.
3. The inoculated plate was left at room temperature for15 minutes, to allow for any excess surface moisture to be absorbed before applying the drug impregnated disks (Lalitha *et al.*, 1997).

c) Application of Discs to Inoculated Agar Plates

1. The predetermined battery of antimicrobial discs was dispensed onto the surface of the inoculated agar plate using disk dispenser.

2. The plates were inverted and placed in an incubator set to 37□C within 15 minutes after the discs are applied in the aerobic conditions (Lalitha *et al.*, 1997).

d) Reading Plates and Interpreting Results

1. After 24 hours of incubation, each plate was examined. The diameters of the zones of complete inhibition (as judged by the unaided eye) were measured, including the diameter of the disc. Zones were measured to the nearest whole millimeter, using graduated a ruler, held on the back of the inverted Petri plate. The Petri plate was held a few inches above a black, nonreflecting background and illuminated with reflected light (Lalitha *et al.*, 1997).

3. The sizes of the zones of inhibition were interpreted by referring to Zone Diameter Interpretative Standards and equivalent Minimum Inhibitory Concentration Breakpoints of the NCCLS M100-S18: Performance Standards for Antimicrobial Susceptibility Testing: Eighteenth Informational Supplement, and the organisms were reported as either susceptible or resistant to the agents that were tested (CLSI, 2008).

Appendix V: Antibiotic panels and Zonal Susceptibility Breakpoints

a) *Staphylococcus aureus* ATCC 25923 was used as control organism in this panel (CLSI, 2008)

Zone Diameter Interpretive Standards Breakpoints for *Staphylococcus spp* from Clinical samples			
Antibiotic	**Concentration (µg/ml)**	**Breakpoints/Zone (mm)**	
		S	**R**
Ampicillin	10	≥29	≤29
Doxycycline	30	≥16	≤16
Azithromycin	15	≥18	≤18
Augmentin	30	≥20	≤20
Cefuroxime	30	≥18	≤18
Ciprofloxacin	5	≥21	≤21
Chloramphenicol	30	≥18	≤18
Oxacillin	1	≥14	≤14
Novobiocin	5	≥17	≤17
Vancomycin	30	≥15	≤15
Netilmicin	30	≥22	≤22

b) Pseudomonas aeruginosa ATCC 49619 was used as control organism in this panel (CLSI, 2008).

Zone Diameter Interpretive Standards Breakpoints for *Pseudomonas aeruginosa* from Clinical samples			
Antibiotic	**Concentration (µg/ml)**	**Breakpoints/Zone (mm)**	
		S	**R**
Amikacin	30	≥17	≤17
Cefepime	30	≥18	≤18
Ciprofloxacin	5	≥21	≤21
Ceftazidime	30	≥18	≤18
Gentamicin	10	≥15	≤15
Imipenem	10	≥16	≤16
Piperacillin	10	≥18	≤18
Tazobactam	100	≥18	≤18
Ceftriaxone	30	≥21	≤21

