SURGICAL SITE INFECTION AT KILIMANJARO CHRISTIAN MEDICAL CENTER, TANZANIA

By

Hanne-Merete Eriksen

Thesis submitted to the International Health Department, University of Oslo
as a partial fulfillment of the requirement for Master of Philosophy degree

SUPERVISORS:

Egil Lingaas MD, PhD

In Tanzania: Professor Samuel Chugulu MD, PhD

ADVISOR:

Salum Kondo MD

COLLABORATING CENTRE:

Kilimanjaro Christian Medical Center, Tanzania

and Department of International Health

Institute of General Practice and Community Medicine,

Faculty of Medicine, University of Oslo

May 2001

List of contacts:

Hanne-M. Eriksen. Stenstrupsgt. 15, 0554 Oslo, Norway.

Egil Lingaas, Department of Infection Control, Rikshosptialet, NO-0027 Oslo, Norway.

Samuel Chugulu and Salum Kondo. Department of General Surgery (S1). Kilimanjaro Christian Medical Center, Moshi. Tanzania.

Common abbreviations used in this paper

ASA: American Society of Anesthesiologists physical status

CDC: Center for Disease Control and Prevention

KCMC: Kilimanjaro Christian Medical Center

NNIS: The National Nosocomial Infection Surveillance

SSI: Surgical site infections

SPSS: Statistical Package for Social Sciences

WHO: World Health Organization

Acknowledgements

I would like to thank many people and organizations for their invaluable assistance. First of all I would like to thank my supervisor Egil Lingaas for his supervision and friendly guidance. I also want to thank Professor Samuel Chugulu and Salum Kondo for their assistance and support during the data collection period. I also want to thank Professor Chugulu for help removing obstacles that our study met.

I want to thank Professor J. Shao, the director at KCMC, for permission to conduct this study. I also want to thank the rest of the administration for their commitment to this study. It has been a nice experience to cooperate with all the employers at KCMC. I also want to thank the administrators for making it possible to start the research on the scheduled day.

I then wish to express my gratitude to R.B.Tarnimo for analyzing all the swabs and for answering all my questions in the field of microbiology.

I am also very grateful for all the help and the valuable information provided by the staff in all the departments I was involved with. A special thank to all the nurses at the general surgical ward and the pediatric ward. I also want to thank them for making me feel welcome at KCMC.

I want to thank all the Tanzanians we met during our stay in Tanzania. They helped make our stay a wonderful and special experience for both me and my family.

Sincere thanks goes to Professor Espen Bjertnes and the everyone at the statistic consultant office at the University of Massachusetts, USA for their help and assistance in statistic and SPSS.

I wish to thank Ellen and Tom Hirschberg and Suraj Bahadur Thapa for proof reading my thesis and for their suggestions for changes.

This study was partially made possible by funding from the “EWS Stiftelsen” and “Lise og Arnifinn Hejes Fond”. I am grateful for their generosity.

Finally I want to thank my partner Tom Hirschberg and our two daughters Emma and Ovidia for being courageous and coming with me to Tanzania. Their support and company was invaluable.

Abstract

The title of this study is "Surgical site infections at Kilimanjaro Christian Medical Center, Tanzania". Hanne Eriksen conducted the study under supervision of Egil Lingaas, Salum Kondo and Samuel Chugulu. Support of this study was given by loans from "Statens lånekasse" and funding from EWS stiftelsen and "Lise og Arnifinn Hejes Fond".

An article from this study is being submitted to Journal of Hospital Infection Control.

The study received ethical clearance from the "Regional komite for medisinsk forskningsetikk, helse regionen Vest" and from the administration at Kilimanjaro Christian Medical Center (KCMC).

Background: Surgical site infections (SSI) are the most common infection among surgical patients. SSI causes patient morbidity and mortality. Local nosocomial infection surveillance and prevention programs are reported to be highly cost effective

Objectives: The main objective was to identify the incidence of SSI and its related risk factors. Other objectives were to identify the aetiological agents, their resistance pattern, and also to see if the rates of SSI would be influenced by feedback to the staff concerning both SSI rates found and observations concerning hygienic practices.

Design and settings: A five-month prospective surveillance study of SSI, an indicator of healthcare quality, was conducted at the department of general surgery at KCMC, Tanzania. The study started 20th of July 2000 and ended the 20th of December 2000. SSI were classified according to Centers for Disease Control (CDC) criteria and identified by active bedside surveillance and post discharge follow up.

Results: There were 396 operations on 388 patients included into this study. This study showed that 19.4% (77 patients) developed SSI. Twenty eight (36.4%) of these infections were apparent only after discharge from hospital. Another finding was that 87% of those who developed SSI had received antibiotic prophylaxis. Significant risk factors for developing SSI during hospital stay were: operations classified as contaminated or dirty, operations lasting for more than 50 minutes, and longer preoperative stays. The only risk factor significantly associated with the development of SSI after discharge was having undergone a clean-contaminated operation.

Staphylococcus aureus was the most frequently isolated microorganism, followed by *Escherichia coli* and *Klebsiella spp*. Most of the pathogens identified were multi-resistant, an exception being *S. Aureus* (54.5% of the isolates were sensitive to all the tested antibiotics).

Conclusion: This study has shown that the incidence of SSI and the prevalence of antibiotic resistance in this teaching and tertiary level care hospital is high. The risk factors were similar to those reported in countries with more resources. Infection prevention measures should be re-evaluated.

TABLE OF CONTENTS

Cover page
Table of contents
List of contacts
List of abbreviation
Acknowledgement
Abstract

1.0 INTRODUCTION 1
- 1.1 Tanzania and KCMC 4
- 1.2 Our study 5
  - 1.2.1 General objective 6
  - 1.2.2 Specific objective 6
  - 1.2.3 Research hypothesis 6

2.0 LITERATURE REVIEW 7
- 2.1 Surgical infection rate 7
- 2.2 Difference in methodology 8
- 2.3 Risk factors 9
  - 2.3.1 Risk indexes 9
  - 2.3.2 Preoperative stay 10
  - 2.3.3 Age 10
  - 2.3.4 NNIS codex 11
  - 2.3.5 Wound class 11
  - 2.3.6 ASA score 11
  - 2.3.7 Nutritional status and hemoglobin level 12
  - 2.3.8 HIV status 12
  - 2.3.9 Antibiotic prophylaxis 12
- 2.4 Pathogens and resistance patterns 13

3.0 REMAINING QUESTIONS 13
- 3.1 SSI rates 14
- 3.2 Risk factors 14
- 3.3 Pathogens 15

4.0 RATIONALE OF THE STUDY 15
5.0 RATIONALE FOR THE CHOICE OF METHOD 16
- 5.1 Choice of method 16
  - 5.1.1 Definition 16
  - 5.1.2 Variables 17

6.0 METHODOLOGY 17
- 6.1 Study design 17
  - 6.1.1 Definitions used 17
  - 6.1.2 Case and risk factors registration 25
  - 6.1.3 Case finding 26
  - 6.1.4 Collection of background information 26
  - 6.1.5 Method for specimen collection and analysis 26
  - 6.1.6 Statistical analysis 27

6.2 Ethical issues 28

7.0 RESULTS 28
7.1 The SSI rate at KCMC 29
7.2 The risk pattern at KCMC 29
7.3 Identified pathogens and its resistance pattern 30
7.4 Consequences of SSI at KCMC 31

8.0 DISCUSSION 35
8.1 The SSI rate 35
8.2 The SSI rate and host factors 36
8.2.1 The SSI rate and different procedures 36
8.3 The half time results 38
8.4 Risk factors 39
8.5 Pathogens and resistance 40

9.0 CRITICS OF THE USED METHOD 41
9.1 Loss to follow-up 42
9.2 Validation of the number of SSI detected 44
9.3 About the risk factors 46
9.4 Changes from the research protocol 46
9.5 Strengths and weaknesses of the study 47

10.0 CONCLUSION 48

11.0 LIST OF REFERENCES

12.0 APPENDIX
12.1 Data collection form
12.2 The article sent to "Journal of Hospital Infection"
12.3 NNIS operations categories
12.4 Map of Tanzania

1.0 INTRODUCTION

Nosocomial infections have been a problem as long as hospitals have existed. Before the mid-19th century, surgical patients commonly developed postoperative infections and sepsis. The first breakthrough in modern understanding of nosocomial infections came in 1861 when Ignaz Semmelweis (1818-1865) published his work.[1] His publication was based on his observation that the death rate from childbed fever among women in one of the obstetric wards, was two or three times as high as those in another. These wards were identical with the exception that medical students were taught in the first and midwives in the second. He put forward the thesis that medical students and doctors who came directly from the dissecting room to the maternity ward carried the infection from mothers who had died of the disease to healthy mothers. He ordered the students to wash their hands in a solution of chlorinated lime before each examination. Under these procedures, the mortality rates in the first ward dropped from 18.27 to 1.27 percent.[2]

Joseph Lister (1827-1912), is called the father of modern antisepsis. His principle was that bacteria must never gain entry to a surgical wound. In 1865 he demonstrated that phenol was an effective antiseptic to sterilize operating fields. With the use of phenol the mortality rate from surgical amputations fell from 45 to 15 percent.[3]

These two pioneers in modern infection prevention showed that with simple means the rate of surgical infections could be drastically reduced. Today these insights are still central to infection prevention.

The field of hospital infection prevention started to get more attention by the end of 1960's. The main focus was on the number and the nature of the microorganisms contaminating wounds and the nature of human microbial flora in disease states. This led to major advancement in the use of prophylaxis and therapeutic antibiotics in surgical patients. From the mid-1980s to the mid-1990s, the focus was on procedure-specific patient risk factors and how they influence the development of SSI. In recent studies the emphasis has been placed on identifying host-related factors in high-risk surgical patients.[4]

The growing attention and advancements in the field of hospital infection prevention has mainly taken place in countries with more resources. Many countries with fewer resources have ineffective hospital infection prevention programs, if they have any at all. While the SSI rates have decreased in countries with more resources, the relatively few studies conducted in countries with more limited health budgets identified higher rates. Extending noscomial infection surveillance and prevention efforts to countries that presently lack effective programs is therefore viewed as a challenge for the future.

There is little knowledge on the magnitude, consequences and the related risk factors of SSI in countries with fewer resources. In countries where there have been studies, the SSI rates frequently are reported higher than 10% (in USA it is estimated that the SSI rate is about 3%).[5] The infection rate in hospitals in Tanzania is not known. The economic impact of nosocomial infections in countries with fewer resources is far greater than in developed countries due to the larger number of infections and smaller health budgets.[6]

SSI causes longer hospital stays, more readmissions, greater patient morbidity and higher mortality rates. In Mexico surveys have ranked nosocomial infections as the third most common cause of death.[6] In a study from a hospital in Ethiopia it was estimated that each patient with postoperative infection did cost at least 100 US dollars extra and that 14 of 18 deaths among surgical patients were attributed to nosocomial infections.[7] In addition to the cost of longer hospital stays is the cost of antibiotic treatment.

Identified risk factors associated with SSI can be divided into those related to the patients and those linked to the operation.[1] Bacterial seeding of the wound with the patient's own flora is the most important source of intraoperative microbial contamination. Exogenous contamination of the wound during the operation also contributes to the occurrence of SSI, but to a lesser degree. Besides the contamination of the wound host factors such as age, nutritional status and reduced immune status influences SSI risk.

It is recommended that risk factors should be included in SSI surveillance.[1] Patient related risk factors for developing SSI are often beyond the control of the surgical team. Nevertheless it is important to identify these factors and be able to target high-risk patients who need specific preventive measures. Several studies conducted in countries with more resources have identified factors like wound class, old age and severity of underlying disease (evaluated by the American Society of Anesthesiologist (ASA) score) as risk factors for SSI. If and to what extent these factors are significant in countries with less resources are unknown.

Similar pathogen patterns have been identified in all countries regardless of size of the health budget. From 1990 to1996 the three most common gram-positive pathogens in the USA were; *Staphylococcus aureus, coagulase negative staphylococci* and *Enterococcus spp*. These accounted for 34% of the nosocomial infections. The four most common gram-negative pathogens were *Escherichia coli, Pseudomonas aeruginosa, Enterobacter spp.*, and *Klebsiella pneumonia* that accounted for 32% of the infections.[1] The most common organisms isolated from SSI in an international survey were; *S. aurus, E. coli* and *P. aeruginosa*.[8] A slightly different pathogen pattern was found in a study from Ethiopia. Approximately 90% of the pathogens were gram-negative, of which 84% were *Enterobacteriaceae*.[7]

Surveillance of SSI with feedback of appropriate data to surgeons has been shown to be an important component of strategies to reduce SSI risk.[9] Corresponding experience has been shown in countries with less resources. In Thailand the nosocomial infection rate decreased from 11.7% in 1988 to 7.3% in 1992, a reduction of 38%. One of the explanations given for this reduction was that all the hospitals included in the study had implemented infection control committees, infection control nurses and ongoing surveillance of nosocomial infection since 1988. This study provides persuasive evidence of the efficacy of these programs.[10]

Governments, external funding agencies and international health organizations are increasing pressure on hospitals to improve patient outcomes and reduce cost. To create an effective hospital infection prevention program, information about local patterns is essential. This type of data is useful both for individual hospitals and national health care planners in setting program priorities, monitoring effects of different preventive actions and in setting goals for their infection control efforts. Nosocomial infection surveillance and prevention programs are reported to be highly cost effective.[11]

In this thesis the knowledge (and the knowledge missing) regarding the variables in our study will be presented first. The rationale for choice of method will briefly be presented before the methodology. The result chapter includes only the results related to the objectives of this study and also the recordings of the frequency of hand washing. Observations of different hygienic activities will be presented in the discussion. Characteristics of those that did not attend the out patient clinic will also be presented there. Strength and weaknesses of the study will be discussed before the conclusion

1.1 Tanzania and KCMC

Tanzania is located on the eastern coast of Africa bordered by the Indian Ocean and lies between Kenya and Mozambique. In year 2000 the population was estimated as 35.3 million, with an 2.57% annual population growth, one of the highest in the world. The population is spread out on the about 945 000 square kilometers that Tanzania consists of.[12]

Tanzania is one of the poorest countries in the world. The economy is heavily dependent on agriculture, which accounts for half of the gross domestic product (GDP), provides 85% of export and employs 90% of the work force. The GDP purchasing power parity was in 1999 estimated as 23.3 billions American dollars (USD). The GDP per capita was 550 USD (compared with 267 328 Norwegian kroner per capita in Norway[13]). It was estimated in 1991 that 51.1% lived below the poverty line. Tanzania has an external debt of about 7.7 billion USD. A big part of Tanzania's budget is therefore allocated to debt service.[12]

The total national health expenditure in 1998 was 4.7% of the gross national budget. The annual health budget worked out to about 4 USD per person. In the rural areas the per capita spending is even less. About 37% of the health budget is devoted to local health care. It is estimated that there are about 22 900 people per physician (about 400 people per physician in Norway[13]), and there are about 1 123 people per hospital bed.[14] There are different levels of the official health system in Tanzania. Dispensaries are the first level and each dispensary serves about 6-10 000 people. Health Centers serves about 50- 80 000 people while districts hospitals cover about 250 000 people. The regional hospital serves as a referral center to the districts in its region.

