WOUND INFECTION AFTER CLEAN OPERATIONS: SOME PREDISPOSING FACTORS AND SURVEILLANCE AT MUHIMBILI MEDICAL CENTER, DAR-ES-SALAAM, TANZANIA.

BY

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CERTIFICATION

The undersigned certify that he has read and hereby recommend for acceptance by the University of Dar es Salaam a dissertation entitled: *Wound infection after clean operations: some predisposing factors and surveillance at Muhimbili Medical Centre, Dar es Salaam, Tanzania,* in partial fulfillment of the requirements for the degree of Master of Medicine, General Surgery.

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DECLARATION

I declare that, this dissertation is original work of my own that has not been submitted to any other university or academic institution for a similar or any other academic award.

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Dedication

To Magodi

A shy person does not learn, nor should

a short-tempered person teach.

Ethics of the fathers, century A.D.

ABSTRACT

OBJECTIVES:

To determine the magnitude of postoperative clean wound infection, some predisposing factors, surveillance, their current pattern and antimicrobial susceptibility among general surgical patients undergoing clean operations.

METHODS

Patients who were scheduled for and had elective clean operations from June 1999 to January 2000 were followed for 30 days. Their demographic data were obtained, wounds examined and those who were found to have infected wounds, had pus swabs obtained for culture. Bacteriological pattern and antimicrobial susceptibility tests were conducted. A study of some predisposing factors was also done.

RESULTS

Of the 476 patients who had clean operations done during the study period, 464 were registered. They comprised of 285 (60.4%) males and 179 (37.2%) females. Sixty(12.9%) patients were clinically found to have wound infection of whom 47(10.1%) had positive cultures. Forty

(85.7%) patients had the diagnosis of wound infection made before discharge and the remaining 7(14.3%) patients were diagnosis as outpatients. Predominantly, the isolates consisted of *Staphylococcus aureas* (36.1%), *Klebsiella spp* (31.2%), *Escherichia coli* (14.8%) and other organisms were less frequently isolated.

CONCLUSION

The magnitude of surgical wound infection obtained is unacceptably high. Prolonged preoperative hospitalization and prolonged operation duration were found to significantly predispose to wound infection. The patients' age and sex, the surgeon's rank, surgical scrub, shaving, and the ward and theatre environment were not found to be statistically significant risk factors. Patients who suffered postoperative wound infection had a significantly prolonged postoperative hospitalization as well.

The operating theatre needs modifications that can suite the requirements of a standard operating suite. Laxity in adherence to the norms of the conduct in the operating theatre was found to exit and it requires emphasis of the continuing education among the theatre personnel. Also a more extensive and long-term study that will

evaluate the risk factors further as well as a surveillance plan that can be suitable in our environment is recommended.

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LIST OF ABBREVIATIONS

B.C.	Before Christ
F.F.A.	Free Fatty Acid
5-HT.	5-Hydroxytryptamine
ESR.	Erythrocyte Sedimentation Rate
UDC.	Unidentified coliforms
Cfu.	colon forming units
CDC.	Centers for Disease Control
IP. No.	In-patient's number
C/s.	Culture and sensitivity
CSD.	Central Sterilization Department

1. INTRODUCTION AND LITERATURE REVIEW

1.1. HISTORICAL BACKGROUND

The history of disease is at least as old as the history of mankind. The basic forms of disease that include tumors, infections, trauma and congenital abnormalities have existed rather unchanged throughout life[1]. Surgery is the treatment option that has been provided in response to these diseases. On the other hand, surgical treatment has been associated with a number of complications and surgical site infection is one of them.

Before the realization that cleanliness was an important factor against infection, surgeons preferred to believe that infection was an act of God rather than the result of their unclean habits[2]. On the other hand most skilled clinicians were convinced that infection of a surgical incision was a favorable sign[3]. In the third millennium B.C. Hippocrates recognized that cleanliness was important[2]. Acceptance of this observation by surgeons and clinicians was not instant[4]. It was not until the middle of the nineteenth century when the theory of antisepsis was proposed. This was pioneered by an American clinician Oliver Wendel Hitmes and Ignaz Philip Semmelweis from Viena in 1847[2,3,5]. Working independently the two physicians observed high mortality among women

hospitalized with puerperal fever. Both also observed a fellow who had been infected during participation in an autopsy of an infected subject. It then came to their attention that infection was being transmitted directly and both urged washing of hands and changing of clothing. After the institution of this practice there was a subsequent decrease in maternal mortality from 11.4% in 1846 to 1.3% in 1848[5].

The discovery of the microscope by Leeuwenhoek[3] in 1673 laid a foundation towards the identification of infectious agents[3]. Pasteur employed it to correctly correlate infection and putrefaction for growth and proliferation of microbes[3]. Therefore this formed a very important step and marked the first phase of the scientific approach to wound infection. In addition, some methods of prevention were realized. Jenner in 1798 described the scientific basis of immunization[3]. As part of this development phase, Joseph Lister, in 1867 applied Pasteur's principles to clinical surgery[3,4]. He used carbolic acid to prevent exogenous contamination and infection in a compound fracture of the tibia.

Koch in 1878 further described the relationship of inflammation to bacterial infection. Again, Kocher in 1883 stressed the role of direct

contamination in the causation of operative infections. Further progress was made by Halsted, an American surgeon, who introduced surgical gloves. He also emphasized the use of meticulous surgical technique as a way of preventing infection[3,4]. Von Bergman in 1891 converted the antiseptic technique into an aseptic one[3,4] by introducing the use of autoclaves and aseptic surgery. This resolved the controversy of whether cleanliness was important or not in the prevention of infection[5].

The second phase of development against infection is rather recent. This is based on effective systemic antimicrobial treatment[3]. In 1928, Alexander Fleming discovered penicillin[2,3] but, his discovery was ignored until 1940 when Florey and Chain introduced the clinical application of penicillin[3]. Seven years after the discovery of penicillin, Domagk, while working on aniline dyes discovered a variety of active compounds that proved to be the progenitor of the sulfa drugs[3]. These were put into clinical practice.

Inspite of these developments, the control of surgical wound infection has remained incomplete. The mainstay of the control is based on the surveillance of those patients operated. In history, surveillance is generally considered to have started in England in the fourteenth

century. This was by Edward I who kept records of people with leprosy so that, they could be expelled from the city of London. By the end of the 19th century, England started a statutory notification system, which followed the outbreak of plague[6]. When introduced the formal notifications were being sent by post on a standard form. Later development in the means of communication allowed reporting of suspected urgent cases by telephone, fax or even modem. Overall this was a community-based surveillance of diseases and it involved both the public health as well as local authority personnel.

At the same time, efforts to control infection in hospitals were going on. There were several fever hospitals which were built. However, with the advent of antibiotics and immunization which took place later, the need for infectious disease hospitals fell. Effective treatment of the infections was therefore being made possible by the use of antibiotics. Despite these changes, patients still acquired infections in the community and in hospitals. And more important was the development of antibiotic resistant bacteria following their use, and these were responsible for hospital infections. In Europe and the States, various professional bodies were established for the aim of infection control[6].

More efforts having been put forward in the 1990's, more efficient methods of surveillance aided by more efficient means of communication made possible the identification of risk factors, preventive and control measures as well as the more accurate means of defining the problem of post-surgical infection.

It was realized that, operations that involved the colon were being associated with high morbidity and mortality because of sepsis[4]. The danger of contamination by patients' own flora came to be recognized as a serious surgical risk, and it is this realization that led into classification of wounds depending on the level of contamination.

The problem of postoperative wound infection therefore is a long term one having had survived ever since the history of man, and still affects many patients.

1.2 STATEMENT OF THE PROBLEM

Postoperative wound infection is one of the nosocomial infections that affect the surgical patient. When it occurs, it threatens the outcome of all forms of surgery. The effects it poses range from a mere nuisance to

disastrous or major disturbances such as delayed wound healing, wound dehiscence, and systemic spread of the infection. Furthermore it prolongs suffering for the patient and creates a risk of spreading the infections to other patients. There is also an associated extra cost as a result of prolonged hospitalization, antibiotics and the overall care of the infected wound as well as its complications.

What leads to surgical wound infection has been a matter of speculation. On review of literature, there is scanty published data to define the magnitude of this problem in Tanzania, though a 6.6% incidence was reported in 1973 in Dar-es-Salaam[7]. The factors that lead to wound infection in our setting and the follow-up of these patients remain individualized to the attending physician.

Several studies report the clean wound infection rate to range between 1.0 and 5.0% [3,4,13,17,18,19]. In a Nigerian study done in 1992, the clean wound infection was found to be 2.0%[8]. As such, this problem affects patients worldwide and is of variable proportions.

It was therefore the concern of the author that, there was a need for establishing the local data that would be useful in the understanding of

the magnitude, underlying factors, and the microbiology of postoperative wound infections. The presence of this data would form a foundation through which surveillance, prevention and control of this problem could be tailored. In addition, future studies can refer to this study as a basis for further, more extensive work.

1.3. DEFINITION OF POSTOPERATIVE WOUND INFECTION

It has been traditional to equate sepsis with infeciton[9]. This is rather unfortunate. The term infection should be used etiologically for disease that is caused by both proliferation of microbes and invasion of body spaces. Sepsis, on the other hand, denotes the physiological response to illness; which may be infection. Essentially it is the host response to any severe illness[9].

In 1961, Barnes et al, while working on abdominal wall incisions defined sepsis as an inflammation of the abdominal wall incision of unusual degree requiring local or systemic treatment or associated with a febrile response or leukocytosis or prolonged hospitalization. He referred to this as minor sepsis. Sepsis was classified as major if the abdominal wall incision or peritoneal cavity or both were associated with spontaneous

or surgically induced purulent drainage greater than a few drops of the discharge. In this category also were included intra abdominal inflammatory masses and abscesses. In both minor and major sepsis positive cultures were not a requirement for diagnosis[10].