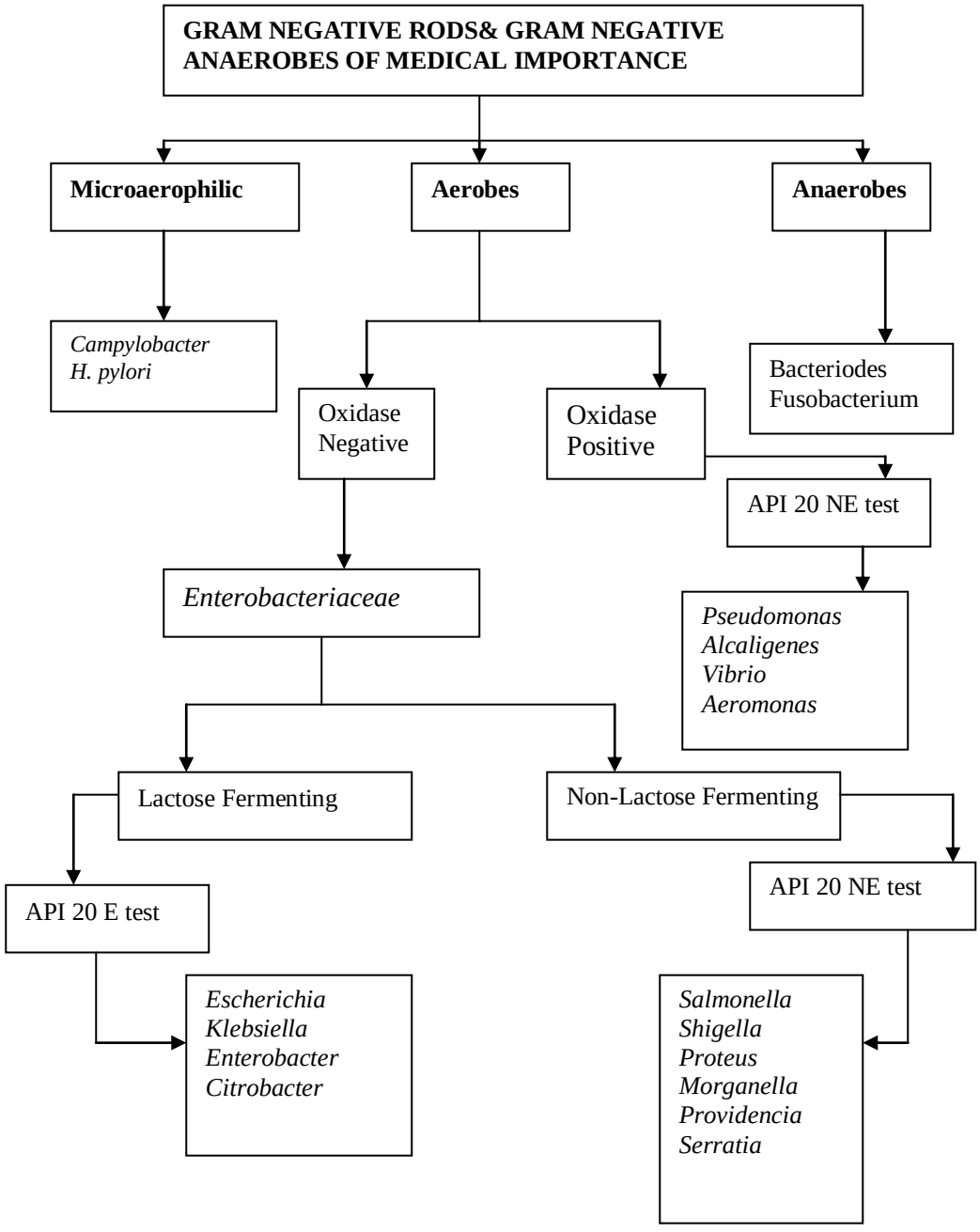
c) *Escherichia coli* ATCC 25922 was used as control organism in this panel

Zone Diameter Interpretive Standards Breakpoints for *Enterobacteriaceae* from Clinical samples			
		Breakpoints/Zone (mm)	
Antibiotic	**Conc. (µg/ml)**	**S**	**R**
Chloramphenicol	30	≥18	≤18
Augmentin	30	≥18	≤18
Cefuroxime	30	≥18	≤18
Doxycycline	30	≥14	<14
Cefotaxime	30	≥21	≤21
Cotrimoxazole	25	≥16	≤16
Ciprofloxacin	5	≥21	≤21
Gentamicin	10	≥15	≤15

(CLSI, 2008)

Appendix VI:

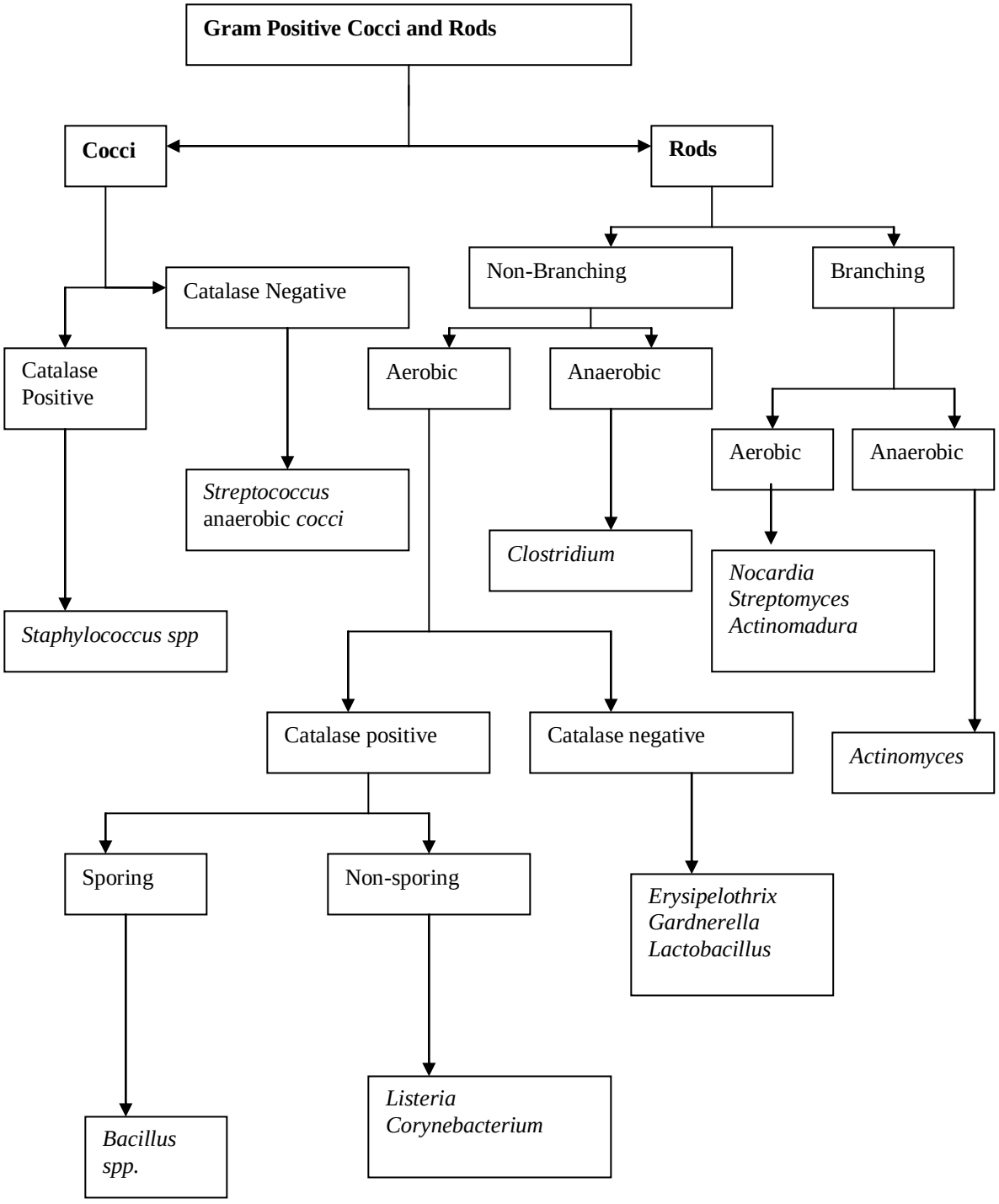
Gram Negative Rods & Gram Negative Anaerobes Identification