KCMC is located right outside the town of Moshi, in the region of Kilimanjaro. Moshi has a population on 96 800 people. The majority of the population in Kilimanjaro are farmers (cultivating coffee and moving livestock herds). A large percentage of those living in Moshi survive on temporary jobs and various small businesses. Chagga, the largest ethnic group in Kilimanjaro, constitute one of the most educated and economically successful in Tanzania.[15]

Tanzania is one of the East African countries most severely affected by the HIV/AIDS epidemic, and the Kilimanjaro region has the third highest rate. The prevalence of HIV in 1998 among pregnant women in urban Moshi was reported to be 19.9%. This was the highest reported prevalence in the country.[16]
KCMC is the zonal referral hospital for the Northern Tanzania. The hospital was established by a mission organization in 1971. Today the governing body of KCMC is the Good Samaritan Foundation- a lutheran organisation. KCMC is the second-largest hospital in the country with a 500 beds capacity. It is one of four referral hospitals in the country. It is the only referral hospital within hundreds of miles. Patients come from throughout the region for consultation. The current in patients occupancy is 110%. The hospital services more than 500 outpatients each day.[17]

The department of general surgery consists of an intensive care unit, a main ward consisting of five patient rooms and a separate room for patients with burns. There is a separate section for pediatric cases in the pediatric ward. There are three surgical theatres allocated to general surgery. One of them was used only for operations classified as dirty.

The General Surgical department has a 35-bed capacity. The average number of patients during the research period was 41. Because of high demand several extra beds were put in the wards rooms. There was usually less than one meter between the beds. The number of patients per room varied. In the room allocated for patients who needed special medical attention it was three too four beds, while the other rooms are meant for about ten beds. The pediatric ward had 18 beds. One parent usually stayed at the hospital with the admitted child. They had to share the bed.

Most of the patient rooms at the surgical department have sinks. There were three sinks in the staff room. A soap bar (disinfecting soap) was available in the staff room. Towels are used for drying hands.

Several types of operations are performed at the General Surgery department. The most common ones are laparotomy, colon surgery and thyroidectomy. Orthopedic, urological and gynecological operations were performed in other wards.

1.2 Our study

The main objective of this study was to identify the SSI rate and its related risk factors in a hospital in Tanzania. Identifying the antibiotic routines, and the effect of antibiotic prophylaxis on the SSI rate was included in the term risk factor. We carried out a five month prosepective incidence surveillance at KCMC.

1.2.1 General objective

Identify the incidence of SSI and its associated risk factors at Kilimanjaro Christian Medical Center, Tanzania.

1.2.2 Specific objectives

- Identify the rate of surgical wound infections developed during hospital stay and after discharge

- Identify risk factors associated with surgical site infections

- Compare the infection rate for the first two and a half months with the last two and a half-months

- Identify the different pathogens and their resistance patterns

1.2.3 Research hypothesis;

- Several of the variables associated with SSI in countries with more resources will be risk factors at KCMC. The infection rate at KCMC will be higher than 3%

- The infection rate will be higher in the first period of the study than the final

- The identified pathogens and their resistance pattern will be similar to patterns found in the literature

2.0 LITERATURE REVIEW

Several studies have been conducted in countries with more resources and most of the knowledge is from this environment. The results might not be adaptable to countries with fewer resources. According to the author of an article from Mexico experience and guidelines from countries with greater resources can not always be applied to hospitals in countries with fewer resources.[6]

There have been two major types of studies in the field of surgical infections; those focusing on identification of rates and risk factor pattern and those trying to establish a scientific basis for the influence of different procedures on the development of SSI. This study's focus is primarily on the first type. The scientific basis of pre-, intra- and post- operative procedures and their influence on the SSI rate was beyond the scope of this study. Some of the results found in the literature will be included in the discussion.

2.1 Surgical infection rate

The SSI rates reported from countries with more resources is often below 5%. In Brazil and Mexico the SSI rates are usually between 10% and 15%.[6, 18] Reported rates from African countries range from about 16%[19] to 38.7%.[20] In an international survey arranged by the World Health Organization (WHO) in 1988 the SSI rates varied between 5.2% and 34.4%.[8]

There are several explanations for these variations. Besides the quality of the infection prevention measures and the differences in the patient population the use of different methodologies also had an influence.

The length of postoperative hospitalization is decreasing in most industrial countries and many SSI are therefore first apparent only after discharge. Between 12% and 84% of SSI reported are detected after patients were discharged.[1] The postoperative stay is often longer in countries with fewer resources. One could therefore expect the post discharge rate to be lower in countries with fewer resources. However a study from Mexico found that 87.5% of the SSI were apparent after discharge.[18] The inclusion of post discharge surveillance will influence the final SSI rate.

2.2 Difference in methodology

Many surveillance methods for SSI have been put forward in the literature, and all have their advantages and disadvantages. The methods used to detect SSI can be classified as either active or passive. Using a passive method SSI are identified by infection control personnel reviewing patient records, laboratory reports, and discussing patients with the ward staff. In an active method SSI are detected either by an infection control personnel or a surgeon examining the surgical site. It is possible to combine elements form the two methods.

One study examined the sensitivity and specificity of different passive methods. They found that the sensitivity varied from 36% to 76%. The specificity values were close to 100% with all the methods (this was due to few patients being falsely identified as infected). The best results were with a combination of review of microbiology reports and regular ward liaison (this method consist of daily reviewing patient records from whom positive microbiology reports had been obtained)[21] In another study it was concluded that for wound infections it was not sufficient to review microbiological reports or antibiotic administration charts. Additional information obtained by changing dressings or participating in ward rounds was necessary to achieve satisfactory sensitivity in the detection of SSI.[22]

CDC guidelines for preventing SSI states that direct observation of the surgical site is the most accurate method to detect SSI.[1]

There exist different definitions of SSI. Some definitions are based upon clinical examinations while other depend only on a positive bacteriological culture. CDC's definition is most frequently used (the definition can be found in 6.1.1). In a study where CDC's definition was compared with ASEPSIS score (ASEPSIS is a nine-item score system, that was introduced to increase the objectivity and reproducibility of case definition). The CDC definition and the ASEPSIS score system agreed on all the grossly infected wounds. Differences appeared between the methods for lesser degrees of wound breakdown. CDCs definition were found less sensitive than ASEPSIS and almost half of the wounds identified were in the minimal disturbance of healing category of ASEPSIS.[23]

It is common to use modified definitions. Findings suggest that using a mixture of definitions, modified definitions and non-CDC definitions, leads to a lower accuracy in defining SSI than by using the standard CDC definition.[24]

Most definitions of SSI are subjective and open to interpretation. The presence of pus in a particular wound can be judged differently by individual health care workers. The experience of the investigator is therefore believed to influence the number of SSI detected. Higher accuracy is dependent on the surveillance experience of the infection control personnel.[25]

2.3 Risk factors

Different risk factors associated with the patients and the operations have been studied to identify to what degree they influence the risk of SSI. Information about the surgical procedure and patient characteristics which might influence SSI development are useful in two ways: (1) they allow stratification of the procedures, making surveillance data more comprehensive, and (2) knowledge of risk factors before surgery may allow for targeted prevention measures.[1] Risk stratification also enables one to identify variations in SSI rates that are not due to differences in unalterable circumstances, such as the susceptibility of the patient.

2.3.1 Risk indexes

There are different systems developed to stratify and predict SSI. Surgical wound classification was the only variable used to predict SSI. Two CDC efforts- the Study on the Efficacy of Nosocomial Infection Control study (SENIC) and the National Nosocomial Infections Surveillance (NNIS) system, incorporated other predictor variables into SSI risk indices. The rationale for this was the observed misclassifications of incisions, and also that even within the category of clean wounds the SSI risk varied by several percentages.[1]

After collecting data on ten variables, four were found independently associated with SSI. Using these four variables (an abdominal operation, an operation lasting more than 2 hours, contaminated or dirty wounds and 3 or more discharge diagnoses) an additive SSI risk index was developed. The SENIC index predicted SSI risk twice as accurately as the traditional wound classification scheme alone.[1]

The NNIS risk index is operation specific. The index values range from 0 to 3 points and are defined by three independent and equally weighted variables (contaminated or dirty wounds, ASA score 3 or higher and the length of an operation >T hours).[1] Another variable, operations through optical scopes has recently been added to NNIS. Optical scope operations were not performed at KCMC. This change will not influence the results.

Both indexes include surgical duration and also whether an operation is classified as contaminated or dirty. In the NNIS index the ASA score replaces the number of discharge diagnoses of the SENIC risk index. Patients who do not meet any of these criteria are not expected to be at risk for getting wound infections.[1]

There are other variables associated with a higher SSI risk beside those included in the NNIS and SENIC risk indexes. Age, timing and duration of antibiotic prophylaxis, duration of preoperative stay, preoperative shaving, diabetes, nicotine use, nutrition status, colonization with microorganisms, use of drains, altered immune response and other factors related to the operation procedure, are variables that often are associated with SSI.[1] These factors have been associated with SSI by some, but not by all of the studied reports. Different methodologies and local variations in risk factors can be the reason different risk factors dominate in different studies. All the studied articles have, in spite of the different methods used, agreed that duration of the operation, wound classification, use of antibiotic prophylaxis, drain through the incision and preoperative shaving affect the risk of developing SSI.

2.3.2 Preoperative stay

Variables that are identified as a risk factor by one study are not always associated with SSI in another. A long preoperative stay has been shown as an independent risk factor in several studies.[1, 26, 27] In a study from Missouri (USA) the infection rate was not lower among patients who underwent elective operation on the same day as their admission, than among those with a longer preoperative stay.[28] Length of preoperative stay might be a surrogate for severity of illness before the operation.

2.3.3 Age

Most of the studies reported age above 50 years has been associated with an increased risk of SSI. One study did show that this factor was not significant.[29] In an international study organized by WHO children under one year of age and those over 64 years had an increased risk for hospital infection.[8]

2.3.4 NNIS codex

It is common to give SSI rates for the different types of operations to determine the specific SSI rate for the different types of operations. One way to do this is by using the NNIS categories that are based on the International Classification of Disease 9th Revision. (See appendix)

2.3.5 Wound class

Operations can be categorized by the cleanliness of the procedure. The classification scheme describes case features that postoperatively grade the degree of intraoperative microbial contamination. This system was developed by the 1964 NAS/NCR Cooperative Research Study and modified in 1982 by CDC for use in SSI surveillance.[1] A patient that undergoes a clean procedure is expected to be at less risk of SSI than a patient that had an operation classified as clean-contaminated. Wound type is included in both the SENIC and the NNIS indexes. In most of the studied literature wound class was a significant factor. The wound classifications can be seen in Table I.

2.3.6 ASA score

The ASA score was developed by the American Society of Anesthesiologists to record the severity of the underlying disease state of patients. The ASA score is determined by the anesthesiologists. Studies have been undertaken to determine the consistency of ASA ratings. Inconsistencies have been shown regarding ratings of age and obesity. Of 116 initial ASA 3 scores, 68 (59%) were corrected to ASA 2.[30] The subjectivity aspect of determining ASA values should be taken into consideration. The ASA classes can be seen in Table I.

2.3.7 Nutritional status and hemoglobin level

Severe protein-calorie malnutrition is associated with impaired wound healing and postoperative infection after some types of operations. It has been difficult to demonstrate an association between SSI and malnutrition for all surgical subspecialties.[1]

At the Muhimbili Medical Centre, Dar es Salaam (Tanzania) 49% of 164 hospitalized, severely malnourished children acquired an additional infection during their hospital stay.[31] A patient's nutritional status is part of the assessment to determine patients' ASA scores.

Anemia was found as a host risk factor in a study from Ethiopia.[7] The reasons for why anemia should increase the SSI risk has not been eluciated.

2.3.8 HIV status

HIV infected persons seem to have a higher susceptibility to bacterial infections. The few incidence studies on nosocomial infections in HIV- infected persons have suggested that HIV positive patients are at increased risk of infections because of their compromised host status. An increased incidence of SSI and sepsis arising as a complication of elective surgical procedures in HIV positive patients has been shown.[32] There are however surgeons that maintain that if sepsis is controlled and a normal hemoglobin level achieved, healing takes no longer than usual.[33]

2.3.9 Antibiotic prophylaxis

The most excessive use of antibiotics in hospitals can be traced to prolonged duration of antibiotic prophylaxis in surgery. A substantial body of literature indicates that short-term prophylaxis is as effective in preventing SSI as more prolonged use of antibiotics. Short-term prophylaxis also results in fewer complications and are more cost-effective.[34] Researchers agree that the optimal antibiotic prophylaxis routines is to initiate the antibiotic during the last two hours before the incision and continue only a few hours after skin closure. Perioperative antibiotic concentration should then be maintained until wound closure.[1,35] Despite this agreement several studies have shown that it is common not to give prophylaxis in accordance with recommendations.[36] The criteria for antibiotic prophylaxis are usually not mentioned in the studied literature and thus it is hard to determine how general the results are.

2.4 Pathogens and resistance patterns

For most SSI the source of pathogens is the patient's endogenous flora. Exogenous sources of SSI pathogens include surgical personnel, the operating room environment and all tools, instruments and materials brought to the sterile field. Exogenous flora are primarily aerobes, especially gram-positive organisms (e.g staphylococci and streptococci).[1]

In the studied literature *S. aureus* is by far the most common species reported to cause SSI. The pathogen patterns are similar, though there are some minor variations between the different studies. There are however similar findings reported from both countries with more and countries with fewer resources.[1, 8, 18] Distribution of pathogens reported to the NNIS system between 1990 and 1996 showed that 20% were *S. aureus*, 14% were *Coagulase-negative staphylococci*, 12% *Enterococcus spp*., 8% *E. coli*, 8% *P. aeruginosa*, 7% *Enterobacter spp*., and 3% of both *Proteus* and *Klebsiella pneumoniae*.[1]

Antibiotic resistance is a worldwide problem. Antibiotic resistance in countries with limited resources is best documented for pathogens identified from infections acquired outside the hospital such as; *Salmonella.spp., Shigella spp*., and *E. coli*.[37] Investigations indicate that outbreaks of multiply resistant *Klebsiella spp*.[38] and *P. aerugionosa*,[39] also are a serious problem.