In 1964 Ljunquist and Lund defined wound infection as a clear collection of pus, which empties itself spontaneously or after incision[11]. A similar account was made by Brötte et al in 1976[12]. In their definition they did equate infection and sepsis. It is important to note here again that, not all wounds with purulent discharge are infected; abacterial wound sepsis has been reported[9]. However the importance of infection as a cause of purulent discharge should not be underestimated. In 1982, Garner considered all wounds with purulent discharge as infected even without the confirmation of a positive culture[13]. The argument here is based on the reasons that a negative culture can occur as a result of culture technique inadequacy, presence of fastidious organisms or in a patient who has received antimicrobial therapy. On the other hand positive cultures do not necessarily mean infection as many wounds, infected or not, are colonized by bacteria[13,14]. From an epidemiological point of view, therefore, a wound is infected if it suits the clinical definition.

Recent reports emphasize the importance of a positive culture. The Infection Control Professionals (ICPs) in hospitals in Australia define surgical wound infection as an infection within 30 days after the operative procedure, plus purulent discharge, plus isolation of organisms from a culture from the incision site, plus diagnosis by a medical officer[15]. The Centers for Disease Control (CDC), however, considers a wound to be infected if the patient has at least one of the following[16]:

a. purulent drainage from the superficial incision;

b. organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision;

c. at least one of the following signs or symptoms of infection:

- pain or tenderness
- localized swelling
- redness or heat and
- surgeons deliberately open superficial incision, unless the incision is culture-negative;

d. diagnosis by the surgeon or attending physician;

e. 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 (38^0C), or
- localized pain or tenderness, unless incision is culture negative;

f. an abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation or by histopathologic or radiologic examination.

Time scale[17] can also be used to define wound infection. The infection is early if it presents within 30 days of operation; intermediate if between one and three months and late if presenting more than three months after surgery.

Wound infection in this context, therefore, would mean the invasion and multiplication of microorganisms in or on a surgical wound producing cellular injury that results into purulent drainage and an organism identified by culture is present[16].

1.4. CLASSIFICATION OF SURGICAL WOUNDS

The risk of postoperative wound infections is closely related to the type of operation performed and hence the type of the resulting surgical

wound. Five types of surgical wounds are defined and they include the following[3];

1.4.1. REFINED CLEAN WOUNDS

These are surgical wounds that are uninfected, no inflammation is encountered and there is no entry into the respiratory, alimentary or genitourinary tract. Most important is that, these are wounds which are found in anatomic areas that can be thoroughly and meticulously prepared[3]. They are usually not adjacent to an endogenous source of bacteria.

The source of bacteria causing infection in such wounds is commonly the patient, and also occurs as a result of airborne contamination or secondary to break in operating room sterile conduct[3]. They are mostly caused by gram-positive bacteria particularly *Staphylococci*

1.4.2. CLEAN WOUNDS

These refer to non-traumatic, uninfected operative wounds in which no inflammation is encountered, no break in aseptic technique and the respiratory, alimentary genitourinary tracts the oropharyngeal cavities are not entered[3,4,13,19,20]. They are surgical wounds that are primarily closed and no drains are applied.

The frequency of infection varies between 1% and 5%[3,4,13,20]. It differs from the refined-clean wounds in that, there is greater likelihood of contamination from an endogenous source[3]. The elective inguinal herniorrhaphy exemplifies this category. Its proximity to the contamination of the groin and perineal areas increases the risk of endogenous contamination and infection.

Cholecystectomy, appendicectomy in passing, and hysterectomy are usually included in this category if no acute inflammation is present[4]. A recent study from England, however, reported a much lower wound infection rate of about 0.8%[20]. As the main sources of infection are the patient's skin and the operating room environment, anaerobic infection is unlikely.

1.4.3. CLEAN CONTAMINATED WOUNDS

These are wounds from clean operations in which either the gastrointestinal or respiratory tract was entered but no significant spillage occurred[4,13,20]. The major source of contamination is therefore intrinsic to the patient. Exogenous sources of contamination during the conduct of the procedure are insignificant[3].

In these types of wounds, active infection at the time of the operation is not present. The wound infection rate ranges between 3 and 20%[3,4,13,20].

1.4.4. CONTAMINATED WOUNDS

These are wounds from operations in which acute inflammation without pus formation is encountered or in which gross spillage from a hollow viscus occurs, fresh traumatic wounds and operation wounds in which a major break in aseptic technique occur[4,18,19]. The wound infection rate among these wounds range between 40 and 60%[19]. Much lower rates that range between 10 and 20% are recently being reported [13,18,21].

1.4.5. DIRTY OR INFECTED WOUNDS

These are created by operations in which pus is encountered or a perforated viscus is found or traumatic wounds more than four hours old[5]. They are wounds in which already there is established infection. The wound infection rate is 100%[21]. Lower infection rates of about 27-40% have been reported[17].

1.5. PREDISPOSING FACTORS

For infection to occur, bacteria must enter the wound and multiply. They may enter the wound during or after operation and they may be autogenous or exogenous in origin. Autogenous (endogenous) sources include the patient's skin, perineum, incised urinary, respiratory, biliary and gastrointestinal tracts[20]. The type of surgery is an important determinant of autogenous infection rate.

With clean wounds this source of bacterial contamination is at a minimum[20] and it is the exogenous contamination that appears to be responsible for a substantial proportion of infections in these wounds. This source of contamination may come from personnel or the

environment. The direct contact with the wound by the surgical team is probably the final pathway for spread of most such contaminants[17]. Therefore most of the infections endogenous or exogenous appear to result from contamination in the operating room.

Few infections are acquired after the operation if wounds are closed primarily, that is, before leaving the operating room, and if drains are not used, and this is probably due to the normal healing process which seals most wounds within 24 hours after closure[13,23]. The predisposing factors therefore can be classified under the anatomical factors (patient's skin), the surgical team, theatre environment and the ward.

I.5.1. PATIENTS ANATOMICAL FACTORS

The sources of contamination can either be exogenous or endogenous[4]. Endogenous contamination is basically the infection that is acquired from the host. These are normally body flora, which are largely available on the skin, bowel, respiratory and genitourinary tracts, the parts of the body which are in direct contact with the external environment and they harbor microorganisms as normal flora.

Operations that are done involving one of these sites carry a risk of postoperative wound infection. The skin, however, is associated with much less risk because it can be treated before any surgical procedure is done and as a result, operations that are done on a healthy skin are considered clean. The skin therefore is considered in detail, as it is the site that will be involved in the surgical wounds which will be studied.

1.5.1.1. THE SKIN

The skin or integument is a tough but elastic sheet that covers the entire body[24]. It extends for a short distance into the body orifices such as the mouth, nostril, anus and genitourinary tract where it blends with the delicate mucous membrane of these orifices. The skin is also the largest and the heaviest organ in the body making up to 16% of the body weight[24,25,26].

The skin is formed of two main layers; the surface epithelium, epidermis and the subjacent connective tissue layer, the dermis or corium[24,25]. The epidermis is differentiated into various structures that are generally referred to as epidermal appendages. They include hair, nails and glands. Otherwise it forms an uninterrupted cellular investment

covering the entire body. The dermis constitutes the greater part of the skin thickness. It contains collagen fibres, nerve endings, lymphatics, blood vessels, hair follicles, sweat and sebaceous glands and some associated smooth muscle fibres.

The functions of the skin include protection against mechanical injury, bacterial invasion and injury by irradiation. It is also waterproof, preventing excessive loss of water through it. It is a sensory organ with receptors for touch, pain, temperature changes and pressure. The presence of sweat glands and the network of small blood vessels to the skin work with the nervous systems in maintaining body fluid balance and temperature regulation[24]. It also provides habitat for microorganisms which exist on the skin as flora[26], and these can contaminate the surgical wound causing an infection.

Physically the skin forms an average of about 1.75 m^2 in a normal adult human being[26,27], 18% being occupied by each lower limb, 37% the trunk, 9% each upper limb, and the head 9%[27].

The distribution of microbial skin colonizers is not uniform and it is also not proportional to the body surface area. The head and thorax carry

more microbes than the limbs. There is also a variation between sexes, males being more colonized with aerobes than females, though anaerobes appear to be equally distributed between the sexes. It is also important to note that, microorganisms are not spread out equally over their habitat, but live in discrete micro colonies of variable sizes. Some of these contain 10 cells but some others have 10^5 viable cells[27].

In one study it was found that, the differences in number and type of microorganisms in different parts of the body is due to a number of factors[27]. Desiccation is one of such factors affecting gram-negative rods more while gram-positive organisms are less susceptible. Because some parts of the body are usually exposed and others are covered, it is apparent that the bacterial flora is different in different areas.

Fatty acids have also been found to have a bacteriostatic effect[25, 27]. The effect to potential skin pathogens may be seen on *Streptococci*, *Micrococci* and coagulase-positive *Staphylococci*. Experiments have shown that removal of FFA by acetone enhances survival of *Staphylococci* and *Streptococci* on the skin and its replacement restores the inhibitory action. As mentioned earlier on, the skin contains glands, which include accrine sweat glands, apocrine sweat glands and sebaceous

glands[22,24,25]. FFA form part of the components of sebum[25] which is a product or secretion released by sebaceous glands. The glands also release diglycerides, triglycerides, and cholesterol esters. Local bacterial flora probably hydrolyzes triglycerides to produce more free fatty acids.

Eccrine sweat glands are found all over the body surface despite some regional differences in density and activity. Total sweat output is greater at the temples and midline of the chest, abdomen and back and is greater is males than in females. These glands secrete lactic acid which when fleshly excreted may be toxic to skin bacteria.

The other compounds secreted by this type of glands include water 99%, inorganic ions for example Ca_2PO_4, organic matter like urea, uric acid, creatinine etc, and vitamins. Apocrine sweat glands on the other hand, which are principally in the axilla, anogenital region and around the nipples, secrete sweat which contains protein. This seems to lack the inhibitory influence on bacterial flora and as a result there is a substantially larger number of microorganisms in these areas.