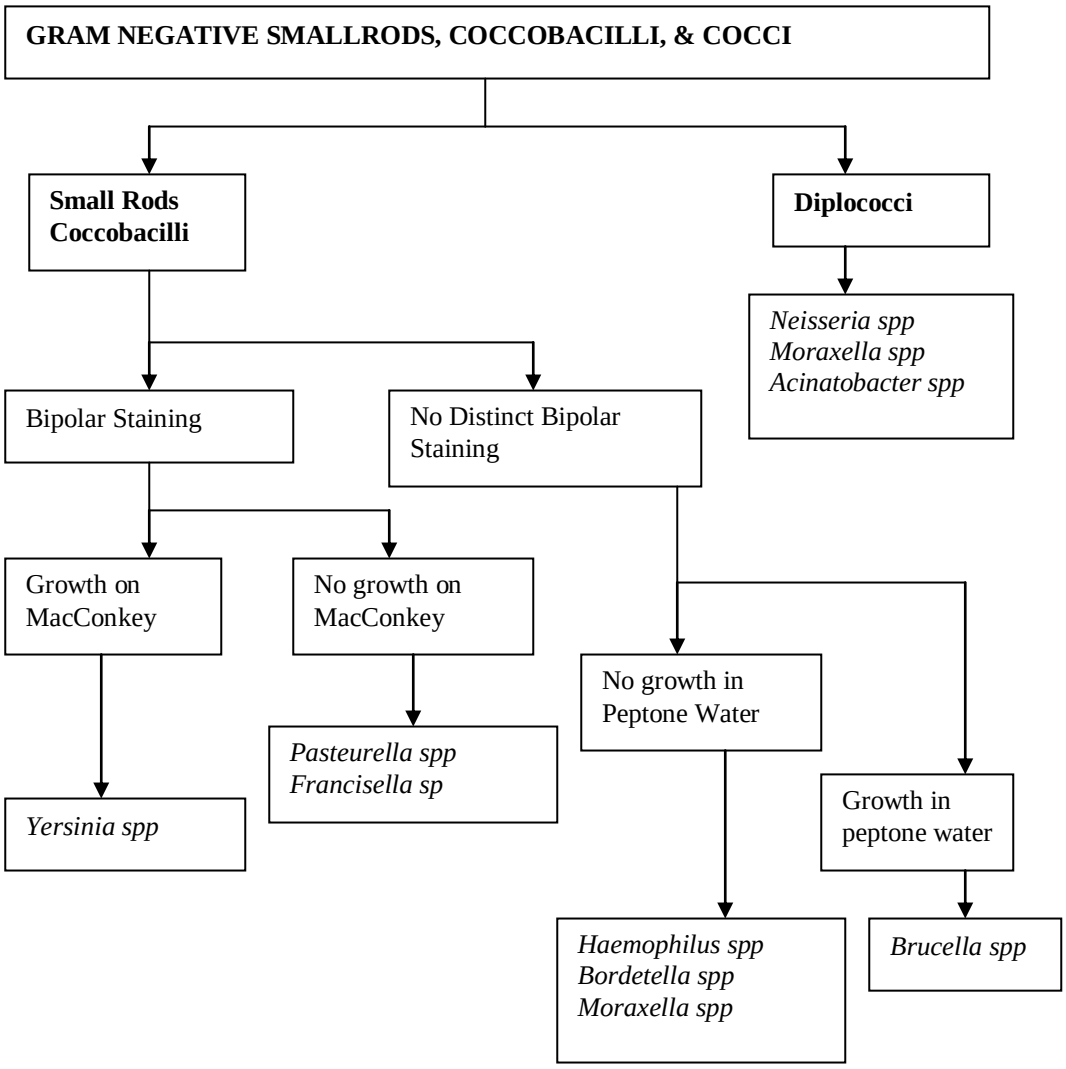
(Modified from Cheesbrough, 1984)

Appendix VII: Gram Positive Cocci and Rods identification

(Modified from Cheesbrough, 1984)