3.0 REMAINING QUESTIONS

There are few reports on hospital acquired infections from countries with fewer resources. When searching for data in Pub Med, an electronic medical data base, entering "surgical wound infections and…" 728 citations from USA appeared where as only 23 citations from African countries and 6 citations from "the developing world". There were no citations on SSI from Tanzania. There were no limits set on the age of the articles searched for in the Pub Med. Most of the articles from African countries were general descriptions of the infection problems and were not based on quantitative, empirical studies. Even fewer of them focused on host risk factors and consequences of SSI. This indicates a knowledge gap in this area between countries with more and fewer resources. As mentioned knowledge from local surveillance is essential in creating an effective infection control program.

3.1 SSI rates

An important question for hospitals lacking knowledge given by SSI surveillance is: what is the magnitude of SSI and what is the related causes at this hospital. Given the global problem of antibiotic resistance it is also important for a hospital to identify the most common pathogens and their resistance pattern.

CDC has produced several recommendations to prevent SSI, many of them are difficult to meet at KCMC. The CDC recommendations are valuable, but there might be a need for guidelines that are more applicable in countries with more limited health budgets.

Studies that try to find the reasons for the higher rates for SSI in developing countries have not been identified. It seems this knowledge is lacking.

3.2 Risk factors

The SENIC and NNIS indexes have been shown effective in several studies. These indexes might not be useful in every setting. Only two of the 16 who developed SSI after hernia surgery in a university hospital in Brazil were included in the NNIS index.[18] There is a need for more studies to determine the usefulness of these indexes in countries with fewer resources.

Young age was found to be a risk factor in WHO's international study, while only old age has shown to be a risk factor in countries with more resources. To what extent other variables usually associated with SSI in "developed" countries also pose a risk in "developing" countries are unknown.

The optimal antibiotic agent to use and whether antibiotic prophylaxis should be given in clean surgical procedures are issues frequently discussed. Many of the antibiotic agents recommended in countries with more resources will not be available in "developing" countries. The optimal agent, among the available antibiotics, in countries such as Tanzania needs to be determined.

Hospitals in countries with fewer resources are known to be more crowded and to host more infected patients. To which degree a long preoperative stay in this environment influences the infection rate is not known.

3.3 Pathogens

Few of the studies conducted in countries with fewer resources have identified the resistant pattern of pathogens associated with SSI. Identification of resistance patterns is important for making both rational choices of antibiotic prophylaxis agents and to determine treatment guidelines.

4.0 RATIONALE OF THE STUDY

The efficacy of programs to prevent hospital-associated infections was examined in the SENIC project in the USA. It was shown that hospitals with effective programs reduced their infection rates by 32%. Effective programs included organized surveillance and control activities, an infection control physician, one infection control nurse per 250 beds, and a system for reporting infection rates to practicing surgeons.[9, 26] This type of infection prevention program does not exist at KCMC. Studies like this can increase awareness on the importance of and the need for infection prevention programs.

The administrators at KCMC and the head of the department of general surgery felt that there was a need for this type of study. This interest and the hospital's cooperation in our study, was also a reason for conducting this research at KCMC.

Documentation of the magnitude of hospital associated infections has been used in many countries to create interest and generate funds from authorities to improve infection prevention programs.[11] Our research documentation belongs to KCMC. The hospital administration can choose to use the report in future funding applications.

5.0 RATIONALE FOR THE CHOICE OF METHOD

Different methodologies and definitions are used in SSI surveillance. Some of them will briefly be presented here. The rationale for designing this project as a prospective incidence study with mainly active case finding is stated below.

5.1 Choice of method

Cases can be identified using passive or active case finding methods as mentioned in 2.2. In the studied literature, including the CDC recommendations, active registration is the most sensitive method to detect SSI. This was the main argument for using active case finding.

SSI can be registered either prospectively or retrospectively. When using a prospective method, infections are registered as they occur, while in a retrospective method, infections from a review of patients journals are registered. The prospective approach was chosen since it is easier to get a complete registration of the chosen variables. The retrospective method requires a good record system. The quality of the records at KCMC was unknown when the research methodology was designed. It was therefor difficult to choose a retrospective design.

Recording of incidence is a more labor-intensive method than a prevalence study. The incidence study design was chosen since hospital infection prevention gets attention over a longer time period with this method than with a prevalence study. Recording of incidence gives not only the frequency of new infections, but also the magnitude, of SSI at any given time.

5.1.1 Definition

As mentioned in 2.2 ASEPSIS was found to be more sensitive than the CDC's definition. In spite of this the CDC definition was chosen because the CDC's definition is the one most frequently used in the studied literature. The CDC's definition was used without any modifications.

5.1.2 Variables

Except for the number of discharge diagnoses, which was difficult for the investigator to document, all the other factors mentioned in the SENIC and NNIS indexes are included in this study. Diabetes, smoking status and a surgeon identifier, variables frequently mentioned in the studied literature as risk factors, were not investigated in this study because it was difficult and impractical to obtain this type of information. A surgical identifier was considered too sensitive to record.

6.0 METHODOLOGY

The study design and the definitions used will be presented below.

6.1 Study design

This was a prospective study where all the patients who underwent an operation between 20th of July and 20th of November at KCMC were enrolled. SSI that appeared within thirty days after operation was documented. Other hospital acquired infections were not included.

6.1.1 Definitions used

A patient was defined as having had an operation when the following had occurred: they were taken to the operating theatre, given anesthesia and an incision was made.

The CDC's case definitions were used without modifications. By CDC's criteria SSIs are classified as being either incisional or organ/space. Incisions are divided into superficial or deep. A "case" will be defined as a patient who undergoes an operation at the department of general surgery in the given time period and who develops SSI that meet the following criteria;

SUPERFICIAL INCISION SSI

Infection occurs within 30 days after the operation AND infection involves only skin or subcutaneous tissue of the incision AND at least one of the following:

1. Purulent drainage, with or without laboratory confirmation, from the superficial incision.
2. Organisms isolated for an aseptically obtained culture of fluid or tissues from the superficial incision.
3. At least one of the following signs or symptoms of infections: pain or tenderness, localized swelling, redness, or heat AND superficial incision is deliberately opened by the surgeon, UNLESS incision is culture-negative.
4. Diagnosis of superficial incision SSI by the surgeon or attending physician.

DEEP INCISION SSI

Infection occurs within 30days after the operation if no implant is left in place or within 1 year if implant is in place and the infection appears to be related to the operation AND infection involves deep soft tissues (e.g. fascial and muscle layers) of the incision AND at least one of the following:

1. Purulent drainage from the deep incision but not form the organ/space component of the surgical site.
2. A deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of the following signs or symptoms: fever (>38’C), localized pain, or tenderness, UNLESS site is culture-negative.
3. An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiological examination.
4. Diagnosis of a deep incision SSI by a surgeon or attending physician.

ORGAN/SPACE SSI

Infection occurs within 30 days after the operation if no implant is left in place or within1 year if implant is in place and the infection appears to be related to the operation AND infection involves any part of the anatomy (e.g. organs or spaces), other than the incision, which was opened or manipulated during an operation AND at least one of the following:

1. Purulent drainage from a drain that is placed through a stab wound into the organ/space.

2. Organisms isolated from an aseptically obtained culture or fluid or tissue in the organ /space.

3. An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiological examination.

4. Diagnosis of an organ/space SSI by a surgeon or attending physician.[1]

The different variables included, and the way they were defined and measured can be seen in Table I.

Table I. The variables included on the data collection form.

CONCEPTUAL DEFINITION OF VARIABLE	OPERATIONAL DEFINITION,	SCALE OF MEASUREMENT/ RECORDING
Age	Age at last birthday	In years (continuous)
Preoperative stay	The number of days from hospital admission to the day of the operation the patient is enrolled into the study for.	In days (continuous). Date of admission and date of operation was recorded. Preoperative stay was calculated.
Number of operations	The number of operations the last thirty days.	• The number of operations during the last 30 days will be recorded • If a patient is reoperated because of SSI, it will be recorded under outcome of the SSI. • If a patient is reoperated due to other causes than SSI, the number of operations will be recorded as potensial risk factor
Duration of operation	The time from the skin incision to skin closure	Continuous in minutes.

Type of operation	Patient that underwent a planned operation was registered as elective operation. Emergency operation was non planned.	Elective/emergency. If an operation was trauma related it was recorded

Conceptual definision continues	Operational definition continues	Scale of measurements continues
Nutritional status	Weight, in relation to height. Determined by the anesthesiologist	Obese, good, fair or poor.
Antibiotic prophylaxes	A patient should be considered to be receiving prophylaxis if; 1. Administration of antibiotics was begun within 24 hours prior to surgery or 24 hours later. 2. There is no record of fever or infections when antibiotics were given.	• Name of antibiotic given • Timing of antibiotic in relation to the operation • Number of days antibiotics were given • Administration of antibiotic prophylaxes; oral, injection, intravenous
Drain	Drain inserted during the operation	• Used / not used • Number of days with drain • Location and type of drain was observed
Operation service and site of oper.	Type of surgery performed.	Defined in accordance with NNIS operation categories
American Society of Anesthesiologists physical status classification (ASA)	Score given by the anesthesiologist according to the ASA score system	1= Normally healthy patient 2= Patient with mild systemic disease 3= Patient with a severe systemic disease which is not incapacitating 4= Patient with an incapacitating systemic disease that is a constant threat to life

		5= Moribund patient who is not expected to survive for 24 hours with or without operation

Conceptual definition continues	Operational definision continues	Scale of measurement continues
Wound classification	Score given by the surgeon in relation to the wound classification system	1.Clean wounds These are uninfected operative wounds in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tracts are not entered. 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. 2. Clean-Contaminated wounds These are operative wounds in which the respiratory, alimentary, genital, or urinary tract is entered under controlled conditions and without unusual contamination. 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.

		3.Contaminated wounds These include open, fresh, accidental wounds, operations with major breaks in sterile technique or gross spillage from the gastrointestinal tract, and in which acute, non purulent inflammation is encountered. 4. Dirty or infected wounds These include old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing postoperative infection were present in the operating field before the operation

Table II. Observation data (background information)

CONCEPTUAL DEFINITION OF VARIABLE	OPERATIONAL DEFINITION, DESCRIPTION	POINTS TO BE OBSERVED
Surgical scrub	Members of the surgical team who have direct contact with the sterile operating field or sterile instruments, wash their hands and forearms by performing a traditional procedure known as scrubbing immediately before donning sterile gowns and gloves.	• Existence of written guideline • Availability of washing- basins • Availability of hot water • Type of antiseptic used • Scrubbing technique • Duration of scrub • Techniques used for drying
Preoperative shaving	Shaving of the surgical site before the operation	Means, indication and timing of shaving
Sterilization of equipment	Surgical instruments can be sterilized by steam under pressure, dry heat, ethylene oxide, or by other approved methods	• Existence of written policy for sterilization routines • Description of sterilization methods • Frequency of monitoring the quality of sterilization procedures • Existence of microbial monitoring of steam autoclave performance

Continue: definition	Continue: operational definition	Continue: point to observe
Incision care / handwashing routines	Incision care defined as a procedure including the removal of the dressing	• Existence of written policy for changing of dressing • Frequency of changing dressing • Use of sterile gloves and equipment • The frequency of hand wash before and after changing the dressings • Physical description of the means used for washing
Preoperative preparation of the patient	Routines for preparation of the patient that occur within 24 hours before the operation.	• Type of antiseptic used • Whether the patient received a preoperative antiseptic showering or not • Preoperative clothing • Transportation to the operating theatre
Infected\colonized personnel	Operation personnel having an infection (fever or diagnosed by a doctor)	• Existence of policies for exclusion of ill personnel from work or patient contact (sick leave arrangements

Continue: definition	Operqational definition	Points to observe
Managements for the operating theater	Operation theater is here limited to the room where the operation is conducted	• Cleaning routines • Physical description of the operating room and its location • Ventilation system • Traffic in the operating theatre (closure of doors)
Number of patients at the ward	The number of patients at the ward. Relatives that stayed over night was not included.	• The number of patients at the ward was recorded each day • Visitors routines

6.1.2 Case and risk factor registration

Hospital identification number and the variables in Table I were recorded on a pre-printed data collection form, developed using the CDC's recommendations on SSI surveillance.[1] These factors, except HIV status (difficult to obtain), were later entered for further statistical analysis. Nutrition status was recorded as obese, good, fair or poor by the anesthesiologists. An exception from the guidelines was that a surgeon identifier was not used or recorded. All the needed data were available in the patient records.

For all SSI there were registered; when they occurred, pathogen identified, type of infection (superficial, deep or if there was a organ/space SSI). The treatment, its outcome, and time of hospital discharge was also registered.

If one patient had two operations more than thirty days apart each operation was recorded independently of the other. If the second operation was a result of SSI it was recorded as a consequence of the SSI. If reoperated for reasons other than SSI, the total number of operations within thirty days was recorded as a potential risk factor. The patient was followed up thirty days after the first operation.

6.1.3 Case finding

The investigator performed bedside surveillance five days a week. The investigator attended the ward round and registered all the patients that were put on antibiotics, had a temperature over 37^{o} Celsius, date of drain removal and SSI diagnosed by the doctor that attended the round. The investigator participated in changing the dressings of all of the patients included in the study. The surgical sites were examined for pain, redness, warmth, swelling and purulent drainage. All patients' charts, including laboratory reports and radiological reports, were reviewed five times a week by the investigator. Patients readmitted were also surveyed for infections. The experience of the investigator is believed to influence the number of SSI detected (see 2.2). The investigator has experience in detecting SSI from work at a surgical ward and through work as a homecare nurse.

All patients received an appointment for a post-discharge examination at the outpatient clinic. The investigator examined the surgical site. It was found to be logistically difficult to follow up those patients that did not attend the post-discharge check up.

6.1.4 Collection of background information

The observation points in Table II were not documented for each patient. This information was gathered by observation and interviews with the staff. The observations were semi structured and were spread out over the entire research period. One day each week (different weekdays) was chosen for observation. Points to be observed were produced in the research protocol (see Table II).

6.1.5 Method for specimens collection and analysis

Bacterial specimens were taken of wounds that met the CDC definition. Specimens were obtained using sterile swabs and an aseptic technique. Stuarts transport medium was used. The swabs were inoculated on blood or MacConkey agar. The type of identified organism and available equipment determined which type of sensitivity tests were run. Testing for vancomycin resistance was not performed. Stokes method for defining resistance was used. According to this method was the sensitivity reporting system as follows: 1. Sensitive where the test organism zone of inhibition was equal or greater than the zone of the standard organism. 2. Intermediate when the test organism zone of inhibition was less than the zone of standard organism by 3 mm or more. 3. Resistant when the test organism showed no zone of inhibition at all. Muller/Hinton agar and Isoseus mediums were used in sensitivity testing.

Growth media was locally made from commercially available powder and prepared according to the manufactures instruction. Analysis was done manually by an experienced laboratory technician using a magnifying glass and a measurer.

6.1.6 Statistical analysis

The results were analyzed using SPSS for Windows, Release 9.0 (SPSS Inc). The data were entered as recorded except that duration of pre- and post operative stay was calculated and then entered. One person reading the data out loud from the forms while another controlled the data on the computer checked the entered data. Descriptive statistic was run to make sure that there were no outliers and that there were 396 patients distributed for each variable.