The skin p^H is another factor which has been shown to influence the bacterial flora[25,27]. While the normal skin p^H is 5.5, varying between 4.0

and 7.5, the normal skin organisms with the exception of *Diphtheroids* grow well in the pH range of 5.0 to 6.0.

The p^H tends to vary depending on the lactate-lactic acid content of eccrine sweat that acts as buffer. Carbon dioxide diffusing through the skin may also serve to neutralize alkali. Because of the pH effect on the skin flora as well as its variation on different parts of the skin, the type and load of skin microorganisms vary.

The skin surface is also anatomically responsible for the dispersal of skin microorganisms. The epidermis is formed of epithelial cells that are derived from a reproductive layer deeper in the skin[24]. This is known as stratum basale or stratum germinativum[24,25]. It is responsible for gradual and continuous reproduction of epithelial cells. As they are produced, epithelial cells gradually move towards the exterior of the body. They loose their cuboidal shape and become flattened. Whilst flattening they become filled with a protein known as keratin and on reaching the surface, they loose their viability. Gradually they are lost as skin scales or squames and this is a natural process. It is estimated that, we all disseminate more than 10^7 particles of skin every day[26,27]. As they are disseminated, these particles move together with

microorganism. Scales detached from heavily colonized areas disperse more. It is this tendency to scaling which is responsible for mechanical dissemination of microorganisms from the body surface.

1.5.1.2. SKIN PREPARATION

Preoperative preparation of the patient's skin is therefore important. It is aimed at rendering the operation site as free as possible from transient and resident microorganisms, dirt and skin oils so that the incision can be made through skin with minimal danger of infection from this source[28]. It involves mechanical cleansing by bathing, hair removal using clippers, depilatory creams or razor. Also, the use of antiseptic solutions is another way through which the skin can be cleaned before operation[4, 28,29].

1.5.2. SHOWER

Preoperative shower removes many microorganisms from the skin[28]. The action can be enhanced by the use of antimicrobial-containing products[4,13,28]. Agents containing chlorhexidine or hexachlorophene have been widely used[4,28]. Many surgeons advise their patients to use

such products at home for several days before an elective operation [28]. While others commend the value of preoperative shower[4,24], other reports do not agree. Garner[13] reported that, this practice has not been proven to reduce colonization with *S. aureus* in the host's natural reservoir, the anterior nares or to reduce infection. In addition, Evans and Meakins do not recommend the use of antimicrobial shower and other skin decontamination treatments in advance of surgery as they are generally ineffective at reducing infection rates. They further conclude that, their use is unnecessary except when patients are known carriers of resistant organisms such as MRSA, or have infectious lesions.

Therefore, preoperative shower using antimicrobial containing agents should not be routine. The patients general skin condition must be observed and if found to have infectious lesions, dirt and debris, the operation may be differed unless it is an emergency one.

1.5.3. SHAVING

Hair on and adjacent to the operation site is often removed to prevent the wound from becoming contaminated with hair during the

operation[13]. Presumably also, hair is removed for aesthetic reasons as well as to allow postoperative dressing changes to be made more easily[28].

Several reports have pointed-out that shaving with a razor can injure the skin and increase the risk of infection[13,28]. The risk of infection increases the longer the time between shaving and surgery[4,13,28,29,30]. It is therefore suggested that, hair removal be avoided, or if necessary shaving be done immediately before operation either on the preoperative unit or in the operating suite[28]. Alternatively, the use of hair clippers or depilatory creams is recommended[4,13,28,29,30].

1.5.4. ANTISEPSIS

Mechanical cleansing of the patients skin at the operation site and the area surrounding it is done using antiseptic solutions[4,13,28,29]. Several types of antiseptics commonly used in general practice are summarized in table 1. The alcohol containing solutions such as betadine and hibiscrub are highly effective. One application of either solution reduces skin flora by 80 to 85%, almost eliminating commensal organisms on the skin[4,28,29].

TABLE 1 Classification of antiseptics commonly used in general surgical practice

Name	**Presentation**	**Uses.**	**Comments.**
Chlorhexidine (Hibisrub) (Hibitane)	0.5%Chlorhexidine 70%Isopropyl alcohol	Skin preparation Surgical scrub In dilute solutions in open wounds	Broad spectrum, rapid and non toxic Cummulative effect. Stable in the presence of pus and body fluids Activity adversely affected by traces of soap and organic matter. Not absorbed through skin.
Povidone-Iodine (Betadine)	10% alcoholic Acqueuos 7.5%	Skin preparation Surgical scrub in dilute solutions in open wounds	Safe, fast acting, broad spectrum. Some sporicidal and antifungal activity Sarfactant wetting and dispersive effect. Should remain on for at least 2 minutes and shouldn't be wiped off because microbial activity is sustained by release of free iodine as agent dries and color fades from skin. It is Iodine combined with Polyvinylpyrrolidone (povidone).
Iodine	1-2%iodine in water or in 70% alcohol	Skin preparation. In dilute solutions in open wounds.	Excellent. Skin irritations and burns. If used, iodine should dry and then be rinsed off with 70%alcohol to neutralize the burning effect
Cetrimide (Savlon)	Aqueous	hand washing. Instrument and surface cleaning.	*Pseudomonas* spp may grow in stored. contaminated solutions
Alcohols	70%ethyl, isopropyl	Skin preparation	Broad spectrum, denatures proteins in cells Therefore shouldn't be used on mucous membrane and open wounds. Volatile and flammable. Shouldn't pool around or under patient, especially if electrosurgical unit or laser will be used.
Hypochlorides	Acqueous preparations (Eusol, Milton, Chloramine)	Instrument and surface cleaning. debriding agent in open wounds.	Mainly reserved for use as disinfectants.
Hexachlorophane	Acqueous biphenol	Skin preparation. Hand washing.	Has action against gram negative organisms.

1.5.5. THE SURGICAL TEAM

The surgical team refers to the individual, each with specific functions to perform surrounding the patient and may include the surgeon and one or two assistants, a scrub nurse or technologist, an anaesthetist or anaesthesiologist and a circulating nurse[31]. It is subdivided according to the functions of its members into the sterile team (operating surgeon, assistant surgeon and scrub nurse or technologist) and the unsterile team consisting of the anaesthetist or anaesthesiologist, circulating nurse, and others (biomedical technicians, radiology technicians etc) [31,32].

While the sterile team enters the sterile zone, the unsterile one does not. Its members function outside and around the sterile zone[31]. The larger the team, the larger the risk of wound contamination as the amount of microorganisms dispersed is likely to be high. Also, there may be an increase in the movements and conversation in the operating room with the resultant increase in air turbulance with subsequent wound contamination.

It was shown by Cruse in the Foothills study that, there was a difference in clean wound infection rates among different surgeons[4]. This was

attributed to differences in operating technique. Other factors, however, may explain the differences in the infection rate. Such factors include hand scrub, gloves and gloving technique, gowning, draping and preoperative preparation of the patient's skin[4,33].

Proper surgical technique is important in the protection against wound contamination and subsequent infection[4,13,30]. Poor technique can result in inadvertent contamination of the wound, may prolong the operation and may result in a wound that cannot adequately resist infection because it contains devitalized tissues or foreign bodies[4,13]. Proper technique therefore requires the use of sharp anatomical dissection, careful manipulation of tissues, proper haemostasis, and use of fine sutures[30]. The following should be avoided: dead space, improper wound drainage, indiscriminate use of electrocautery, mass ligatures, improper choice of sutures, excessive tissue trauma, inadequate debridment and unnecessary use of foreign material eg. mesh prosthesis. Failure to adhere to these principles leads to tissue devitalization, wound contamination and subsequent infection[30].

Contamination of the surgical wound from the hands of the surgical team can be reduced by the application of surgical scrub and wearing

sterile gloves. Surgical scrub is defined as the process of removing as many microorganisms as possible from the hands and arms by mechanical washing and chemical antisepsis before participating in an operation [16].

Mechanical washing removes debris, natural oils, hand lotions and transient flora from the hands and forearm of the sterile team member. On the other hand, chemical antisepsis further reduces resident flora and inactivates microorganisms with a microbicidal or antiseptic agent. It is recommended that, the antiseptic formulation that is ideal for surgical scrubbing is a nonirritating agent with a broad spectrum, fast action, and prolonged, persistent or sustained effect [13,17,34].

The process of surgical scrub varies as does the length[17]. The duration tends to vary depending on frequency of scrubbing, agent used and the method. Generally however, the ideal duration of the surgical scrub is not known, but times as short as 5 minutes spent on a vigorous scrub with a reliable agent may be as effective as a 10 minutes scrub done with less mechanical action[13].

Other reports, however, recommend a much shorter scrub duration[4,34].

In his report, Babb noted that two minutes is the scrub duration that is usually adopted[34]. Further mention is made that there is little or no additional benefit in prolonging this activity to 5 or 10 minutes[4,34]. Persistent scrubbing, or the application of harsh antiseptic detergents, may damage the skin encouraging the proliferation or survival of potentially pathogenic microorganisms.

As pointed out earlier on, the scrub procedure varies. However, the essential components include[17,34];

- washing of the hands and arms several times thoroughly to 2 inches (5cm) above elbows. The nails are cleaned with a manicure stick under running water, and then scrubbed using a sterile nailbrush or sponge.
- Repeat this as necessary but preferably for a half minute for each hand.
- Then rinse the hands and arms, reapply antimicrobial detergent and wash hands and arms.
- Dry hands on sterile towel.
- Then proceed to gowning and gloving.

The use of gloves during surgery serves two purposes[35]: to protect the surgeon from contamination by blood and exudates from the patient and

the patient from transfer of microorganisms from the surgeons' hands. Punctures to the gloves usually occur during the procedure[4,33,35]. It is through these holes that microorganism can pass through to enter the wounds. However, this has not been found to carry a significant risk of infection[33,35].