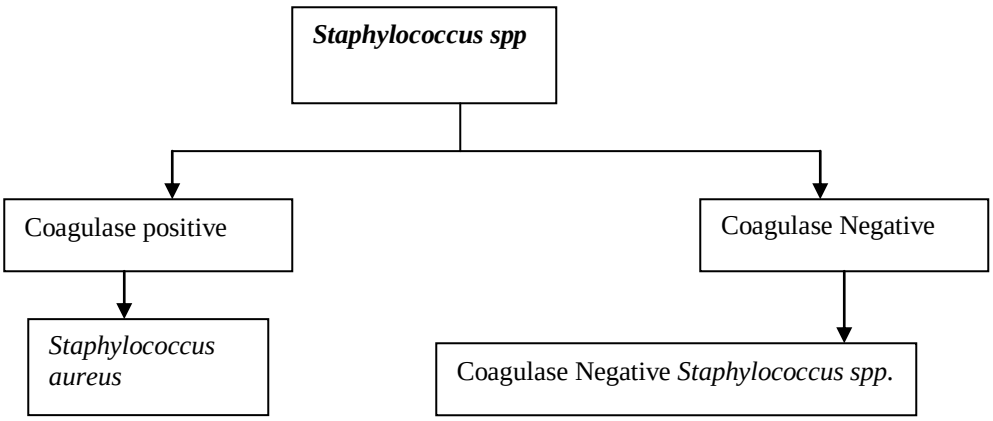


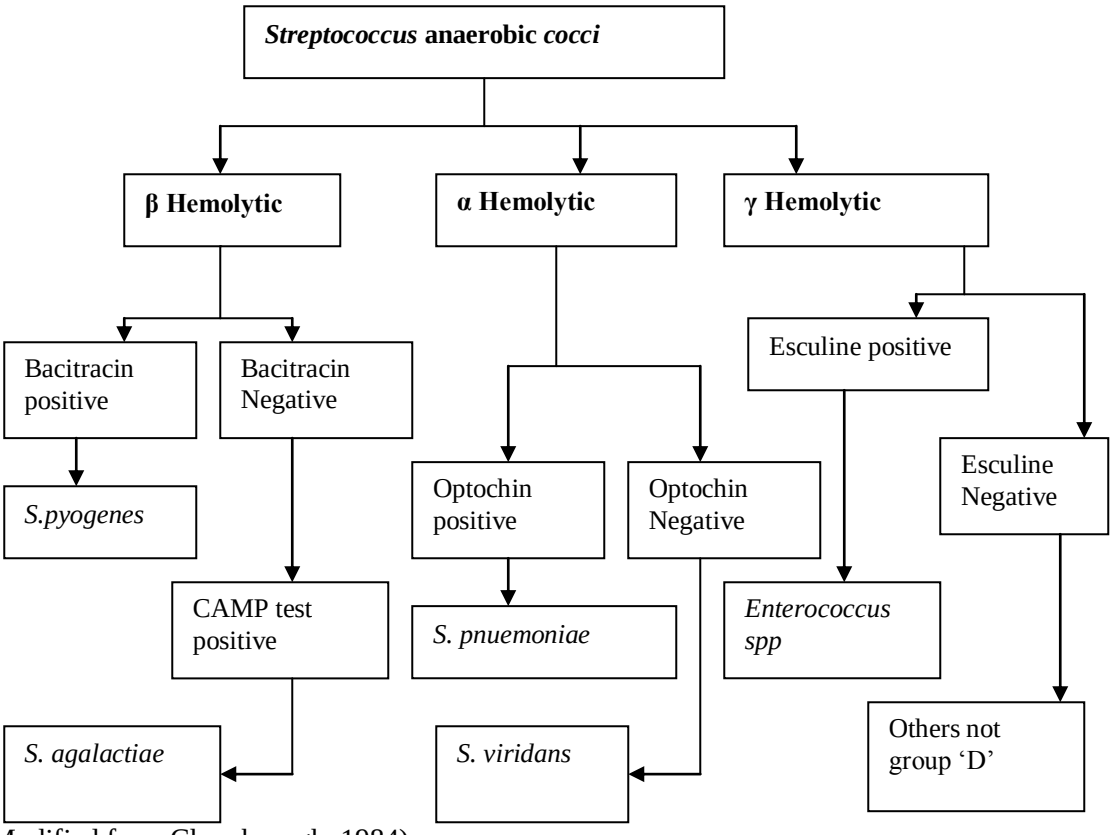
Appendix VIII: Gram Negative small Rods, Cocco-bacilli and Cocci identification



(Modified from Cheesbrough, 1984)

Appendix IX: *Staphylococcus* & *Streptococcus spp* identification





(Modified from Cheesbrough, 1984)