For each continuous variable the mean and standard deviation was calculated and a histogram was made to determine distribution. Data that departed from normal distribution was not transformed. In logistic regression normal distribution is not necessary. Continuous variables were recorded into new variables to see whether any special range of the results were significantly associated with SSI. Recoding principles were either to get similar number of patients in the different categories or cut-points identified in the literature was used. The used cut-points can be seen in Table III.

Patient characteristics related to SSI were compared using Chi-square. Associations between SSI and all other possible risk factor variables were sought by calculating odd's ratio using logistic univariate analysis. Predictors of SSI were identified from multivariate logistic analysis with backward elimination. The model was built up by entering all the variables having significant or close to significant association ($p<0.25$) with SSI in univariate analysis. Statistical results are reported as P values, odd's ratios and 95% confidence intervals ($CI_{95\%}$).

Cross tabulations and scattergrams were made to identify any relation between the number of patients in the ward and the number of patients that developed SSI. These numbers were categorized by weeks. Patients that developed SSI after discharge were entered for the dates they were in the ward.

Two sample tests and cross tabulation were run to identify any pattern among those that did not attend the outpatient clinic.

6.2 Ethical issues

This study received ethical clearance by the "Regional committee for medical research, health region West, Norway" and locally by the administrators at KCMC.

Analysis of the data was conducted outside the hospital. To prevent the use of personal data no names were recorded on the data collection form.

An informed consent was not sought from the patients included into this study. This study documented only the aspects of the treatment given. During data collection the patients were informed orally about the project. Since this was a descriptive study, with the intention only to describe ongoing procedures, it was not necessary with written informed consent. We thus followed the Declaration of Helsinki recommendations guiding ethical research (48th World Medical Assembly, Declaration of Helsinki, 1997)

7.0 RESULTS:

All the patients that had an operation in the given period were included. No patients were exclude from this study.

This study included 396 operations, on 388 different patients (179 women and 217 men). The mean age was 31.4 (range 0.1 to 85 years). Sixty one patietns were under five years of age and 54 were older than 55 years. The age followed a normal distribution. The mean age was similar in both men and women. There were 271(69.6%) elective operations. Thirty six (9%) of the operations were trauma related. About 230 (57.8%) of the patients had their operation either on the day of admission or the day after. The mean preoperative stay was 5.1 days (range 0-85). In Table III the distribution among the different variables can been seen together with the number of SSI cases in each category.

The most common procedures performed at the ward were exploratory laprotomy (15.4%), appendectomy (15.4%), hernia repair (8.8%), colon surgery (8.3%), thyroidectomy (8.1%), and plastic, pediatric and cardiothoracic operations contributing to the rest.

7.1 The SSI rate at KCMC

There were 77 (19.4%) patients that developed SSI after surgery. Twenty eight of the 205 patients seen at the outpatient clinic were diagnosed with SSI (36.4% of the total SSI). According to the CDC definition 53 (68.9%) of the infections were superficial, 16 (20.7%) were deep and 8 (10.4%) involved organ or space. The total incidence of SSI was outlined as follow: clean 34/216 (15.6%), clean-contaminated 24/135 (17.7%), contaminated 10/27 (37%) and dirty 9/18 (50%).

The SSI rate reported for the two first months of the study was 16% (16 of 100 patients). Twelve of the infections were identified during hospitalization.

7.2 The risk pattern at KCMC

Several known risk factors for SSI are statistically significant in this study. The best predictor for SSI was having undergone a contaminated or dirty operation. Table III shows that the SSI risk increased with the duration of the operation. Operations lasting for more than 50 minutes were associated with SSI more frequently than shorter operations. All the preoperative stay categories were associated with SSI in the multivariate analysis. Those with a preoperative stay of more than six days had the highest risk of SSI. There was a significant difference between the mean preoperative stay for those who developed an infection (7.9 days) as compared to those who did not develop an infection (2.2 days). Procedures involving the colon, amputations or vascular operations were also found to be significantly associated with infection. The SSI rate per NNIS procedures can be seen in Table IV.

The above mentioned risk factors were significant for the SSI diagnosed at the hospital as well as for all the infections seen together. None of these factors were associated with post-discharge SSI. The only variable significantly associated with SSI diagnosed at the outpatient clinic was clean-contaminated surgery. There was no significant difference between men and women or for the different age groups.

Antibiotic prophylaxis were given in 300 of the 396 included operations. Antibiotic prophylaxis was usually prescribed and given after the operation. Two hundred and thirteen patients were prescribed antibiotic prophylaxis for five or more days (median five days, range one-14 days). The median time for the initiation of antibiotic prophylaxis was 3.5 hours after the operation (range 24 hours before and 24 hours after incision). Six patients received antibiotics just before undergoing surgery. Many patients (see Table V) were given a combination of two or three different antibiotics. The most frequently used antibiotics were gentamicin 138 of the patients (34.8%) received it and ampicillin that was given to 91 patients (22.9%). Of the 77 patient that developed SSI did 67 (87%) receive antibiotic prophylaxis. In the univariate analysis antibiotic treatment longer than five days was significantly associated with development of SSI. Duration of antibiotic was not significant in the multivariate analysis.

The frequency of hand washing was recorded. During the ward round it was observed that 53 wounds were touched. Hands were washed 21 times after and never before touching the operation site. Sterilised gloves were used seven times. It was never observed that hands were washed before the dressing of wounds. Dressing of wounds was observed 63 times, and only eight times were the hands washed between dressings. Sterile gloves were used during dressing twenty times. It was observed that several items were touched with the sterile gloves on, before the dressing started. Hand washing was not performed between change of gloves.

7.3 Identified pathogens and its resistance pattern

A positive culture was obtained from 59 out of 77 infected wounds. Tests were not performed on the rest of the wounds because of previous antibiotic treatment, misunderstanding between the investigator and patients, or the lack of equipment. As seen in Table VI, *S. aureus* was the most frequently isolated microorganism followed by *E. coli* and *Klebsiella spp*.

Of the 59 positive cultures 40 were pure and 19 were mixed growth cultures. Eighteen (30.5%) of the 59 positive cultures were sensitive to all tested antibiotics. Twelve out of the 18 sensitive positive cultures were *S. aureus*. Table VI shows the number of different pathogens identified and their resistance patterns. With the exception of *S. aureus,* were the other identified pathogens often resistant to the tested antibiotic. Four cases of c*oagulase negative staphylococci* were resistant to all available antibiotics. The pathogens were most frequently resistant to ampicillin and chlorampheicol, followed by tetracycline, cotrimoxalzole and gentamicin.

7.4 Consequences of SSI at KCMC

As showed in Table VII the mean length of postoperative hospital stay was 5.4 days for those without an infection (range 1-30) and about thirteen days for all those with SSI (range 1-64 days). The mean postoperative stay for the 49 that developed SSI while hospitalized was 18 days. The mean number of days in hospital was similar for the different type of SSI.

Forty seven of the 77 diagnosed with SSI received antibiotic treatment for the infection, six were readmitted and eight were re-operated. Four of the patients that developed SSI died. At least two of the deaths can be associated with SSI.

TABLE III. The number of patients and SSI distribution per variable included in this study. The odd’s ratio is given for the univariate and multivariate analysis.

VARIABLES	N* TOTAL (SSI CASES)	ODD`S RATIO (95% CI) univariable anal.	P-value for the univariable analysis	ODD`S RATIO (95% CI) Multivariable
Age 0-18 years	120 (23)	Reference cat.	Reference cat.	
Age 19-40 years	145 (24)	1.2 (0.7-2.3)	0.472	
Age 41-100 year	131 (24)	0.9 (0.5-1.6)	0.609	
Male gender	217 (46)	Reference cat.	Reference cat.	
Female gender	179 (31)	1.3 (0.8-2.1)	0.332	
ASA 1	224 (36)	Reference cat.	Reference cat.	
ASA 2	99 (26)	0.5 (0.3-0.9)	0.034	
ASA 3	63 (11)	0.9 (0.4-1.9)	0.792	

ASA 4	9 (4)	0.2 (0.6-0.9)	0.039	
ASA 5	1 (0)	34.5 (0.0-1.1 E)	0.793	
0 days preop.	56 (6)	Reference cat.	Reference cat.	Reference cat.
1 day preop.	173 (34)	0.5 (0.2-1.2)	0.132	0.3 (0.1-0.8)
2-6 days preop.	95 (19)	0.5 (0.2-1.3)	0.144	0.3 (0.1-0.8)
> 6 days preop.	72 (18)	0.4 (0.1-0.9)	0.045	0.2 (0.1-0.6)
Oper. 0-45 min.	134 (15)	Reference cat.	Reference cat.	Reference cat.
Oper. 50-85 min.	124 (26)	0.5 (0.2-0.9)	0.034	0.4 (0.2-0.9)
> 85 min.	138 (36)	0.4 (0.1-0.7)	0.002	2.3 (0.2-0.7)
No antibiotics	99 (10)	Reference cat.	Reference cat.	
ABP 1-4 days	84 (13)	0.6 (0.3-1.5)	0.277	
ABP 5 days	164 (37)	0.4 (0.2-0.8)	0.012	
ABP 6-15 days	49 (17)	0.2 (0.1-0.5)	0.001	
Elective opr.	271 (49)	Reference cat.	Reference cat.	
Emergency opr.	125 (28)	0.8 (0.5-1.3)	0.312	
No drainage	176 (26)	Reference cat.	Reference cat.	
Used drainage	209 (51)	0.5 (0.3-0.9)	0.013	
Clean opr.	216 (34)	Reference cat.	Reference cat.	Reference cat.
Clean-cont. Opr.	135 (24)	0.9 (0.5-1.5)	0.617	0.9 (0.5-1.6)
Contamin. opr.	27 (10)	0.3 (0.1-0.7)	0.009	0.2 (0.1-0.5)
Dirty operation	18 (9)	0.2 (0.1-0.5)	0.001	0.1 (0.0-0.3)
NNIS- COLO	33 (15)	0.3 (0.1-0.9)	0.348	0.1 (0.0-0.9)
NNIS- AMP	10 (5)	0.2 (0.0-1.1)	0.063	0.1 (0.0-0.6)
NNIS- VS	3 (2)	0.1 (0.0-1.5)	0.093	0.1 (0.0-0.9)
Hgb >167	195 (43)	Reference cat	Reference cat	
Hgb 33-167	185 (28)	0.6 (0.4-1.1)	0.0856	

Only variables with significant or close to significance associations ($p<0.25$) in univariate analysis were included in the multivariate analysis. Only variables that were shown to be significant in the multivariate analysis are in the table. There are 11 missing recordings of drain use and six missed hemoglobin levels.

Abbreviations used in the table: opr.: operation, ABP: antibiotic prophylaxis, min.: minutes, preop.: preoperative hospital stay. The NNIS categories can be seen in table two. Only significant NNIS categories is included in this table.

TABLE IV. The total number of patients and SSI for the eleven most commonly NNIS categories.

	AMP	*APPY*	*CHOL*	**COLO**	CRAN	***SKGR***	*VS*	*XLAP*	*HER*	*OMS*	*HN*
N* (SSI cases)	10 (5)	61 (8)	15 (3)	33 (15)	23 (4)	13 (4)	3 (2)	61 (16)	32 (3)	29 (4)	32 (3)

N*: The total number of patients in the NNIS category

¤ The percentage of the total number in a NNIS category that developed SSI.

Amp=amputation, Appy= removal of appendix, Chol= cholecystectomy, Colo= colon surgery, Cran= craniotomy, Skgr= skin grafting, Vs= vascular surgery (venouse vains), Xlap= exploratory laparotomy, Her= hernia repair, Oms= other surgery on musculoskeletal system, Hn= Incision of the larynx or trachea

TABLE V. Antibiotics given as prophylaxis to 300 surgical patients

Antibiotics	Patient receiving
Gent	59
Gent + amp	38
Cefu	31
Clox	28
Amp	25
Gent + clox	11
Amox	11
Amp + chlor	9
Chlor	8

Gent + chlor	6
Cefu + gent	5
Amp + gent + metacil	5
Other compinations*	58
Other single antibiotics	6
Total	300

* If less than five patients received the type of prophylaxis, is it included in others

Abbrevations: gent = gentamicin, amp = ampicillin, cefu = cefutriaxone, clox = cloxacillin, amox = , chl = chloramphenicol, met = metacillin

TABLE VI. Antimicrobial susceptibilities of bacterias isolated from the surgical wound. The number of resistant pathogens identified is given first. The total number of bacteria tested for the antibiotic is in brackets.

	S-aureus N* 22	E-coli N*12	Klebsiella N*12	Psudomonas N*9	Coliform N*9	Coag.neg staph. N*8	Proteus N*6	Entero-Coccus N*3
Amp	--	8 (9)	9 (9)	0 (1)	5 (9)	--	3 (5)	2 (2)
Gent	1 (18)	1 (10)	4 (10)	1 (9)	3 (9)	5 (7)	2 (6)	--
Chlor	4 (14)	4 (8)	9 (11)	--	4 (7)	5 (8)	5 (5)	--
Clox	1 (11)	--	--	--	--	5 (6)	--	--
Erythro	3 (18)	--	--	--	--	5 (7)	--	1 (2)
Tetracy	1 (5)	4 (4)	7 (11)	--	3 (4)	3 (3)	3 (3)	--
Amika	0 (1)	0 (3)	0 (1)	0 (1)	0 (2)	4 (4)	0 (3)	--
Cotrim	--	4 (4)	3 (2)	--	4 (6)	5 (5)	--	--
Carbenic	--	--	--	8 (9)	1 (1)	--	--	--
Trimeto	1 (1)	--	--	--	--	--	--	--
Cefu	--	1 (3)	--	--	--	--	--	--
Polymix	--	--	--	2 (9)	0 (1)	--	--	--
Ciprofla	--	0 (2)	2 (3)	4 (7)	3 (4)	--	--	--
Metacil	0 (3)	--	--	--	--	--	--	--
Penicil	--	--	--	--	--	2 (2)	--	--

¤ The number of each bacteria identified

The full name of the antibiotics starting from the top is: ampicillin, gentamicin, chloramphenicol, cloxacillin, erythromycin, tetracycline, amikacin, cotrimoxazole, carbenicillin, trimethoprim, cefutriaxone, polymixin- B, ciprofloxacin, metacillin, penicillin

TABLE VII. Postoperative length of stay (in days): mean with standard deviation (SD) in patients without and with postoperative SSI.

Patients	N*	Mean postoperative length of stay in days	SD
Without SSI	320	5.4	5.8
With SSI	77	12.9	13.8

N*: Total number of patients with or without SSI.

8.0 DISCUSSION

Several of the findings were in accordance with the hypothesis. The results will be discussed further in relation to the reviewed literature and the observations of hygiene practices.