Theatre gowns prevent dispersal of microorganism from the surgeons skin into the air[35]. They need to be made of tightly woven fabrics so that the holes between interstices are too small for microorganisms to pass through. However, its protective effect decreases when the gown becomes soaked. Similarly drapes, apart from isolating the area of operation, they prevent bacteria from striking through[4]. When soaked, chances for passage of the microorganisms to the surgical wound increase.

1.5.6. THE OPERATING THEATRE

The operating theatre forms an area where the wound is laid open, and exposed to the environment. This area therefore has to be controlled and made infection-free if wound contamination is to be avoided. The factors that contribute to contamination of the theatre environment and

hence the wound include the surgeon and assistants, the patient and the environment of the operating suite.

The operating suite should be designed in such a way that contamination is at its minimum. This is effected by the arrangement that allows air movement from clean to less clean areas even when a door is opened[35]. In a conventional operating theatre airborne contamination is reduced when the following air related control measures are followed[33];

- Maintenance of air under positive pressure (plenum) by an inflow of air filtered to remove particles about 5 microns in size.
- Inflow of air from outside at a steady rate, changing not less than 20 times per hour, giving a volume change in the range of 30 to 60 m^3 per hour.
- Improving the filtration by high efficiency particulate air (HEPA) filters.
- Increasing the air turnover rates around the operating site to achieve maximum positive pressure flushing effects.
- Altering the pattern of air movements so that the air passes in a non-turbulent fashion over the operating site. Such unidirectional flow can be either downwards, as in the vertical

laminar flow, or from a side wall as in a horizontal laminar flow.

The operating suite is usually located in an area accessible to the critical care surgical patient areas and the supporting service departments[36] ie, the CSD, pathology and radiology. Also, it is necessary to prevent unrelated traffic from passing through the suite. A location on a top floor is not necessary for microbial control because all air is filtered to control dust[36].

There are two zones in the operating room which include a sterile zone and an unsterile zone[32]. The sterile zone includes the operation site, the first three members of the team and that part of the theatre immediately around them. The unsterile zone on the other hand includes the head end of the patient, and the rest of the theatre. This includes also the anesthetic, scrub rooms or areas and sluice rooms as is shown in the figure below[32].

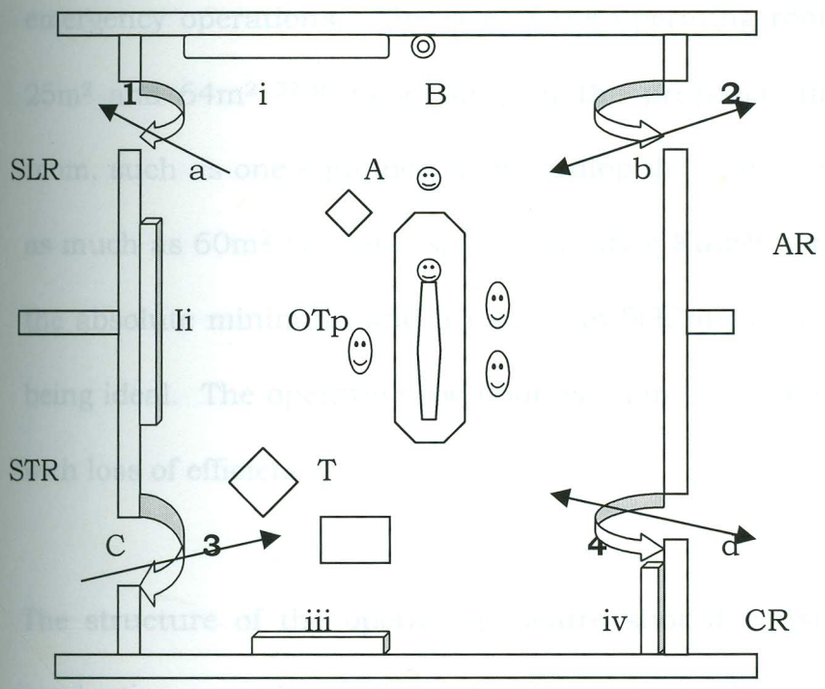


Figure I: The diagrammatic representation of a simple operating suite.
Arrow a= used items out, b= patient in and out, c= sterile items in and d=surgical staff in and out.
Numbers 1, 2, 3 and 4 = Doors.
Numbers I, ii, iii, and iv represent work top and cupboard, shelf for sutures, shelf for drum and shelf for gowns and drapes respectively.
A=Anaesthetist/Anaesthesiologist.
T=Trolleys
OTp=Operating table and patient.
STR= Sterilization room, SLR=sluice room, AR=Ante room and CR=Changing room.

The sizes of individual operating rooms vary. Whatever the size, however, adequate space is essential, so that, staff can move freely within the zones of the operating rooms. Atkinson-Lucy[36], commenting on the interest of economy and operational flexibility, suggests that all operating rooms in the operating theatres have the same size, so that they can be used interchangeably to accommodate elective and

emergency operations. The size of the operating room ranges between $25m^2$ and $64m^2$ [32,36] depending on the proposed use. A specialised room, such as one equipped with cardiopulmonary bypass, may require as much as $60m^2$ of useful space. Maurice King[32] considers $25m^2$ to be the absolute minimum and a room 5x6.5($32m^2$) as better, but $42m^2$ as being ideal. The operating room larger than $60m^2$ to $64m^2$ is associated with loss of efficiency[32,36].

The structure of the operating theatre should consist of floor that is conductive enough to dissipate electrostatic charges from equipment and personnel, but not conductive enough to endanger personnel from shock. Also, it must not be porous, but suitably hard for cleaning by the flooding, wet-vacuuming technique. The walls and ceiling surfaces should be hard, non-porous, fire resistant, water proof, stain-proof, seamless, non-reflective and easy to clean. The ceiling may have acoustic sound-proof tiles in addition[36].

It is also important to note that, the rooms in the operating suite vary in their level of cleanliness[33] as it is shown on the diagram below;

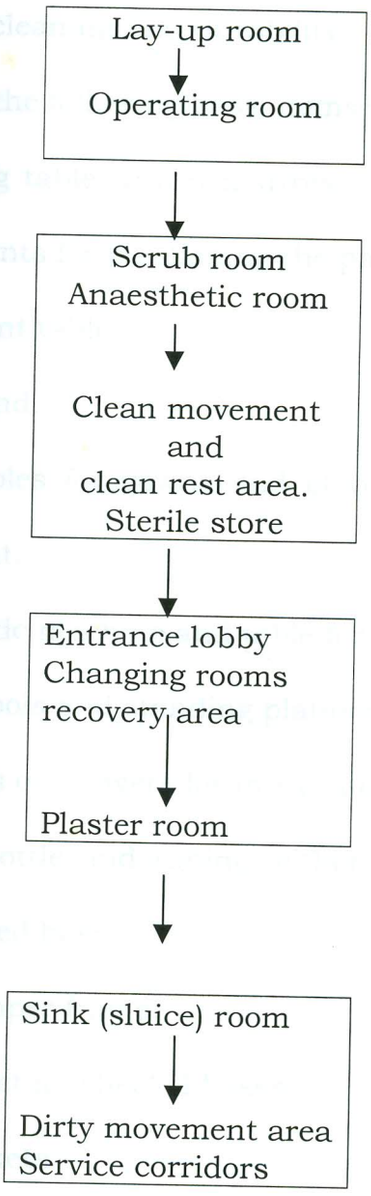


Figure II: Operation suite areas in descending order of cleanliness[33].

Furniture and other equipment in the operation room should include only the necessary ones. Those made of steel should be stainless and plain for easy cleaning and durability. Generally, the operating room is equipped with the following basic items[36];

- Operating table with a mattress covered with conductive rubber, attachments for positioning the patient and armboards.
- Instrument table.
- Mayo stand.
- Small tables for gowns and gloves and/or patient's preparation equipment.
- Anaesthetic machine and table for anaesthesiologist's equipment.
- Sitting stools and standing platform.
- Standards or hangers for intravenous solution bags.
- Suction bottle and tubing, either wall-mounted or portable in a low-wheeled base.
- Linen hamper frame.
- Kick bucket in wheeled bases.
- Wastebaskets.
- Writing surface.

Air temperature and humidity control is another function of ventilation

in the operating room. There is a substantial difference between individual temperature preferences as well as between the surgeon and the other members of the operation team, for example the sedentary anaesthetist[33]. It is generally accepted to set the temperatures between 15 and 25^{0}c with preference to the temperature most acceptable to the surgeon, who is wearing warmer clothing. Also relative humidity should be held within the range 40 to 60 per cent[33].

1.5.6.1. BACTERIOLOGICAL AIR SAMPLING

Air delivered to the suite by the ventilation equipment as well as the humidifiers may contain pathogenic microorganisms, such as *Clostridium perfringens, Staphylococcus aureus, Pseudomonas* spp, *Legionella* spp etc[33]. Ideally it should not contain more than 1 colony of microorganisms in a sample of 30m^3 of air.

In the past, agar plates (Settle plates) were placed on the floor of quiet (unused) theatres and the bacterial counts made after 24 hours. This rather haphazard method has now been replaced with set air volume sampling using the Casella slit sampler[33].

Air sampling is important as a monitoring process through which undue contamination of the operating room air can be detected. Also, it can be used during surgical procedures to detect *Staphylococcus aureus* skin dispersers. And it may be needed if the clean wound infection rate increases and a disperser of *Staphylococcus aureus* is suspected after case controlled studies[33].

1.5.7. THE WARDS

The modes of cross-infection in the ward include direct contact from the surgeon, nurses or attendants, from the air and from contaminated instruments. Particularly important here is the presence of many other patients who form another potential source of infection[35].

In one study, it was found that clean wound infection rate was not different among wards. It was shown significantly that there was a variation in clean wound infection rate among different surgeons[4]. This was attributed to the differences in surgical technique.

However, certain factors may affect postoperative wound care resulting into wound infection. The presence of patients with obvious septic

lesions e.g. extensive skin infections with copious purulent exudates is particularly dangerous[35]. These contaminate the bedding and are shed into the air. They may also be carriers of some virulent strains that can lead to ward epidemics.

It has also been recently found that the use of gloves or masks by nurses during dressings is not important[4]. They can therefore perform their procedures without these gadgets unless they need them for their own protection.

1.6. SURVEILLANCE OF WOUND INFECTION

The word surveillance means different things to different people. Literally, it means to watch. In the context of a health situation it is generally agreed that surveillance is the collection, collation, analysis and dissemination of information related to health for early identification of infection outbreaks or potential outbreaks of the infection in both the hospital and community[6].

Bryan and Deave[23] define two types of surveillance: process surveillance and outcome surveillance. Process surveillance involves the observation,

description, and measuring of the process of implementation of infection control policies. On the other hand outcome surveillance involves the measurement of the outcome of infection control practices namely the infection rate.

In the hospital setting, surveillance forms an essential component for the prevention and control of infection. Its important role is based on the fact that there is continuous monitoring of the patients on treatment for the aim of early detection of infections particularly hospital-acquired infections. Outbreaks of infections can also be easily detected as well as their possible sources.

1.6.1. OBJECTIVES OF SURVEILLANCE

There are two main objectives of hospital Surveillance[6]. They are;

- The early detection and prevention of hospital outbreaks
- The assessment and comparison of infection levels over a period of time so that the need for and effect of infection control measures can be seen.

1.6.2. SOURCES OF INFORMATION DURING SURVEILLANCE

The records that provide information for surveillance may be obtained from clinical as well as laboratory data[13,14,15] and each of these has its implication. The data that is based on a clinical definition is advantageous, because, a positive culture does not necessarily indicate infection. On the other hand, infected wounds may not yield pathogens by culture because some pathogens are fastidious, culture techniques are inadequate or the patient has received antimicrobial therapy. In addition, granulocytopenic patients may not always produce purulent material[13]. Further still, the information obtained from specimens can hardly distinguish between clinical infection and carriage[14].

1.7. BACTERIOLOGICAL PATTERN OF WOUND INFECTIONS

In history, *Staphylococci*, Pseudomonades and *Escherichia coli* have been the nosocomial infection troika[37]. Cyclical changes of the microorganisms have been seen in different hospitals. In the Semmelweis era[2, 3,5,37] group A *Streptococci* created most nosocomial infections. Later came gram-positive cocci and in the 1940 to 50s, the *Staphylococcus* was the major problem[37]. In the 1970's, gram-negative

bacilli, particularly *Pseudomonas aeruginosa* and *Eutrobacteriaceae* became synonymous with nosocomial infection.

Shija in his preliminary report of 1973 documented more gram-negative bacilli in his isolates in Dar-es-Salaam[7]. However, a study done in Zambia during the same period did not demonstrate that, Instead a higher proportion of *Staphylococcus aureus* was isolated than gram-negative cocci[38].

In the 1990's, gram-positive cocci and negative pathogens were isolated almost equally in the United States of America[37]. While 34% of the isolates consisted of gram-positive pathogens namely *Staphylococcus aureus*, coagulase negative *Staphylococci*, and enterococci, there was a 32% isolate consisting of gram-negative pathogens. These included *Escherichia coli*, *P.aeruginosa*, *Enteobactacter* spp and *Klebsiella pneumoniae*.

In the United Kingdom, a report from the Royal United Hospital indicates that there were 45% gram-positive pathogens, which were dominated by *Staphylococci* as isolates in 1999. Concurrently, 30% of the isolates were Gram-negative pathogens[20]. Studies done elsewhere

indicate a similar picture. In Saudi Arabia, there were 37.2% gram-positive cocci and 29% gram-negative pathogens[39]. In that study however, there is a reported high isolate rate of *Staphylococcus epidermidis*, which accounted for about 13.5%.

It would therefore mean from this regard that, there is an approaching equality in the pathogenicity between gram positive and gram-negative pathogens. With time, the tendency for mixed infections is highly likely.

1.8. PATHOLOGY OF WOUND INFECTION

Like other infections, wound infection is followed by a local reaction. This is an inflammatory response. It involves the alteration in the capillary bed that is, vasodilatation, and arrival of humoral substances, which are mediators of inflammation and also the phagocytic and other inflammatory cells.

The cells in general mediate the removal of the infecting microorganisms and finally effect tissue repair. It is this pathological process that is responsible for the manifestations of wound infection. In the first century, Celsius, a Roman physician described four cardinal features of

inflammation[2,3,17] which include rubor (redness), calor (heat), dolor (pain) and tumor (swelling). Virchow is credited for the fifth important sign, which he later added; this is loss of function.

The vascular response begins with constriction of small blood vessels[2]. This is brief and is subsequently followed by persistent vasodilatation. There is increased blood flow as well as hydrostatic pressure which leads to opening up of the capillary sphincters and hence more capillaries become open, thus more blood flows into the area. The affected area will thus appear red (rubor). As blood flow increases, the temperature at the affected area also increases. This is responsible for the warmth or increased temperature over the inflamed area, which is referred to as calor.

The other local reaction that occurs as a result of trauma is the release of chemical substances, which are known as mediators of inflammation. They include histamine, serotonin (5-HT) etc. These are responsible for, among other things, pain and the increase in vascular permeability. The increase in the vascular permeability is also augmented by vasodilatation, which result in increased hydrostatic pressure, which worsens the escape of proteins, fluids and blood cells from the

intravascular compartment.

The chemical mediators in addition are responsible for the cellular response. They attract the monocytes and other leucocytes to the area of inflammation. Overall leucocytes function in phagocytosis of bacteria, foreign particles and cell debris and eventually effect healing and repair.

1.9. CLINICAL FEATURES

The clinical manifestation of patients with postoperative wound infection tends to vary depending on the depth of the infection, the source of contamination and the causative microorganisms. Also this tends to vary depending on the host immune status.

The contamination, which occurs during the operation, that is, infections acquired from the operating theatre, tend to be deep seated. They are first seen at first dressing and they are unique reflecting the source of infection[21]. Such early presentation of wound infection, within 24 to 72 hours is due to virulent microorganisms such as *Clostridium* spp, *Streptococcus* spp and *Staphylococcus*[40]. When acquired in the ward, the infections are seen after first dressing or 3 to 4 days

postoperatively. These are usually superficial. If thorough search in made, other patients will usually have the same or similar type of infections[21].

Overall most wound infections are apparent within the first week following operation. Less than 5% become apparent more than four weeks post operatively and of this category, many involve prosthetic materials[33].

Irrespective of the source and depth of wound infection, the symptomatology of wound infection may include fever, erythematous skin changes and drainage of pus from which bacteria may or may not be cultured[41]. The severity of wound infection varies[18] Minor ones are associated with discharge of pus but without cellulitis, lymphangitis, deep tissue destruction or systemic disturbance. On the other hand, there are major wound infections which discharge pus in association with breakdown, and dehiscence of deep fascial layers of the wound or with evidence of systemic illness accompanying a spreading cellulitis or lymphangitis.

It is also important to distinguish between superficial and deep wound

infection[16,42]. The former involves the skin and subcutaneous tissue and are exterior to the fascia and muscles. Deep wound infections involve the muscles, fascia and structures deep to them e.g. intraabdominal infections.

Commonly superficial wound infections present with wound cellulitis. This may occur without pus, but it is frequently a sign of a collection deep in the wound[42]. Deep wound infection may present with wound dehiscence, fever, elevated white blood cell count, superficial wound infection with pus draining between the fascial sutures or a combination of these. Intra-abdominal deep wound infections can present with signs of ileus such as distention, nausea and vomiting. It may also take the form of peritonitis[42].

In both superficial and deep wound infections, tenderness is the usual encounter though deep wound infections may present with subtle symptoms and signs.

2.0. DIAGNOSIS OF WOUND INFECTION

The diagnosis of postoperative wound infection is based mainly on

clinical criteria[2,17,41]. Bacteriological results, both microscopy and culture are merely supportive. False negative results of culture may occur and difficulties may be encountered in the interpretation of some cultures leading to a false-positive diagnosis.

Clinically, the wound is infected if the patient develops fever postoperatively, the skin adjacent to the wound is erythematous, tender, edematous and there is extension of the margin around the wound. The infection is therefore present as cellulitis[17,41]. This is classified as nonpurulent wound infection. When there is pus discharge from superficial, subfascial or visceral locations, it is referred to as purulent wound infection[43].

Despite the importance of the clinical criteria in defining wound infection, the diagnosis still remains non-specific. Clinically, the etiology can hardly be deduced. With the help of the laboratory, a particular organism can be isolated[2]. Also assessment of the response to treatment can be made. White blood cell count is a useful non-specific test that aids in the diagnosis and in the follow-up of the progress of an infection. The differential count may help in diagnosing the type of infection. Acute pyogenic infection produces a

polymorphonuclear leukocytosis, chronic infection a lymphocytosis and those associated with an immune response an eosinophilia. ESR can be used to monitor the course of a chronic infection.

For bacteriological diagnosis, a sample of exudates or pus should be taken via aseptic technique and examined for organisms and their sensitivity to antibiotics. The examination here involves microscopy, culture and bacteriological tests that are used in the identification of microorganisms[44,45].

2. RATIONALE OF THE STUDY

The determination of clean wound infection rate is important. It provides a guide for quality care and surveillance research. Risk factors related to exogenous contamination can be assessed reasonably. With this type of wounds, endogenous bacterial contamination can be adequately minimized as most of the risk factors are controlled

In addition there have been a growing number of patients being discharged early in the postoperative period and some of them develop wound infection thereafter and in order to establish the actual

magnitude of the problem, a surveillance research is required.