8.1 The SSI rate

Differences in methodology call for great care in comparing infection rates in different countries. A rate of 19.4% is high compared to results from countries with more resources, but not when compared to SSI rates found in other African countries.

Different factors affect the SSI statistic in this study. The low attendance at the outpatient clinic (142 (36%) were not seen after discharge) and the low number of follow up days (10.5 days on average) indicates that the actual infection rate might be even higher than 19.4%. The mean hospital stay for those not seen after discharge was six days. Studies have shown that over 50% of the infections occur within the first week after operation, and about 90% within two weeks.[26] Many patients live far away from the hospital, which makes it more convenient for many to seek help at a nearby health center for any post operative problems. Patients with more sever infections would most likely be transferred to KCMC.

Our rate of post discharge SSI was 36.4%, a figure greater than the 14% reported in one study[40], but less than the 87.5% found in an other.[18] These differences may be reconciled in parts by the different surveillance methods used.

8.2 The SSI rate and host factors

Different patient related factors and hygienic principles in the health care setting may have an effect on the SSI rate. Some of these factors will be briefly discussed here.

The Kilimanjaro region has a relatively high HIV/AIDS rate. Some researchers have reported an increased SSI risk among people with HIV infection.[32, 33] The high prevalence of HIV infection in the area might have influenced the results. It was not possible to record the HIV status of the patients in this study as originally planned.

The nutritional status of the patients might influence the rates of wound infection. The nutritional status was documented for the patients. Around 70% of those included in the study were classified by the anesthesiologists as having good nutritional status and 2.5% as having poor (the rest were classified as either obese or as having fair nutritional state). It is likely that this factor did not contribute to the number of infections.

8.2.1 The SSI rate and different procedures

Several of the CDC recommended actions[1] to prevent SSI was not applicable to KCMC. To what degree the lack of a ventilation system in the operation theatre, re-sterilization and reuse of equipment and preoperative shaving the evening before the operation influenced the SSI rate at KCMC, is not known.

Hand washing is often mentioned as the single most important way to prevent infections. Knowledge of infection prevention is usually not emphasised in the health professions training in Tanzania. Many of the staff were unfamiliar with different infection prevention methods for example the importance of hand washing. Given the lack of quality equipment for hand washing (only soap bars were available, one had to continuously press the knob on the basin while washing, spirit for disinfection was not available and the towels used often hung for days (average 2.5 days (range one to eight days)), it is understandable that compliance with hand washing was often poor. Swabs from the sink and towle were not taken. In a study from Muhimbili Medical Centre (Tanzanaia) it was shown that pathogens cultured from patient infections were similar to random samples taken from the towels, sinks, antiseptic containers and beds on the ward.[31]

The timing and frequency of wound dressing were in accordance with the CDC recommendations. An exception was that the dressings were often left on for days after the operation before getting changed at the pediatric ward (P2). Several of the operation sites at P2 were already infected by the time the bandages were removed the first time.

Re- sterilized wound dressing packages were delivered daily to the wards. The packages included tin bowls, cotton, gaze and three tweezers. One of the tweezers was used to remove the old bandage while the other two were used when cleaning the wound. The equipment was kept on a tray that was put on the patient's bed during the dressing. Since the tray was not cleaned between dressings, pathogens might have been transferred from bed to bed. Edinburgh University Solution (EUSOL, a chlorinated lime and boric acid solution), produced locally and kept in big containers, was used to clean the surgical site. Swabs were taken from the EUSOL solution. All three were negative. There was no routine for first changing known infected wounds before the clean one at the ward. This increases the chance for cross infection. Tests were not taken to identify cross infection, but during a period of one week four strains of *coagulase negative staphylococci* were identified. They had similar resistance patterns and they were resistant to all available antibiotics. It is likely that this outbreak was a result of cross infection.

Fifty one of 209 patients that had a drain inserted developed SSI. Drains were placed at a distance from the surgical site as recommended by CDC. The CDC recommendations state that the use of open drains increase the SSI risk.[1] At the department of general surgery drains consist of a plastic pipe covered with a sterile glove. It was frequently observed that the glove fell off, leaving the drain uncovered for hours.

The department of general surgery has three operating theatres available. One is allocated for dirty operations and is separated from the other two. The CDC recommends that operating rooms should be maintained at positive pressure with respect to corridors and adjacent areas. There are also several recommendations related to filters, air exhaust and air changes.[1] These recommendations were not met at KCMC. There is no ventilation system in the operation theatres. To maintain air quality one or both of the doors between the operating theater and the surrounding hallways were kept open during surgery. The microbial level in the operating room is directly proportional to the number of people moving about in the room. The number of people in the operating theater should therefore be limited.[29] The recommendations at KCMC states that maximum of six persons should be present during an operation. The average number of people observed during an operation was seven (range five to ten). KCMC is a teaching hospital. It is therefore difficult to limit the number of personnel present to less than the local recommendation. To which degree the low air exchange and the number of persons present during the operations influence the SSI rate at KCMC is not known.

Rigorous adherence to the principles of asepsis by all scrubbed personnel is the foundation of SSI prevention. Surgical techniques such as maintaining effective homeostasis while preserving adequate blood supply, preventing hypothermia, gently handling tissue, removal of necrotic or charred tissue, choice of suture material and appropriately managing the postoperative incision, are widely believed to reduce the risk of SSI.[1] Observation of surgical technique was not included as a part of this study. Assessment of the quality of surgical procedures should be included in future surveillance.

All equipment brought to sterilization was first cleaned with Jik (chlorine) and then put in an autoclave for thirty minutes. There was only one working sterilizer and it was often packed full. It was quality checked once a day using “Sterilometer plus” strips. If the equipment was not sterilized, it would be re-sterilized and a new test taken. Overloading of autoclaves is reported to reduce the sterilization quality.[41] However there were few tests that indicated items were not sterilized properly.

The ward was usually given forty bed sheets per day. Two bed linens are needed for each bed. Therefore, on any given day only a limited number of patients received new sheets. It was not uncommon that some patients had to lie in bed sheets with stains from body fluids on them. Stains from body fluid provide a good environment for bacterial growth. Patients wore their bed linen on them when taken to the operating theatres. This could be a vector for the "ward-bacteria" to the operating theatres.

8.3 The half-time results

A hypothesis was that the halftime rate would be higher than the final SSI rate. The infection rate for the two first months plus some descriptive statistics were presented to the surgeons halfway out in the study. The SSI rate was then 16%. The final SSI rate was 19.4%. A possible explanation for the fact that the full time rate was not lower than the half time rate is that rates were not given for each individual surgeon. It is also possible that the 100 patients included in the halftime rate developed fewer SSI than average. There were 52 SSI diagnosed during the first eleven weeks of this study, while 25 were identified the last eleven weeks. This indicates: 1. the time allocated to note changes were too short. 2. the surveillance had an effect on the number of SSI that developed. Fewer SSI developed in the second part of the study. It can be argued that the timing of the halftime results were not optimal, being that it did not capture the change in SSI rates that occurred during the surveillance period.

8.4 Risk factors

This study identified contaminated or dirty operations, operation lasting for more than fifty minutes, duration of preoperative stay, procedures involving colon, amputation, and operations on varicose vein as significant factors. Several other studies have reported wound class, duration of operation and preoperative stay as risk factors.[42, 43] It was unexpected to find that as many as 50% of the amputations and 67% of the varicose vein operations became infected. These procedures are classified as clean. The low number of these operations in this study (ten amputations and three varicose veins) should be taken into consideration. Otherwise our study showed that the SSI rate for clean operations was 15.6%, which is higher than the 13% clean wound rate reported from Brazil.[18]

In the univariate analysis an antibiotic prophylaxis for five or more days was a significant SSI risk factor (it was not significant in the multivariate analysis). Several researchers have concluded that a short-term preoperative prophylaxis is as effective as more prolonged use. Fewer days of antibiotic treatment results in fewer complications and lower cost.[34,35] One would expect patients to be less likely to have SSI when prophylactic antibiotics were used. Our finding suggest that the antibiotic prophylaxes given is not optimal and therefore should be reevaluated.

Four of the patients with SSI had a NNIS score three (two had score 2 and 30 had score 1) 33 of the patients with an infection had non of the risk factors included in the NNIS index. ASA scores are one of the components in the NNIS risk index. In this study higher ASA scores were not a significant risk factor in the multivariate analysis. The final ASA score given has a subjective element.[30] Some of the patients classified by the anesthesiologists at KCMC as having good nutrition status would have been classified as obese by the investigator. More research should be conducted in countries with fewer resources to determine the usefulness of the NNIS index in such settings.

A longer preoperative stay in a crowded hospital is suggested as a cause of increased SSI rate. In this study patients with preoperative stays longer than six days had a slightly increased risk of SSI compared with those operated one day after admission. SSI rates were not higher in weeks with more than average patients admitted to the ward. A longer preoperative stay is suggested as a surrogate for severity of underlying disease. Most of those with a preoperative hospital stay longer than six days, were classified as ASA 1 or ASA 2 (74%) and only 26% were classified with ASA scores higher than three. Eleven of the 15 SSI patients with ASA sore 3 or 4 had preoperative stay less than three days (the remaining four had 6, 7, 23 and 24 days). Duration of preoperative stay did not seem to correlate with severity of underlying disease.

The hemoglobin level and the nutrition status were not associated with increased SSI risk.

The only variable associated with SSI identified at the outpatient clinic was clean-contaminated surgery. One explanation is that clean-contaminated wounds have a lower intrinsic degree of microbial contamination, than contaminated and dirty wounds. The lower degree of contamination would require a longer incubation time for the development of infection and might thus explain why SSI in clean-contaminated wounds manifests later.

None of the risk factors associated with infections found in the hospital was associated with infections detected at the outpatient clinic. This pattern has also been reported elsewhere.[27] This implies that surveillance focusing on high risk hospital patients will miss identifying those infections developed post-discharge. The fact that only 205 patients were seen after discharge and only 28 infected wounds were diagnosed at the outpatient clinic might have affected the statistical power to detect weak associations.

8.5 Pathogens and resistance

In this study *S. aureus* were isolated in 22 of the infections, while *E. coli* and *Klebsiella spp* were isolated in 12. One difference from the results reported to the NNIS surveillance system between 1990 and 1996 is that more *Klebsiella* infections and slightly less *coagulase negative staphylococci* were identified in our study.[1] One possible explanation for why fewer *coagulase negative staphylococci* was identified, is that this pathogen is mainly associated with implant operations. No implant operations were included in this study. The pattern of identified pathogens are otherwise similar to what is reported elsewhere, both in countries with more and fewer resources.[18, 1]

The occurrence of multi-resistant microorganisms was common. Four of the infections with c*oagulase negative staphylococci* were resistant to all available antibiotics at the hospital. Most of the patients received antibiotics, often broad -spectrum, for several days. Prolonged antibiotic prophylaxis[44] and the use of broad-spectrum antibiotics[34] have been reported by researchers to be associated with increased emergence of resistance. The susceptibility data collected in this study suggest that some antibiotics have very limited usefulness for prophylaxis or empirical treatment of SSI. The availability of antibiotics at KCMC is influenced by financial constrains and type of antibiotics that are contributed from different sources. These factors makes optimal antibiotic use more difficult.

The use of degraded antibiotic powder and antibiotic disks for susceptibility testing are reported to be common in many laboratories in developing countries and has lead to exaggerated estimates of bacterial resistance levels.[34] If this is the case at KCMC is unknown to the investigator. Laboratory facilities in countries with fewer resources are often less extensive than in countries with more resources. The reliability of the microbiological results might be influenced by this. The pathogens and their resistance pattern identified by this study is similar to what is reported elsewhere. It can therefore be argued that the reliability of the results are acceptable.

9.0 CRITICS OF THE USED METHOD

Below some aspects of the used methodology will be discussed. The possibility of selection bias is low since all the patients that had undergone an operation were followed up. Cohort studies are also known to have the advantage of low observational bias and few confounding factors. Possible confounding risk factors were adjusted for by regression analysis. These factors will therefore not be discussed.

9.1 Loss to follow-up

A methodological weakness in this study's design is the lack of follow-up of all patients after discharge. According to the CDC's definition of SSI patients should be followed for thirty days after surgery. In this study 142 (36%) of the patients did not come to the outpatient clinic (patients with SSI diagnosed at the hospital are not included among the 142 that were not seen after discharge). Cross tabulations and two sample tests were run to see if there was any pattern among those not seen after discharge. The percentage of patients that did not attend the outpatient clinic varied from 20%-60% for the different NNIS operation categories. Around 60% of the patients that underwent operations such as skin grafting, exploratory laparotomy and gastric surgery did not attend the outpatient clinic. The non attendance proportion was similar for the different age groups, except that slightly more of those between 19 and 29 years did not attend the post discharge control. Those with a shorter operation and with fewer hospital days, both pre- and postoperative, were more likely not to attend the clinic (as seen in Table VII). Those that did not attend the outpatient clinic had a significantly lower mean duration of surgery and mean number of postoperative days

In the studied literature shorter preoperative hospital stay and shorter duration of the operation are associated with lower SSI rates than longer duration. Generally there are fewer infections in the age group 19-29 years.[1, 8] This supports the argument that few infections were unidentified.

The mean number of days the patients were followed up was 10.5 days. This number, lower that the 30 days recommended by CDC, was caused by the loss of follow up and by patients attending the outpatient clinic only about a week after discharge. Patients seen at the outpatient clinic might have developed an infection after the visit. Since they attended the clinic with no SSI problem, they most likely would have come back if they developed SSI. It can be argued that there are no missed infections among patients seen at the outpatient clinic.

One of the main reason why patients did not show up at the outpatient clinic were probably the fact that several patients live far away from the hospital. It is more convenient for them to seek help at a nearby health center for minor infection problems. This indicates that the actual infection rate might be higher than 19.4%, but most of the severe SSI were most likely identified in this study.

In spite of the lack of follow up it can be argued that the results of this study give both an insight into the problem of SSI and shows that several of the infections first appear after discharge.

Table VIII. Characteristic of those that did not attend the outpatient clinic (OPC). The continuous and categorical variables are separated.

Continuous variables	Mean of those attended OPC	Mean of those not attend. OPC	Mean difference (CI)	P-value
Age	32.1 years	30.5 years	1.6 (-2,5- 5.8)	0.43
Preop. stay	5.7 days	4.4 days	1.2 (-1.1- 3.6)	0.29
Dur. op.	84.5 minutes	67.4 minutes	17.5 (8.3- 26.0)	0.00

Days with AB	3.7 days	3.4 days	0.4 (-0.2—0.9)	0.19
Post op. hosp.	7.8 days	5.6 days	2.2 (0.6-3.8)	0.01

Categorical variables	Total number in the category	N* not seen at OPC (%)
ASA1	224	93 (42%)
ASA 2	99	47 (47%)
ASA 3	63	33 (52%)
ASA 4	9	3 (38%)
ASA 5	1	1 (100%)
Clean operations	216	99 (46%)
Clean-contaminated op.	135	62 (46%)
Contaminated operations	27	11 (41%)
Dirty operations	18	5 (28%)
Used drain (11 missing)	209	82 (39%)
No drainage	176	88 (50%)
Emergency operations	125	50 (40%)
Elective operations	271	127 (46%)
Male gender	216	100 (46%)
Female gender	179	77 (43%)

The number of SSI in each category is not subtracted from the total number, but patients with SSI is not counted among those seen at the outpatient clinic.