This study was therefore planned so as to try and establish the local magnitude of postoperative wound infection, current bacteriological pattern and the antimicrobial susceptibility of the infecting microorganisms. The findings obtained may reflect the quality of surgical care in the department of general surgery and hence form a basis of interventional programs if necessary.

3. STUDY OBJECTIVES

3.1. BROAD OBJECTIVE

To determine the magnitude of postoperative wound infection, surveillance, the current bacteriological pattern and antimicrobial susceptibility among general surgical inpatients undergoing clean operations at Muhimbili Medical Centre, Dar es Salaam Tanzania.

3.2. SPECIFIC OBJECTIVE

1. To determine the prevalence of postoperative wound infection among general surgical inpatients.

2. To determine the association between preoperative stay in hospital and post operative wound infection.
3. To establish the association between the duration of operation done and post operative wound infection.
4. To determine the bacteriological pattern and antimicrobial sensitivity among postoperatively infected wounds.
5. To establish the association between the number and type of operations per day in each operating theatre and postoperative wound infection.
6. To determine the association between scrubbing practices and postoperative wound sepsis.
7. To determine the postoperative hospital stay attributable to postoperative wound infection.

4. MATERIALS AND METHODS

4.1. TYPE OF STUDY

A prospective study was conducted at Muhimbili Medical Centre's general surgical wards. It was planned to determine some of the factors that predispose to wound infection. The factors such as the environment in the two operating theatres, the patients' age and sex, the wards, the surgeon's rank and the scrubbing practices among members of the surgical team were studied. A surveillance program was designed so as to establish a follow up plan for the identification of the risk factors and detection of the infections that present after the patients are discharged from hospital.

4.2. STUDY AREA

Muhimbili Medical Centre is the largest hospital in the country, located in Dar es Salaam city. It serves as the Muhimbili University College teaching hospital as well as the main national referral hospital. From its location, it receives the majority of the patients from within Dar es Salaam and the nearby regions, some being referred and others non-referred.

The study was conducted in the general surgical wards, which serve both children and adults. The wards are identified by numbers and they include the following; wards 2,11,12,13,14,15,16 and 21. Wards 2, 15, and 21 are specially reserved for female patients of which ward 2 is shared by surgical firm II and orthopedic and trauma unit and ward 21 by surgical firm I and III. Ward 12 is for general pediatric surgical patients, ward 11, 13, and 14 are for male patients being used by firms II, I, and III respectively. Wards 15 and 16 are shared by all general surgical firms. They are reserved for private female and male patients respectively.

The hospitalization process required the patient to be attended first at the casualty from which the patients were either admitted to the wards or referred to the outpatient's clinic. A majority of patients who undergo elective surgery first attended the outpatient's clinic where work up was conducted and once the patient was declared fit for surgery, he or she was scheduled and listed for the planned operation. At this point the patient was then admitted in the respective ward.

Some patients, however, particularly those referred from upcountry, were directly admitted into the ward. The necessary work-up was

conducted while the patient was in the ward.

Daily records of the type and number of operations in each operating theatre were kept. This was considered important in that, it may determine the possibility of cross-infection especially when too many emergency operations were to be done. Data regarding the daily total number of patients in each ward was obtained as well. This was compared with the number of beds, the main aim being to see whether overcrowded wards suffer the risk of easy cross infection.

4.3. STUDY POPULATION

Patients who were registered for the study were all those who were planned for elective surgery during the study period. These were both female and male patients, and all age groups were included with the exception of neonates and other patients with risks for postoperative wound infection. Known diabetic patients, jaundiced patients, patients with AIDS, and patients with advanced malignant diseases were excluded from the study.

4.4. SAMPLE SIZE:

This was estimated by using the formula below which was obtained from Epiinfo 6

$$n = \frac{Nz^2p(1-p)}{d^2(N-1)+z^2p(1-p)}$$

Where; n = sample size

N = Total study population estimated at 1000 patients which is the total number of patients operated for one year.

z = confidence interval, considered to be 1.96 at 95%

p = prevalence of postoperative wound infection which was 2%

d = Marginal error or degree of accuracy considered to be 1%

From this formula the sample size was estimated to be 430 patients.

4.5. STUDY PERIOD AND DATA COLLECTION

The study lasted for eight months starting from 1st June 1999 to 31st January 2000. Data was collected using English written questionnaires prepared and used by the author. Special forms for the planned investigations were designed and used in the reporting of wound infection culture results. The forms were used by the author and the laboratory technician. Information obtained from the investigation

forms was transferred to the questionnaires from which final analysis was made.

Each questionnaire consisted of both open ended as well as closed questions. The information was obtained from the patients by interviewing, after which the wound was examined and the diagnosis (whether infected or not) was reached. Reference to the patient's case notes was made so as to obtain information regarding the diagnosis(es), treatment and type of surgery done.

4.6. OPERATING THEATRES

The department of general surgery uses two of the six operating rooms that form the main operating suite. The two operating rooms are named operating theatre III and IV respectively. Operating theatre III is shared by surgical firms I and III and theatre IV by firm II and pediatric surgery.

The two operating theatres are situated adjacent to each other on the right wing of the main operating suite. The diagram below illustrates the floor plan of the two operating theatres.

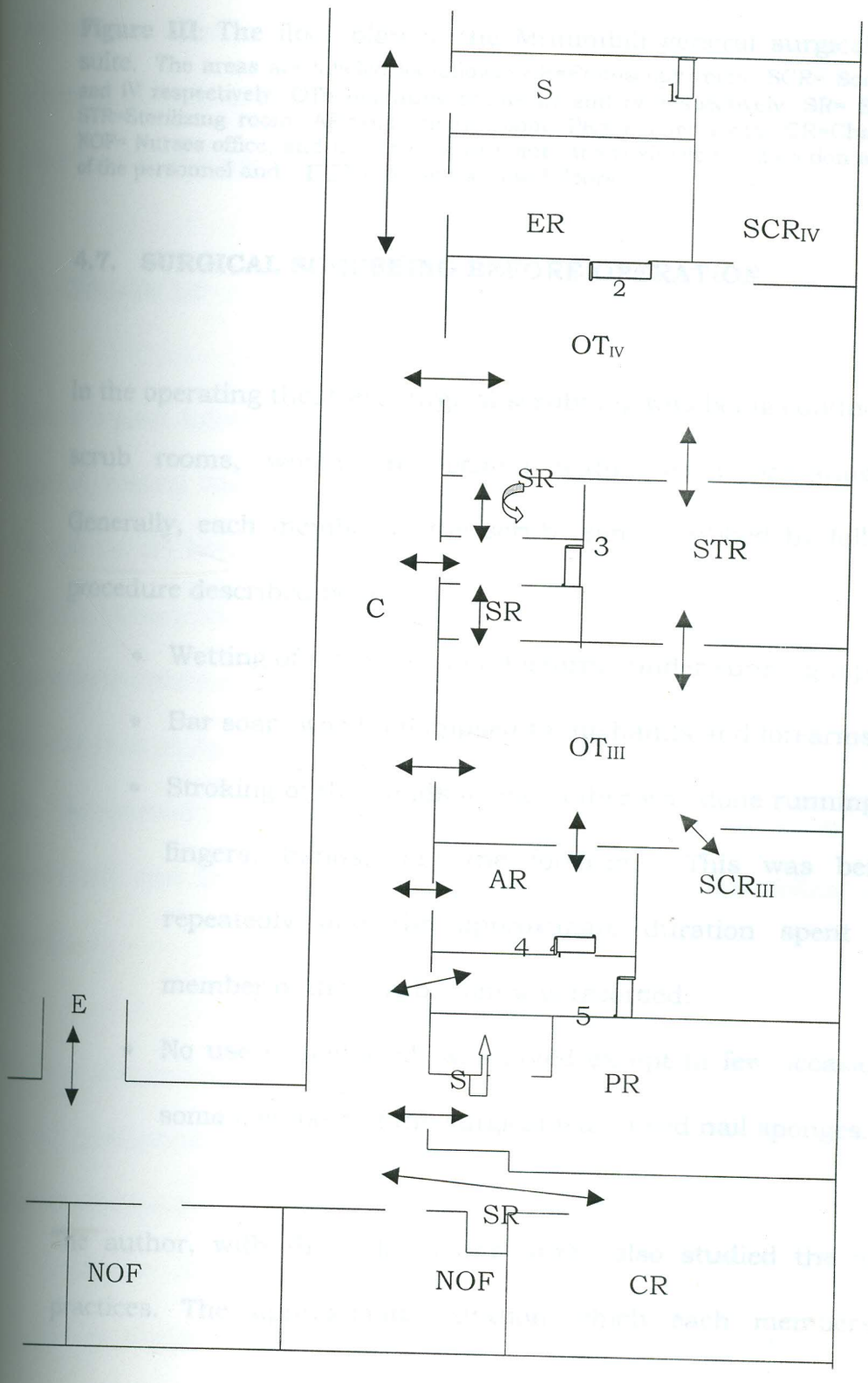

S
1
ER
SCR$_{IV}$
2
OT$_{IV}$
SR
3
STR
C
SR
OT$_{III}$
AR
SCR$_{III}$
4
5
E
S
PR
SR
NOF
NOF
CR

Figure III: The floor plan of the Muhimbili general surgical operating suite. The areas are labeled as follows; ER=Endoscopy room, SCR= Scrub rooms III and IV respectively, OT= operating rooms III and IV respectively, SR= Sluice rooms, STR=Sterilizing room, AR=anaesthetic room, PR= Plaster room, CR=Changing room, NOF= Nurses office, and E= Entry/Exit point. Arrow shows the direction of movements of the personnel and ▭ represents closed doors.

4.7. SURGICAL SCRUBBING BEFORE OPERATION

In the operating theatres, surgical scrubbing was being conducted in the scrub rooms, which are located within each operating theatre. Generally, each member of the scrub team scrubbed by following the procedure described below;

- Wetting of the hands and forearms under running tap water
- Bar soap, was then applied to the hands and forearms.
- Stroking of the hands to each other was done running between fingers, hands, and the forearm. This was being done repeatedly and the approximate duration spent by each member of the scrub team was recorded.
- No use of nailbrush was noted except in few occasions when some members of the surgical team used nail sponges.

The author, with the help of one nurse also studied the scrubbing practices. The approximate duration which each members of the

surgical team spent on scrubbing was determined. Bar soap was used in both scrub rooms. The adequacy of scrubbing was defined as being proportional to the scrub duration.

4.8. FOLLOW UP

Because wound infection requires several days to develop and become apparent, several visits and wound review need to be made. After the first visit i.e. 24 hours postoperatively, other reviews were planned on days 3,7, 14 and 30. Patients who were discharged before the planned days of review were appointed to a special clinic where examination and review of their surgical wounds and scars was made. This follow-up plan, determined only early postoperative wound infection as intermediate and late wound infections requires a longer follow up duration.

Following the review, patients who were found to have evidence of infected postoperative wounds had pus swab taken under aseptic technique for bacteriological evaluation. Once taken, the specimen was kept in sterile Stuart's transport medium and was sent to the microbiology laboratory for analysis within one hour after collection.

In the laboratory, the pus swabs were inoculated on two blood agar plates and one MacConkey agar plate. One of the blood agar was incubated anaecrobically between 35 and 37^{0}c for 48 hours. The other blood agar together with the MacConkey agar plate was incubated aerobically at temperatures between 35 and 37^{0}c. A single film was then made from a different swab obtained from the same patient; stained by Gram's stain, examined microscopically and findings recorded.

These techniques for investigating the pus swab were the same as the methods described by Joan Stokes and Ridgway[44], and Raphael [45] for bacteriological examination of pus and body fluid. After 24 hours of aerobic incubation and 48 hours of anaerobic incubation, the plates were examined and colonies of different organisms were picked for biochemical identification using standard identification reagents. Another colony was processed for antimicrobial susceptibility testing.

The antibiotic discs used for sensitivity tests were selected basing on the experience in clinical practice. This was based on broad coverage of both gram negative and gram-positive bacteria. They include;

1 For gram-positive bacteria:

i. Penicillin G

ii. Ampicillin

iii. Methicillin

iv. Erythromycin

v. Tetracycline

vi. Sulfonamide

2 For gram-negative bacteria:

i. Ampicillin

ii Erythromycin

iii. Tetracycline

iv. Ceftriaxone

v. Septrine

vi. Kanamycin

vii. Gentamicin

viii. Chloramphenicol

ix. Augmentin

4.9. DATA ANALYSIS

Manual analysis of the data was done by using dummy tables. These were used to summarize the information obtained. Tables of results with simple proportions were used there after. For significance testing of the results, the P value was calculated.

5.0. VALIDITY

It is hereby being considered that, the information obtained from this study was valid. This was assured by the fact that patients who had open surgery done through the department of general surgery shared similar operative conditions. The instruments used were all being sterilized at the CSD. All the operations were then conducted in the main operating theatre though in two adjacent rooms and being operated by different surgical teams. The transfer of patients to and from the operating theatre was not patient specific. Each one was being transported to the operating theatre by a nurse who was assisted by a theatre attendant. The same was done on returning the patients back to their respective wards. Generally, adherence to the study design and

methodology was emphasized as this would address and define the study objectives.

5.1. ETHICAL CONSIDERATIONS

For ethical reasons, the whole exercise was conducted after being granted permission by the college and the Muhimbili Medical Centre's ethical committee. From the patients an informed consent was obtained before review and examination. Useful investigation results were cordially utilized for the management of the patient.

5. RESULTS

5.1. NUMBER OF OPERATIONS

During the study period, June1, 1999 to January 31, 2000 a total of 476 patients were scheduled and operated electively as clean cases. They were patients under the care of the department of general surgery including general pediatric surgery.

Four hundred and sixty four (97.5%) patients met the registration criteria and were recruited for the study. Twelve patients were excluded because of the following reasons; ten patients were day care cases and thus, they were discharged on the same day, and two patients died. Those registered comprised of 285(61.4%) males and 179(38.6%) females. The table below summarizes these results.

TABLE II: The clean operations done during the study period.

Status	Males N(%)	Females N(%)	Total N(%)
Registered	285(60.4)	179(37.2)	464(97.5)
Day care cases	3(0.6)	7(1.5)	10(2.1)
Died	1(0.2)	1(0.2)	2(0.4)

Monthly number of patients operated and clean wound infections

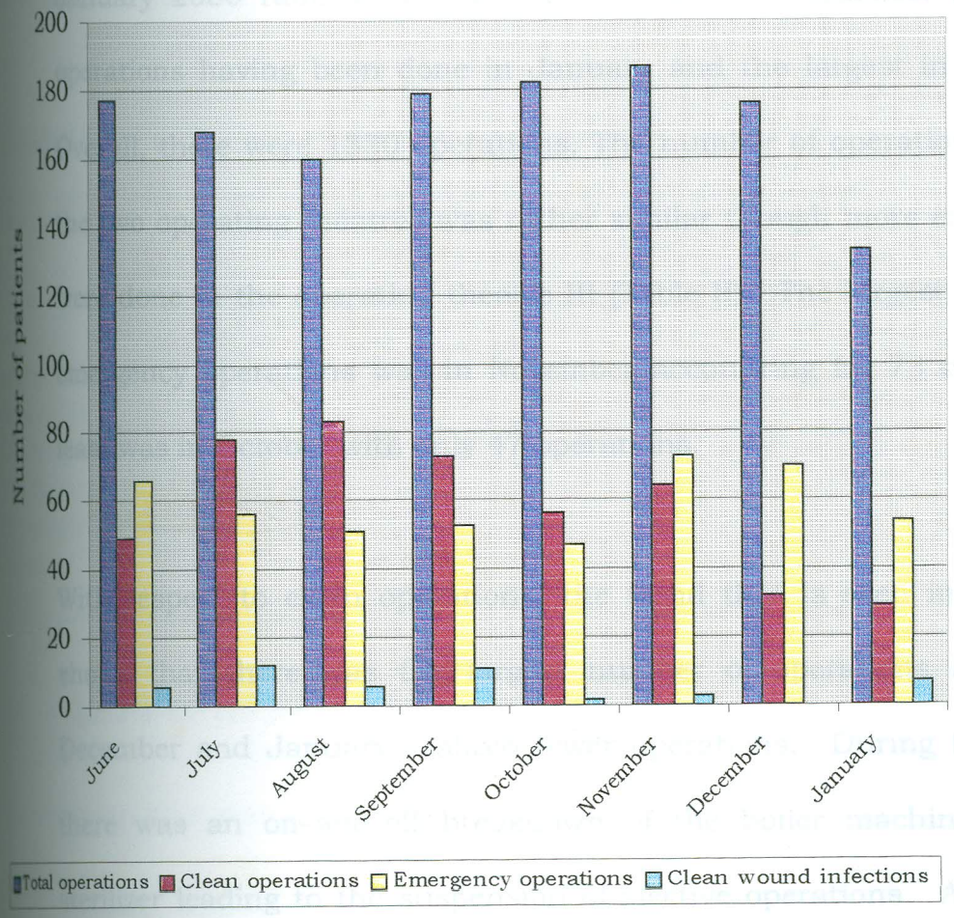


Figure IV: The number of different types of operations done during the study period and clean wound infection.

* Note that clean and emergency operations do not total 100%. This is because, some elective operations were not included as they were not clean.

The monthly total number of patients operated from June 1999 through January 2000 ranged from 133 to 187 with the smallest number of operations having been done in January and the largest in November Overall, there were 1330 operations. The number of operations done in the two operating theatres was rather similar though more emergencies were done in the operating theatre III (Table II). The largest number of emergency operations was in November accounting for 73 cases. The least was in October with only 47 operations.

With respect to clean operations, the trend that is seen in Figure IV shows that there was the largest number of operations in August. December and January realized fewer operations. During this period there was an on–and-off breakdown of the boiler machine and the sterilizer leading to the suspension of elective operations. As a result, therefore, fewer operations were done as elective procedures. Figure IV summarizes these results.

5.2. EMERGENCY OPERATIONS

There were 470 emergency operations done during the study period. Most 421/470(89.6%) of them were done in the operating theatre III.

The number of patients operated ranged between 47 and 73 per month as summarized below.

TABLE III: Total number of emergency operations

Month	operating theatre		Total
	III	IV	
June	59	7	66
July	51	5	56
August	49	2	51
September	45	8	53
October	42	5	47
November	66	7	73
December	65	5	70
January	51	3	54
Total	421	49	470

5.3. FOLLOW-UP OF PATIENTS

The follow-up plan was designed to review the patients on days 1, 3, 7, 14 and 30. Day one was for registration where 100% of the patients were seen. Further reviews were made and the number of patients seen progressively declined to about 25% on day 30. Table IV summarizes this information

TABLE IV. The follow-up of patients

Visit day	Number of patients	Percentage
1	464	100.0
3	451	97.2
7	325	70.1
14	273	58.8
30	116	25.0

5.4. MODE OF DIAGNOSIS

During the study period, the follow-up of patients detected on clinical parameters 60(12.9%) patients as infected. Out these, 47 (10.1%) had pus swab culture positive results. The remaining 13 pus swabs obtained from clinically infected patients did not grow organisms. There were 8/60(13.3%) patients in whom the diagnosis was made after discharge and at follow up. Seven of these patients had positive results on culture. Table V summarizes the information.