N* Total number of patients seen at the OPC, CI: Confidence Interval, op.: operation, hosp.: hospitalized, dur.: duration, OPC: outpatient clinic

9.2 Validation of the number of SSI detected

The number of SSI detected per week and the number of negative / positive swabs taken were used to validate the result of the number of detected SSI.

As seen in Table VIII do the number of SSI detected per week vary. This can probably be explained by statistical variations like the number of patients followed at a given time.

Of the 62 swabs taken 59 were positive and three showed no bacterial growth. The fact that some few swabs were negative, indicates that the level of interpreting the CDC's definition was acceptable. If all the swabs had been positive it could have meant that the number of swabs taken was too low. More negative swabs could indicate that the definition was not followed correctly. Two of the negative swabs were from fluid filled cavities. The content did not seem like pus. The negative swabs confirmed this observation. The third negative swab was taken from a clinically infected wound. A new swab was taken days later. It was positive.

The investigator did not visit the ward during the weekends. It is however unlikely that SSI were missed because of this. Patients were usually not being discharged if SSI was present and it was never observed that SSI appeared before the third postoperative day.

The identified infection rate varies depending on the method and definition used. The experience of the investigator is also reported to influence the rate.[25] In this study there were no discrepancies between the clinical diagnoses made by the staff, the investigator and bacterial test. Active surveillance that includes elements of passive registration is reported in the literature as the method with the highest accuracy.

It can, on the basis of the above mentioned points, be argued that the sensitivity of the results are acceptable. The specificity values must be close to 100%. This is due the fact that none of the patients were falsely identified as infected. The combination of clinical diagnosing, and also use of results from the swabs, decreases the likelihood of a false positive.

Table VIIII. The average number of patients at the ward in relation to the number of SSI detected that week. The SSI detected at the outpatient clinic were entered the week the patient had most days at the hospital.

DATES	Average number of patients per week	SSI identified at hospital	SSI identified at OPC
20.7 - 27.7	36.8	0	0
28.7 - 3.8	33.4	5	0

4.8 – 10.8	37.7	0	0
11.8 – 17.8	38.7	3	3
18.8 – 24.8	41.0	3	3
25.8 - 31.8	39.3	4	1
1.9 – 7.9	40.3	4	3
8.9 – 14.9	39.4	3	3
15.9 – 21.9	42.0	2	2
22.9 - 28.9	43.4	6	3
29.9 – 5.10	41.0	2	2
6.10 – 12.10	47.0	1	2
13.10 – 19.10	42.0	1	0
20.10 – 26.10	41.3	2	0
27.10 – 2.11	43.1	4	0
3.11 – 9.11	45.0	3	0
10.11- 16.11	42.9	2	2
17.11-23.11	43.7	3	3
24.11-30.11	39	1	0
1.12 – 7.12	Unknown	0	1
TOTAL		49	28

9.3 About the risk factors

The chance of bias in the choice of which risk factors to include for study is slim. The choice of risk factors included were based on recommendations in the field. The data collection forms were made before the study start. All the needed information, except some of the wound classifications, were available in the patient's records. The wound class was given in some, but not all the surgical records. Missing classifications were determined by the investigator, according to the classification shown in Table I, by using the description of the operation found in patient journal. The surgeon was consulted if necessary.

There is subjective elements in the determination of some of the variables. This might have led to misclassification. Misclassification of ASA scores were shown in one study.[30] It was not possible to validate the classifications in this study. It was however observed that some patients classified with good nutritional status seemed obese to the investigator.

The correctness of the copied data was always rechecked twice.

9.4 Changes from the research protocol

Four changes were made from the protocol. It was stated in the protocol that the patient's HIV status would be recorded. The HIV test had to be paid by the patients and was usually not mandatory. Most of the patients chose not to take the test. The investigator had no means to influence the decision to take the test.

It was originally intended to identify all the pathogens and their resistance pattern. Due to the lack of funding this objective was initially dropped. KCMC reported that swabs were routinely taken of all infected wounds. The head of the surgical department appointed one experienced lab-technician to analyze all the tests. This objective was therefore re-included into the protocol.

The investigator noticed that several of the patients had a lower hemoglobin level than expected. This factor was therefore included in order to see if a low hemoglobin level would influence the risk for SSI.

Based on information given from the general surgical ward, it was estimated that about 650 patients would be included in the study. In the end 396 patients were followed up. All the patients that underwent an operation were included. The expected number was not reached due the fact that operation theatres were lent out to other departments (their theaters were being renovated).

9.5 Strengths and weaknesses of the study

A strength of this study is that it contributes to fill a gap of knowledge regarding SSI and its related risk factors at KCMC. In addition the pathogens and their resistance pattern were identified. All the objectives of the study were met.

This study was carried out over a period of five months and received a lot of attention from the staff. The investigator noticed an increasing awareness and interest in the field of infection prevention. The investigator was invited to speak about the study and infection control at both the school of nursing and for nurses at different departments at KCMC. After the lecture given to the nurses at S1, several infection prevention measures were improved.

A possible weakness of this study was that only 36% of the patients were seen after discharge. Some SSI might have been missed because of lack of follow up. The low number of patients seen after discharge might have affected the statistical power to detect weak associations. As has been argued earlier most of the SSI were probably detected.

This study was conducted during the winter months. The air is colder and dryer than during the rest of the year. It is recognized that seasonal variations exist in some disease patterns. It was not possible in this study to record whether seasonal variations had an effect on the magnitude of the SSI rates.

There are other variables that could have been included into this study. It would have been interesting to record the preoperative shaving for each patient, coexistence of a remote infection and a surgeon identifier. It was, however, difficult to include more variables than those used, due the fact that they were not documented in the patient's record.

10.0 CONCLUSION

This study has identified the SSI rate at the general surgical ward at KCMC to be 19.4%. Several of the infections first appeared after discharge from hospital. This indicates that in countries with fewer resources a post discharge surveillance is important for getting a more accurate SSI rate.

Wound class, an operation lasting for more than fifty minutes, longer preoperative stay, colon surgery, amputation and varicose veins operation, were risk factors for infections diagnosed at the hospital. Having undergone a clean-contaminated operation was the only variable associated with SSI identified at the out patient clinic. The alteration in risk factors for SSI diagnosed during hospital stay, when compared to those apparent first after discharge, implies that surveillance focusing only on high risk hospital patients will miss identifying those infections that develop after discharge.

Most of the patients that developed SSI received antibiotics in relation to surgery. One would expect a lower SSI rate when antibiotic prophylaxis is given. Our findings suggest the opposite and a reevaluation of antibiotic prophylaxis routines.

Hand washing is viewed as the single most efficient way to prevent the spread of infection. The frequency of hand washing could be improved at the department of general surgery. Different means to improve the rate of hand washing should be discussed.

In spite of the loss of follow up (only 36% were seen at the out patient clinic) and that the mean number of days followed up was about ten days, the results of this study give an insight into the problem of SSI.

The identified SSI contributed to increased morbidity, mortality and cost. The average hospital stay increased with 7.5 days for those who developed a wound infection. In addition to the cost of extra hospital days there is also the cost of additional treatments. The cost is not specified here but it can be stated that surgical infections do increase the expenses both for the hospital and for the patients.

This study identified a relatively high SSI rate and several antibiotic resistance pathogens. The study demonstrates the need for surveillance and reevaluation of the infection prevention measures. Hospital hygiene should be given more attention by the government and hospital administrators in Tanzania, since surveillance and prevention programs are reported to be highly cost efficient.

Surgical site infections at Kilimanjaro Christian Medical Center

H.M. Eriksen*, S. Chugulu§, S. Kondo§, E. Lingaas¤.

**Department of General Practice and Community Health, University of Oslo. ¤ Department of Infection Control, Rikshospitalet Norway, § Department of General Surgery, Kilimanjaro Christian Medical Center, Tanzania*

Correspondence can be sent to:

Hanne-M. Eriksen, International Community Health. Department of General Practice and Community Medicine. University of Oslo. Kirkevn 166. 0407 OSLO, Norway.

Summary: A five-month prospective surveillance study of surgical site infections (SSI), an indicator of healthcare quality, was conducted at the department of general surgery at Kilimanjaro Christian Medical Center (KCMC), Tanzania. SSI were classified according to Centers for Disease Control (CDC) criteria and identified by active bedside surveillance and post discharge follow up. This study showed that 77 (19.4%) of the patietns developed SSI. There were 396 operations on 388 different patients included. Twenty eight (36.4%) of these infections were apparent only after discharge from hospital. Another finding was that 87% of those who developed SSI had received antibiotic prophylaxis. Significant risk factors for developing SSI during hospital stay were: operations classified as contaminated or dirty, operations lasting for more than 50 minutes, and the length of preoperative stay. The only significant risk factor for those who developed SSI after discharge was having undergone a clean-contaminated operation. Staphylococcus aureus was the most frequently isolated microorganism followed by Escherichia coli and Klebsiella spp. Most of the pathogens identified were multi-resistant. An exception was S. aureus where 54.5% of the isolates were sensitive to all the tested antibiotics.

This study has shown that the incidence of SSI and the prevalence of antibiotic resistance in this teaching and tertiary level care hospital are high. The risk factors were similar to those reported from countries with more resources. The finding of this study suggest that infection prevention measures could be re-evaluated.

Keywords: Surgical infection; surgical site infection; Tanzania; risk factors; antibiotic resistance

INTRODUCTION

Nosocomical infections increase the morbidity, mortality and expected economic burden of hospitalized patients. SSI is the most common nosocomial infection among surgical patients. In the studied literature SSI is reported as the second or third most frequent nosocomial infection in the general hospital population. A study from the USA showed that patients who develop SSI on average had five extra hospital days, and was five times more likely to be readmitted to hospital and reoperated than those without infection. Patients infected with a hospital acquired infection were also reported to be twice as likely to die during the postoperative.[1]

Few studies have been conducted in countries with fewer resources regarding the consequences of SSI. A study from a hospital in Ethiopia estimated that each patient with postoperative infection cost at least 100 US dollars extra and it is reported that 14 of 18 deaths among surgical patients were attributed to nosocomial infections.[2]

Incidence studies of SSI, its related causes and the control measures needed in African countries are few, but they nonetheless illustrate the enormous health and economic burden of wound infections. In USA the SSI rate is estimated to be 2.8%[3], while reported rates from African countries range from 16%[4] to 38.7%.[5]

It is recommended to include risk factors for SSI in surveillance.[6] Patient related risk factors for developing SSI are often beyond the control of the surgical team. It is nevertheless important to identify these factors, to be able to target high-risk patients who need specific prevention measures. Factors like old age, wound class and severity of underlying disease (captured by American Society of Anesthesiologist (ASA) score) are identified by several studies conducted in developed countries as risk factors for SSI. If and to what extent these factors are significant in countries with less resources are unknown.

Governments, external funding agencies and international health organizations are increasing pressure on hospitals to improve patient outcomes and reduce cost. Nosocomial infection surveillance and prevention programs are reported to be highly cost efficient. [7] To create an effective hospital infection prevention program, information about local patterns is reported as essential.[8] Such data is useful for individual hospitals as well as for national health care planners in setting program priorities, monitoring effects of different preventive actions and in setting goals for their infection control efforts.

The main objectives of the present study were to identify the incidence of SSI and the associated risk factors. Specific objectives were to identify the aetiology agents, their resistance patterns, and to find out if the rates of SSI would be influenced by feedback to the staff concerning both SSI rates found and observations concerning hygienic practices.

PATIENTS AND STUDY AREA:

Surveillance of SSI was performed in the 35 bed department of general surgery at KCMC, a 500 bed referral hospital, established in 1971. The hospital is located right outside the town of Moshi on the slopes of Mt. Kilimanjaro. KCMC is the zonal referral hospital for the Northern Tanzania and is the second-largest hospital in Tanzania. It is one of four referral hospitals. The current in patients occupancy is 110%, in addition more than 500 outpatients seen each day.[9]

The department of general surgery consists of three operating rooms (one is allocated for dirty operations), an intensive care unit and four patient rooms (two four patient rooms and two ten patient rooms). There is also a special room were patients with burn injury is kept. This room is planed as a special burn unit, but during the study period it's function was to separate the burn patients from the other patients. There is also a separate room for paediatric cases in the paediatric ward.

METHOD

A prospective incidence surveillance was conducted. All patients that underwent surgery in the department between 20th of July and the 20th of November were included in the study.

Orthopedic, urological and gynecological operations were performed at other surgery units and were not included in this study. A patient was defined as having had an operation when the following had occurred: they were taken to the operating theatre, given anesthesia and an incision was made. The wounds were observed 30 days after surgery for the development of SSI. Other nosocomial infections were not recorded.

The following information was recorded on a pre-printed data collection form, developed using the Center for Disease Control and Prevention's (CDC) recommendations on SSI surveillance: sex, age, admission, operation and discharge date, type of operation (emergency or elective), wound class, National Nosocomial Infections Surveillance system (NNIS) operation codes, ASA score, hemoglobin level, nutrition status, duration of the operation, number of operation in last thirty days, if a drain was inserted, HIV status, and type and timing of antibiotic prophylaxis.[6] These factors, except HIV status (difficult to obtain), were later entered for further statistical analysis. An exception from the guidelines was that a surgeon identifier was not used or recorded. All the data collected was available in the patient record's.

SSI was classified according to CDC criteria without modifications.[6] Patients were assessed for systemic (e.g., fever, chills) and local (e.g., pain, redness, warmth, swelling, purulent drainage) signs of infections. The investigator performed bedside surveillance five days a week, including examination of surgical incision during dressing changes, participation in ward rounds, and review of patient records and laboratory results. Patients readmitted to the hospital were also surveyed for infections.

If one patient had two operations more than thirty days apart each operation was recorded independently of the other. If the second operation was a result of SSI it was recorded as a consequence of the SSI. If reoperated for reasons other than SSI, the total number of operations within thirty days was recorded as a potential risk factor. The patient was followed up thirty days after the first operation.

All patients received an appointment for a post-discharge examination at the outpatient clinic. The investigator examined the healing incision. It was found to be logistically difficult to follow up those patients that did not attend the post-discharge check up.

If SSI was present, the type of SSI according to the CDC criteria, date of onset, and the microorganism(s) cultured were reported. The treatment given, readmission and re-operation were documented.

Specimens were obtained with sterile swabs using an aseptic technique, and stored in Stuarts transport medium. The swabs were then inoculated on blood or MacConkey agar. Type of identified pathogen and equipment available determined which types of antibiotic sensitivity tests that would be run. Testing for vancomycin resistance was not performed. Stokes method for defining resistance was used. According to this method was the sensitivity reporting system as follows: 1. A phatogen was defined as sensitive when the test organism zone of inhibition was equal or greater than the zone of the Standard organism. 2. Intermediate, was defined when the test organism zone of inhibition was less than the zone of Standard organism by 3mm or more. 3. A pathogen was defined as resistant when the test organism showed no zone of inhibition at all. Muller/Hinton agar and Isoseus were the medium used in sensitivity testing.

All growth media were locally made from commercially available powder and prepared according to the manufactures instruction. Analysis were done manually by an experienced laboratory technician at KCMC using a magnifying glass and a measurer.

The results were analyzed using SPSS for Windows, Release 9.0 (SPSS Inc). Patient characteristics in relation to SSI were compared with Chi-square. Associations between SSI and all other possible risk factor variables were sought by calculation of Odd's ratio using univariate logistic analysis. Predictors of SSI were identified from multivariate logistic analysis with backward elimination. The model was built up by entering all variables that had significant or close to significant association ($p<0.25$) with SSI in univariate analysis.

RESULTS:

This study included 396 operations on 388 different patients (179 women and 217 men). The mean age was 31.4 (range 0.1 to 85 years). The mean age was similar in both men and women. Several of the operations were elective 271 (68.4%) and 36 (9%) of the operations were trauma related. Most of the patients 229 (57.8%) had their operation either on the day of admission or the day after. The mean preoperative stay was five days (range 0-85).

The most common procedures performed were lapratomy (15.4% of the operations), appendectomy (15.4%), hernia repair (8.8%), colon surgery (8.3%) and thyroidectomy (8.1%). Plastic, paediatric and cardiothoracic operations were also frequently performed.

Of the 396 operations included in our study did 77 patients (19.4%) developed SSI after surgery. Twenty eight (36.4%) of the infections were diagnosed after discharge on the outpatient clinic. According to the CDC definition 53 (68.9%) of the infections were superficial, 16 (20.7%) were deep and eight (10.4%) involved an organ or space. The total incidence of SSI was outlined as follow: clean 34/216 (15.6%), clean-contaminated 24/135 (17.7%), contaminated 10/27 (37%) and dirty 9/18 (50%).

The average number of hospitalized patients during the research period was 41, six more than the calculated capacity. The mean number of female patients was 20 and 21.5 for men. An increase of SSI was not identified in those weeks with higher number of patients than average on the ward.

The SSI rate reported after the first two months of the study was 16%. Twelve of the SSI were identified during hospitalisation. At this point only 100 patients had been followed for thirty days.

Several known risk factors for SSI turned out statistically significant in this study. The best predictor for SSI was having undergone a contaminated or dirty operation. The numbers of SSI for the different variables can be seen in Table I. The SSI risk increased with the duration of the operation. Operations lasting for more than 50 minutes were associated with SSI, more frequently than shorter operations. All the preoperative stay categories were associated with SSI in the multivariate analyze. Those with a preoperative stay of more than six days had the highest risk of SSI. There was a significant difference between the mean preoperative stay for those who developed an infection (about eight days) as compared to those who did not develop an infection (two days). Procedures involving the colon, amputations or vascular operations were also found to be significantly associated with infection. The infection rate per NNIS procedure can be seen in Table II.

The above mentioned risk factors were significant for the SSI diagnosed at the hospital as well as for all the infections seen together. None of these factors were associated with post-discharge SSI. The only variable associated with SSI diagnosed at the outpatient clinic was clean-contaminated surgery. There was no significant difference between men and women.

Antibiotics were given in 300 of the 396 included operations. Of the 77 patient that developed SSI did 67 (87%) receive antibiotic. Most of the patients were given a combination of two or three different antibiotics. Antibiotic prophylaxis was usually prescribed and given after the operation. was five days (range one-14 days). The median time for the initiation of antibiotic treatment was 3.5 hours after the operation (range 24 hours before and 24 hours after incision). Six patients received antibiotics just before undergoing surgery. The most frequently used antibiotics were gentamicin 138 of the patients (34.8%) received it and ampicillin that was given to 91 patients (22.9%). In the univariate analysis antibiotic treatment longer than five days was significantly associated with development of SSI. Duration of antibiotic was not significant in the multivariate analysis.

A positive culture was obtained from 59 out of 77 infected wounds. Tests were not performed on the rest of the wounds because of previous antibiotic treatment. As seen in Table III, S. aureus was the most frequently isolated microorganism followed by E. coli and Klebsiella spp.

Of the 59 positive cultures 40 were pure and 19 were mixed growth cultures. Eighteen (30.5%) of the 59 positive cultures were sensitive to all tested antibiotics. Twelve out of the 18 sensitive positive cultures were S. aureus. Table III shows the number of different pathogens identified and their resistance patterns. Table III also shows that with the exception of S. aureus, the other identified pathogens were often resistant to the tested antibiotic. Four of the coagulase-negative staphylococci were resistant to all available antibiotics. The pathogens were most frequently resistant to ampicillin and chlorampheicol, followed by tetracycline, cotrimoxalzole and gentamicin.

As showed in Table IV the mean length of postoperative hospital stay 5.4 days for those without an infection (range 1-30) and about 13 days for all those with SSI (range 1-64 days). The mean postoperative stay for the 49 patients that developed SSI while hospitalized was 18 days. The mean number of days at the hospital was similar for the different type of SSI.

Antibiotic treatment for the infection was given to 47 of the 77 patients that developed SSI. Six patients with SSI were readmitted, eight were re-operated and two deaths can be associated with the infection.

TABLE I. The number of patients and SSI distribution per variable included in this study. The odd's ratio is given for the univariate and multivariate analysis.

VARIABLES	N* TOTAL (SSI CASES)	ODD`S RATIO (95% CI) univariable anal.	P-value for the univariable analysis	ODD`S RATIO (95% CI) Multivariable
Age 0-18 years	121 (24)	Reference cat.	Reference cat.	
Age 19-40 years	146 (24)	1.2 (0.7-2.3)	0.472	
Age 41-100 year	129 (29)	0.9 (0.5-1.6)	0.609	
Male gender	217 (46)	Reference cat.	Reference cat.	
Female gender	179 (31)	1.3 (0.8-2.1)	0.332	
ASA 1	224 (36)	Reference cat.	Reference cat.	
ASA 2	99 (26)	0.5 (0.3-0.9)	0.034	
ASA 3	63 (11)	0.9 (0.4-1.9)	0.792	
ASA 4	9 (4)	0.2 (0.6-0.9)	0.039	
ASA 5	1 (0)	34.5 (0.0-1.1 E)	0.793	
0 days preop.	56 (6)	Reference cat.	Reference cat.	Reference cat.
1 day preop.	173 (34)	0.5 (0.2-1.2)	0.132	0.3 (0.1-0.8)
2-6 days preop.	95 (19)	0.5 (0.2-1.3)	0.144	0.3 (0.1-0.8)
> 6 days preop.	72 (18)	0.4 (0.1-0.9)	0.045	0.2 (0.1-0.6)
Oper. 0-45 min.	134 (15)	Reference cat.	Reference cat.	Reference cat.
Oper. 50-85 min.	124 (26)	0.5 (0.2-0.9)	0.034	0.4 (0.2-0.9)
> 85 min.	138 (36)	0.4 (0.1-0.7)	0.002	2.3 (0.2-0.7)

No antibiotics	99 (10)	Reference cat.	Reference cat.	
AB 1-4 days	84 (13)	0.6 (0.3-1.5)	0.277	
AB 5 days	164 (37)	0.4 (0.2-0.8)	0.012	
AB 6-15 days	49 (17)	0.2 (0.1-0.5)	0.000	
Elective opr.	271 (49)	Reference cat.	Reference cat.	
Emergency opr.	125 (28)	0.8 (0.5-1.3)	0.312	
No drainage	176 (26)	Reference cat.	Reference cat.	
Used drainage	209 (51)	0.5 (0.3-0.9)	0.013	
Clean opr.	216 (34)	Reference cat.	Reference cat.	Reference cat.
Clean-cont. Opr.	135 (24)	0.9 (0.5-1.5)	0.617	0.9 (0.5-1.6)
Contamin. Opr.	27 (10)	0.3 (0.1-0.7)	0.009	0.2 (0.1-0.5)
Dirty operation	18 (9)	0.2 (0.1-0.5)	0.000	0.1 (0.0-0.3)
NNIS- COLO	33 (15)	0.3 (0.1-0.9)	0.348	0.1 (0.0-0.9)
NNIS- AMP	10 (5)	0.2 (0.0-1.1)	0.063	0.1 (0.0-0.6)
NNIS- VS	3 (2)	0.1 (0.0-1.5)	0.093	0.1 (0.0-0.9)
Hgb >167	195 (43)	Reference cat	Reference cat	
Hgb 33-167	185 (28)	0.6 (0.4-1.1)	0.0856	

Only variables with significant or close to significance association (p<0.25) in univariate analysis were included in the multivariate analysis.

Variables that were not significant in the multivariate analysis are not in the table.

Abbreviations used in the table: opr.: operation, AB: antibiotics, min.: minutes, preop.: preoperative hospital stay. The NNIS categories can be seen in table two. Only significant NNIS categories is included in this table.

TABLE II. The total number of patients and SSI for the most common NNIS categories.

	AMP	*APPY*	***CHOL***	COLO	**CRAN**	***SKGR***	*VS*	*XLAP*	*HER*	*OMS*	*HN*
N*	10	61	15	33	23	13	3	61	32	29	32
(SSI	(5)	(8)	(3)	(15)	(4)	(4)	(2)	(16)	(3)	(4)	(3)

cases)											
SSI % ¤	50%	13%	20%	45%	17%	31%	67%	26%	9%	14%	9%

N*: The total number of patients in the NNIS category

¤ The percentage of the total number in a NNIS category that developed SSI.

Amp=amputation, Appy= removal of appendix, Chol= cholecystectomy, Colo= colon surgery, Cran= craniotomy, Skgr= skin grafting, Vs= vascular surgery (venouse vains), Xlap= exploratory laparotomy, Her= hernia repair, Oms= other surgery on musculoskeletal system, Hn= Incision of the larynx or trachea

TABLE III. Antimicrobial susceptibilities of bacteria isolated from the surgical wound. The number of resistant pathogens identified is given first. The total number of bacteria tested for the antibiotic is in brackets.

	S. aureus N* 22	*E. coli* N*12	***Klebsiella*** N*12	***Psudomonas*** N*9	*Coliform* N*9	Coag.neg staph. N*8	*Proteus* N*6	Enter-Coccus N*3
Amp	--	8 (9)	9 (9)	0 (1)	5 (9)	--	3 (5)	2 (2)
Gent	1 (18)	1 (10)	4 (10)	1 (9)	3 (9)	5 (7)	2 (6)	--
Chlor	4 (14)	4 (8)	9 (11)	--	4 (7)	5 (8)	5 (5)	--
Clox	1 (11)	--	--	--	--	5 (6)	--	--
Erythro	3 (18)	--	--	--	--	5 (7)	--	1 (2)
Tetracy	1 (5)	4 (4)	7 (11)	--	3 (4)	3 (3)	3 (3)	--
Amika	0 (1)	0 (3)	0 (1)	0 (1)	0 (2)	4 (4)	0 (3)	--
Cotrim	--	4 (4)	3 (2)	--	4 (6)	5 (5)	--	--

Carbenic	--	--	--	8 (9)	1 (1)	--	--	--
Trimeto	1 (1)	--	--	--	--	--	--	--
Polymix	--	--	--	2 (9)	0 (1)	--	--	--
Ciprofla	--	1 (5)	2 (3)	4 (7)	3 (4)	--	--	--
Metacil	0 (3)	--	--	--	--	--	--	--
Penicil	--	--	--	--	--	2 (2)	--	--

¤N*: The total number of bacteria identified

The full name of the antibiotics starting from the top is: ampicillin, gentamicin, chloramphenicol, cloxacillin, erythromycin, tetracycline, amikacin, cotrimoxazole, carbenicillin, trimethoprim, polymixin B, ciprofloxacin, metacillin, penicillin

TABLE IV. Postoperative length of stay (in days): mean with standard deviation (SD) in patients without and with postoperative infection.

Patients	N*	Mean post operative length of stay in days	SD¤
Without infection	319	5.4	5.8
With infection	77	12.9	13.8

* Total number

DISCUSSION

Differences in methodology call for great care in comparing SSI rates in different countries. A rate of 19.4% is high compared to results from countries with more resources, but not when compared to SSI rates found in other African countries.

Different factors affect the SSI statistic in this study. Low attendance at the outpatient clinic (142 (36%) were not seen after discharge) and the low number of follow up days (10.5 days on average), indicates that the actual infection rate might be even higher than 19.4%. The mean hospital stay for those not seen after discharge was six days. Studies have shown that over 50% of the infections occur within the first week after operation, and about 90% within two weeks.[10] Several patients live far away from the hospital. This makes it more convenient for many to seek help at a nearby health center for postoperative problems. Patients with more sever infections would most likely be transferred to KCMC.

Our rate of post discharge SSI was 36.4%, a figure greater than the 14% reported in one study[11], but less than the 87.5% found in an other.[12] These differences may be reconciled in parts by the different surveillance methods used.

There was a slightly pattern among patients that did not attend post discharge visit. Those with a shorter operation and with fewer hospital days pre- and postoperative were more likely not to attend the clinic. Those that did not attend the outpatient clinic had a significant lower mean duration of the operation and mean number of postoperative days. There were slightly more of those between 19 and 29 years that did not attend the post discharge visit. In the studied literature fewer preoperative hospital days and shorter duration of the operation are less associated with SSI than longer duration. There are also usually reported fewer infections in the age group 19-29 years. This supports the argument that not too many infections were unidentified.

The investigator did not visit the ward during the weekends. It is however unlikely that SSI were missed because of this. Patients were usually not being discharged if SSI was present and it was never observed that SSI appeared before the third postoperative day.

Different patient related factors and hygienic principles in the health care setting could have an effect on the SSI rate. Some of these factors will be briefly discussed here.

The Kilimanjaro region is one of the regions in Tanzania with the highest rates of HIV cases. The HIV prevalence in 1998 among pregnant women was reported to be 19.9% in urban Moshi.[13] Researchers have reported an increased SSI risk among people with a HIV infection.[14] The high prevalence of HIV infection in the area might have influenced the results. HIV statuses were not included in the statistical analyze, since this status were unknown for the majority of the patients.

The nutritional status of the patients might influence the rates of SSI. About 70% of those included in the study were classified by the anesthesiologists as having a good and only 2.5% as having poor nutritional status (the remaining were categorized as obese or fair nutritional status). It is likely that this factor did not contribute to the number of infections.

Several of the CDC recommended actions[6] to prevent SSI was not applicable to KCMC. The CDC recommendations are valuable, but need to be adjusted to the situation in countries with fewer resources. To which degree lack of ventilation system in the operation theatre, re-sterilization and reuse of equipment, like dressing pads and gloves, extensive use of "flash sterilization" (here understood as boiling of operation instruments between operations) and preoperative shaving the evening before the operation influence the SSI rate at KCMC is unknown.

Hand washing is often mentioned as the single most important way to reduce the spread of infections. Knowledge of infection prevention is usually not emphasized in the health professions training in Tanzania. Many of the staff were unfamiliar with different infection prevention means such as the importance of hand washing. The frequency of hand washing was low. It was common to dress wounds without washing hands before or after the procedure. Given the lack of quality equipment for hand washing (only soap bars were available, one had to continuously press the knob on the basin while washing and the towel used to dry hands often hung for days) it is understandable that compliance with hand washing often was poor.

CDC recommends that operating rooms should be maintained at positive pressure with respect to corridors and adjacent areas. There are also several recommendations related to filters, air exhaust and air changes.[6] These recommendations were not met at KCMC. There is no ventilation system in the operating theatres. To maintain air quality one or both of the doors between the operation theater and the surrounding hallways were kept open during surgery.

Surveillance of SSI with feedback of appropriate data to surgeons has been shown to be an important component of strategies to reduce SSI risk.[6, 15] In this study the infection rate for the two first months and also some descriptive statistics were presented to the surgeons halfway through the study. The SSI rate at this time was 16%. The final SSI rate was reported to be 19.4%. A possible explanation for the fact that the final SSI rate was higher, is that rates were not given for each individual surgeon and that the time allocated was too low and the number of patients included halfway through was too low (100 patients included).

This study identified a contaminated or dirty operation, operation lasting for more than fifty minutes and preoperative stay, as significant risk factors. Several other studies have reported these variables as risk factors.[16, 17] Procedures involving colon, amputation and varicose vein operations were also associated with an increased SSI risk. It was unexpected to find that as much as 50% of the amputations and 67% of the varicose vein operations became infected. These procedures are classified as clean. The low number of these operations included in this study (ten amputations and three varicose veins) should be taken into consideration. Otherwise this study showed that the SSI rate for clean operations was 15.6%.

In the univariate analysis an antibiotic prophylaxis for five or more days was a significant risk factor for developing SSI during the hospital stay. Several patients received antibiotics hours after the operation. Researchers have shown that a single dose of antibiotic immediately before the incision is the most efficient way to prevent SSI[18]. One would expect patients to be less likely to develop SSI when prophylactic antibiotics were used. Our finding suggest that the antibiotic prophylaxis given was not optimal and therefore could be reevaluated.

Fifty one of 209 patients that had a drain inserted developed SSI. Drains were placed at a distance from the operation site as recommended by CDC. The CDC recommendations state that use of open drains increase the SSI risk.[6] At the department of general surgery drains consist of a plastic pipe covered with a sterile glove. It was frequently observed that the glove fell off and the drain left uncovered for hours.

ASA score is included in the NNIS risk index and is shown by several studies to be a valid predictor of SSI in countries with more resources. In this study higher ASA score was not a significant risk factor in the multivariate analysis. More research should be conducted in countries with less resources to determine the usefulness of the NNIS index in such settings.

None of the risk factors associated with SSI found before discharge were associated with infections detected at the outpatient clinic. This pattern has also been reported elsewhere.[16] This implies that surveillance focusing only on high risk hospital patients, will miss identifying those infections developed post-discharge. The fact that only 205 patients were seen after discharge and only 28 SSI were diagnosed at the outpatient clinic, might have affected the statistical power to detect weak associations.

In this study S. aureus were isolated in 22 of the infections, while E. coli and Klebsiella spp were isolated in 12. More Klebsiella spp infections and slightly less coagulase negative staphylococci were identified in our study than what has been reported to the NNIS surveillance system between 1990 and 1996.[6] One possible explanation for why fewer *coagulase negative staphylococci* was identified, is that this pathogen mainly is associated with implant operations. None implant operations were included in this study. The pattern of identified pathogens is otherwise similar to what is reported elsewhere both in countries with greater and fewer resources.[6, 12]

The occurrence of multi-resistant microorganisms was common. Tests were not taken to identify cross infection, but during a period of one week were four strains of coagulase negative staphylococci identified. They were resistant to all available antibiotics. It is likely that this outbreak was a result of cross infection.

Most of the patients received antibiotics, often broad-spectrum, for several days. Prolonged antibiotic prophylaxis[18] and use of broad-spectrum antibiotics have been reported by researchers to be associated with increased emergence of resistance.[19, 20] The susceptibility data collected in this study suggest that some antibiotics have very limited usefulness for prophylaxis or empirical treatment of SSI.

The use of degraded antibiotic powder and antibiotic disks for susceptibility testing are reported to be common in many laboratories in developing countries. This lead to exaggerated estimates of bacterial resistance levels.[21] If this was the case at the laboratory at KCMC, it is unknown to the investigator.

CONCLUSION

This study identified a 19.4% SSI rate and showed that several pathogens were resistant. Over 36% of the SSI were diagnosed after discharge. To get more accurate SSI rates it is important to include a post discharge surveillance.

Several well known risk factors were associated with SSI in this study. However ASA score was not associated with SSI. The usefulness of the NNIS index in countries like Tanzania should be assessed. The risk factor pattern was different for SSI diagnosed in the hospital and those diagnosed at the outpatient clinic. Having undergone an operation classified as clean contaminated was the only variable associated with SSI that was first apparent after discharge.

The identified SSI contributed to increased morbidity, mortality and cost. The average hospital stay increased with seven and a half days for those who developed a wound infection

(18 days for the 49 patients that developed infection while hospitalized). In addition to the cost of extra hospital days is the cost of antibiotic treatment and reoperation. The cost is not specified here but it can be stated that SSI increase the expenses both for the hospital and for the patients.

The study demonstrates the need for surveillance and reevaluation of the infection prevention measures. Hospital hygiene could be given more attention by the government and hospital administrators in Tanzania, since surveillance and prevention programs are reported to be highly cost efficient.

ACKNOWLEDGEMENTS

Thank you to the director at KCMC Professor J. Shao for permission to conduct this study at the hospital. We appreciated the good cooperation with the administration and their interest in this study and the field of hospital infection prevention.

We also want to show our gratitude to the surgeons and the nurses at S1, P2, the operation theatres and the sterilization ward for their assistance and valuable information. It would have been difficult to conduct this study without their commitment.

A special thank to R.B. Tarnimo and the rest of the employees at the microbiology ward for performing all the analyses of the swabs.

This study was supported by a grant by “EWS stiftelsen” and “Lise og Arnfinn Hejes Fond” .

References thesis

1. Mangram AJ, Horan TC, Pearson ML, Silver LC, Javis WR. Guidelines for Prevention of Surgical Site Infection, 1999. *Infect Control Hosp epidemiol* 1999; **20:** 250-272
2. Britannica.com. Encyclopaedia Britannica. http://www.britannica.com/seo/i/ignaz-philipp-semmelweis/
3. Britannica.com. Encyclopaedia Britannica. http://www.britannica.com/eb/article?eu=120230&hook=616261#616261.hook
4. Nichols RL. Surgical infections: prevention and treatment- 1965-1995. *Am J Surg* 1996; **172**: 68-79
5. Nicholos RL. Surveillance of the surgical wound. *Infect Control Hosp Epidemiol* 1990; **11**: 513-514
6. Ponce-de-Leon S. The needs of developing countries and the resources required. *J Hosp Infect* 1991; **18** (supplement A): 376-381
7. Habte-Gabr E, Gedebou M, Kronvall G. Hospital-acquired infections among surgical patients in Tikur Anabessa Hospital, Addis Ababa, Ethiopia. *Am J Infect Control* 1988; **16**: 7-13
8. Tikomirov E, Mayon White RT, Ducel G, Kereselidze T. An international survey of the prevalence of hospital-acquired infection. *J Hosp Infect* 1988; **11** (supplement A): 43-48
9. Haley RW, Culver DH, White JW, Morgan WM, Emori TG et Al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. *Am J Epidemilol* 1985; **121**: 182-205
10. Danchaivijitr S, Tangtrakool T, Waitayapiches S, Chokloikaew S. Efficacy of hospital infection control in Thailand 1988-1992. *J Hosp Infect* 1996; **32**: 147-153
11. Wenzel RP. The economics of nosocomial infections. *J Hosp Infect* 1995; **31**: 79-87
12. CIA- The World Factbook 2000- Tanzania. www.cia.gov/cia/publications/factbook/geos/tz.htlm
13. Statistik Sentralbyrå Norge 2001. www.ssb.no/
14. Center for International Health Information 1999. www.cihi.com/PHANstat/TANZANIA
15. Klepp KI, Biswalo PM, Talle A. Young people at risk. Fighting AIDS in northern Tanzania. Scandinavian University Press, 1995
16. UNAIDS. Report on the global HIV/AIDS epidemic; June 1998. http://www.unaids.org/unaids/document/epidemio/june98/index.htlm.1998
17. The East Africa Medical Assistance Foundation 1998-99. www.eastafricafoundation.org/eaf.aboutproject/eaf.about.history.1.htlm
18. Santos KRN, Bravo Neto GP, Fonseca LS, Gontijo Filho PP. Incidence surveillance of wound infection in hernia surgery during hospitalization and after discharge in a university hospital. *J Hosp Infect* 1997; **36**: 229-233
19. Moreea S, Rajah F, Rycken J. Pilot study of post operative infections in incisional wounds and split skin grafts in a provincial hospital in Zimbabwe. *Trop Doct* 1993; **23**: 160-164
20. Kotisso B, Aseffa A. Surgical wound infection in a teaching hospital in Ethiopia. *East Afr Med J* 1998; **75**: 402-405
21. Glenister HM, Taylor LJ, Bartlett CL, Cooke EM, Sedwik JA, Mackintosh A. An evaluation of surveillance methods for detection infections in hospital inpatients. *J Hosp Infefct* 1993; **23**: 229-242
22. Gastmeier P, Brauer H, Hauer T, Schumacher M, Daschner F, Ruden H. How many nosocomial infections are missed identification is restricted to patients with either microbiology reports or antibiotic administration?. *Infect Control Hosp Epidemiol* 1999; **20**: 124-127

23. Wilson APR, Helder N, Theminimulle SK, Scott GM. Comparison of wound scoring methods for use in audit. *J Hosp Infect* 1998; **39**: 119-126
24. Lee T, Baker O, Lee JT, Scheckler WE, Steel L, Laxton CE. Recommended practice for surveillance. *Am J Infect Control* 1998; **26**: 277-288
25. Gasmeier P, Kampf G, Hauer T, Schlingmann J, Schumacher M, Dashner F, Ruden H. Experientce with two validation methods in a prevalence survey on nosocomial infections. *Infect Control Hosp Epidemiol* 1998; **19**: 668-673
26. Mishriki SF, Law DJW, Jeffery PJ. Factors affecting the incidence of postoperative wound infection. *J Hosp Infect* 1990; **16**: 223-230
27. Lecuona M, Torres-Lana A, Delgado-Rodrigues M, Llora J, Sierra A. Risk factors for surgical site infections diagnosed after hospital discharge. *J Hosp Infect* 1998; **39**: 71-74
28. Manian FA, Meyer L. Surgical –site infection rates in patients who undergo elective surgery on the same day as their hospital admission. *Infect Control Hosp Epidemiol* 1998; **19**: 17-22
29. Pryor F, Messmer PR. The effect of Traffic Patterns in the OR on Surgical Site Infections. *AORN Journal* 1998; **68**: 649-660
30. Salemi C, Anderson D, Flores D. American Society of Anesthesiology Scoring Discrepancies Affecting the National Nosocomial Infection Surveillance System: Surgical- Site- Infection Risk Index Rates. *Infect Control Hosp Epidemiol* 1997; **18**: 246-247
31. Isaack H, Mibise RL, Hirji KF. Nosocomial bacterial infections among children with severe protein energy malnutrition. *East Afr Med J* 1992; **69**:433-436
32. Petorsillo N, Pugliese G, Girardi E, Pallavicini F, Carosi G, Moro ML, Ippolito G. Nosocomial infections in HIV infected patients. *AIDS* 1999; **13**: 599-604
33. Bayley AC. Surgical pathology of HIV infection: lessons from Africa. *Br J Surg*. 1990;**77**: 863-868
34. Reggiori A, Ravera M, Cocozza M, Mukasa F. Randomized study of antibiotic prophylaxis for general and gynaecological surgery from a single centre in rural Africa. *Br J Surg*. 1996; **83**: 356-359
35. Kunin CM. Evaluation of Antibiotic usage: A comprehensive Look al Alternative Approaches. *Reviews of Infect Diseases* 1981; **3**: 745-753
36. Trudeau M, Kuhr L, Solano-McGuire S. Timing of preoperative prophylactic antibiotics: Old project and still improving. *Am J Infect Control* 1998; **26**: 581-583
37. Okeke IN, Lamikanra A, Edelman R. Socioeconomic and Behavioral Factors Leading to Acquired Bacterial Resistance to Antibiotics in Developing Countries. *Emerg Infec Disease* 1999; **5**: 18-27
38. Coovadia YM, Johnson AP, Bhana RH, Hutchinson GR, George RC, Haffeerjee IE. Multiresistant *Klebsiella pneumoniae* in a neonatal nursery: the importance off maintenance of infection control policies and procedures in the prevention of outbreaks. *J Hosp Infect* 1992; **22**: 197-205
39. Centron GD, Ruiz T, Botto L, Cervetto M, Sarubbi MA, Zorzopulos J. An outbreak of multiply resistant *Pseudomonas aeruginosa* in a neonatal unit: plasmid pattern analysis. *J Hosp Infect* 1989; **14**: 99-105
40. Medina-Cuadros M, Sillero-Arenas M, Martinez Gallego G, Delgado-Rodriguez M. Surgical wound infections diagnosed after discharged from hospital. Epidemiological differences with in-hospital infections. *Am J Infect Control* 1996; **24**: 421-428
41. Huys J. Drastic performance improvement of hand-operated sterilizer. *Trop Doct* 1999; **29**: 224-227

42. Boer AS, Mintjes-de Groot AJ, Seerijnen AJ, Van den Berg JMJ, van Pelt W. Risk assessment for surgical-sit infections in orthopedic patients. *Infect Control Hosp Epidemiol* 1999, **20**: 402-407
43. Harbarth S, Samore MH, Lichtenberg D, Carmeli Y. Prolonged Antibiotic Prophylaxis After Cardiovascular Surgery and Its Effect on Surgical Site Infections and Antimicrobial Resistance. *Circulation* 2000; **10**: 2916-2921
44. Cohen, ML. Epidemiology of Drug Resistance: Implications for a Post-Antimicrobial Era. *Science* 1992; **275**: 1050-1055