TABLE V: The mode of diagnosis of wound infections

Diagnosis	Before discharged N(%)	After discharge (N(%)	Total
Clinical	52(86.7)	8(13.3)	60(12.9%)
Laboratory	40(85.7)	7(14.9)	47(10.1%)

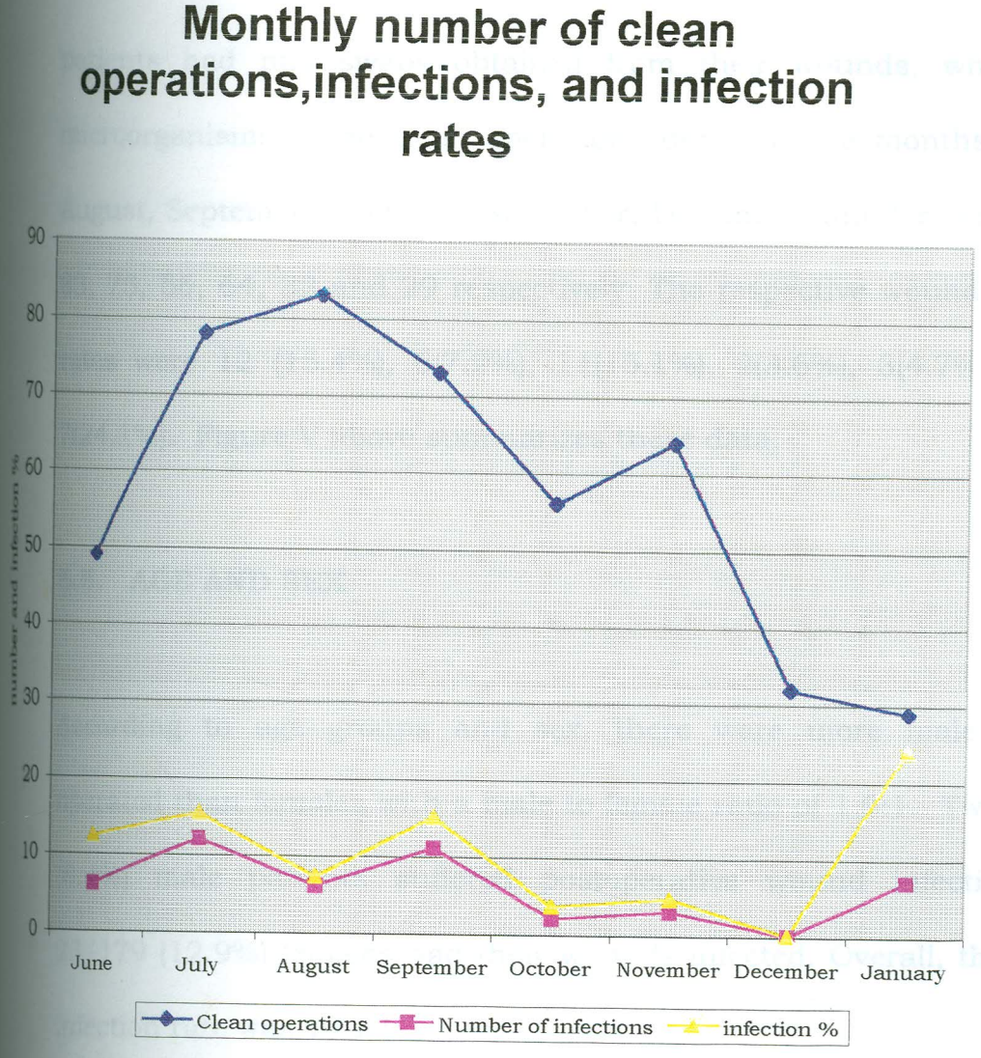


Figure V: Monthly number of clean operations, wound infections and infection percentage

During the study period patients were followed up postoperatively. Each patient was followed for 30 days, first while in the ward and subsequently after discharge. In June 49 patients were operated out of whom 6(12.3%) were clinically found to have wound infection. All the six

patients had pus swabs obtained from their wounds, which grew microorganisms. The clean operations done for the months of July, August, September, October, November, December and January are 78, 83, 73, 56, 64, 32 and 29 respectively. The respective wound infection rates were 12 (15.4%), 6(7.2%), 11(15.1%), 2(3.6%), 3(4.7%), 0, and 7(24.1%). Figure V above summarizes these data.

5.5. AGE AND SEX

According to age groups and sex, there were more male patients operated than females with a male to female ratio of 1.6:1. Twenty four (8.4%) male patients suffered postoperative wound infections and 23/179 (12.9%) females had their wounds infected. Overall, the wound infection rate was 10.1%.

TABLE VI Wound infection by sex

Sex	Wound Infection status		Total	Percentage
	Yes	No		
Male	24	261	285	8.4
Female	23	156	179	12.9
Total	47	417	464	10.1

P=0.12

The age ranged between 4 months and 88 years. The age group one month to 10 years constituted a peak that is 141(28.2%) patients. The other extreme, i.e. 70 years and more accounted for the smallest number of operated patients, 16(3.5%). The peak infection rate, 16.4% affected patients who aged between 41 and 50 years. Both extremes of age showed the lowest wound infection rate.

Wound infection according to age

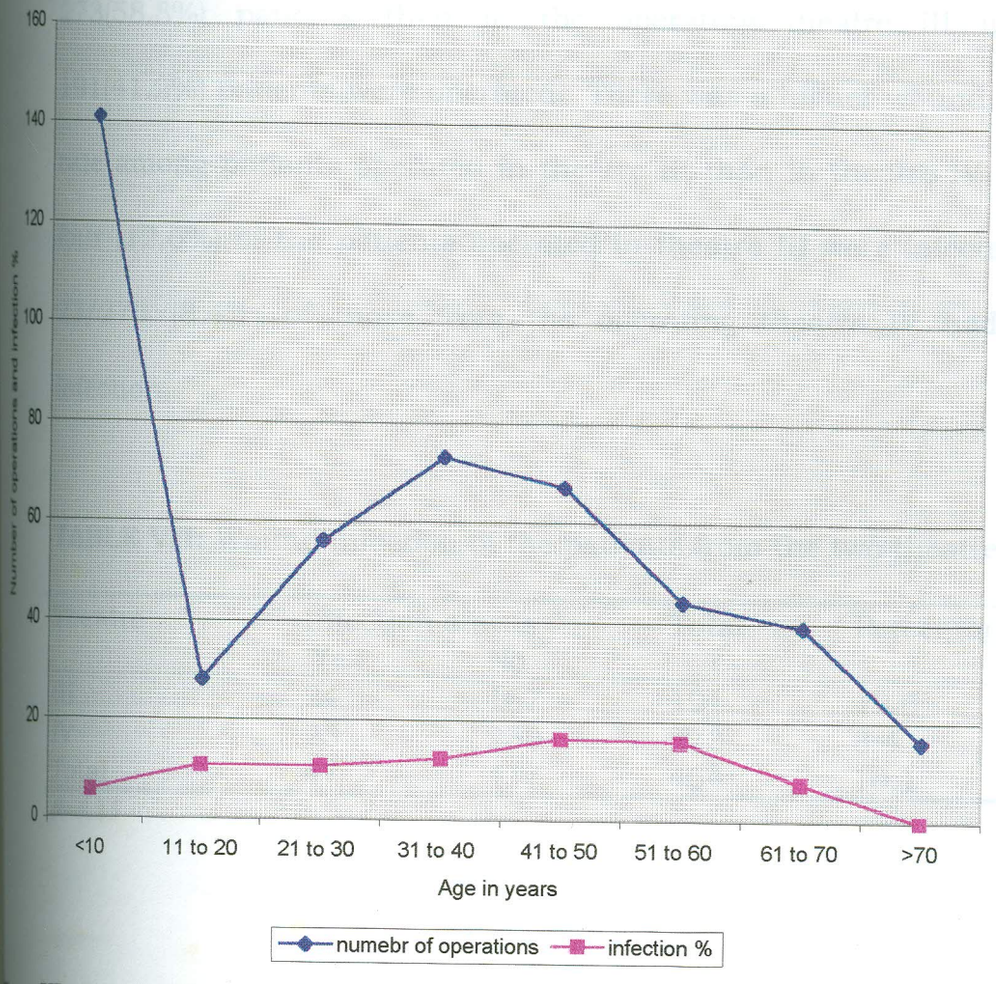


Figure VI: The distribution of wound infection by age

Figure VI: The distribution of wound infection by age

5.6. THE OPERATING THEATRES

Follow up of the postoperative patients was made for those operated from the operating theatres III and IV. Between the two operating theatres, there were more clean operations done in theatre IV ie 273(58.8%) patients than in the operating theatre III in which 191(41.2%) patients were operated. There was a higher wound infection rate among patients operated in theatre III than in theatre IV. Twenty four (12.6%) of the patients operated in theatre III were infected, while 23/273 (8.4%) of those from the operating theatre IV had wound infection.

TABLE VII: Wound infection of the patients from the two theatres

Theatre	Infection status		Total	Percentage
	Yes	No		
III	24	167	191	12.6
IV	23	250	273	8.4
Total	47	417	464	10.1

P=0.15

5.7. SURGEON

Of the 464 operations 244(52.6%) were done by specialists, 92(19.8%) by residents, 89(19.2%) by registrars and consultants performed only 39(8.4%). Of the patients operated by consultants 6(15.4%) became infected. This was the highest wound infection rate followed by those operated by residents, specialists and lastly those by registrars. The wound infection rates were 11.9%, 10.3% and 5.6% respectively. See table VIII.

TABLE VIII: Wound infection rates among different surgeon ranks.

Surgeon	Wound infection status		Total	Percentage
	Yes	No		
Registrar	5	84	89	5.6
Resident	11	81	92	11.9
Specialist	25	219	244	10.3
Consultant	6	33	39	15.4
Total	47	417	464	10.1

P=0.32

5.8. WARDS

There were eight wards into which patients were admitted postoperatively. None was spared from the problem of postoperative wound infection. However, the female ward number 21 appeared to be

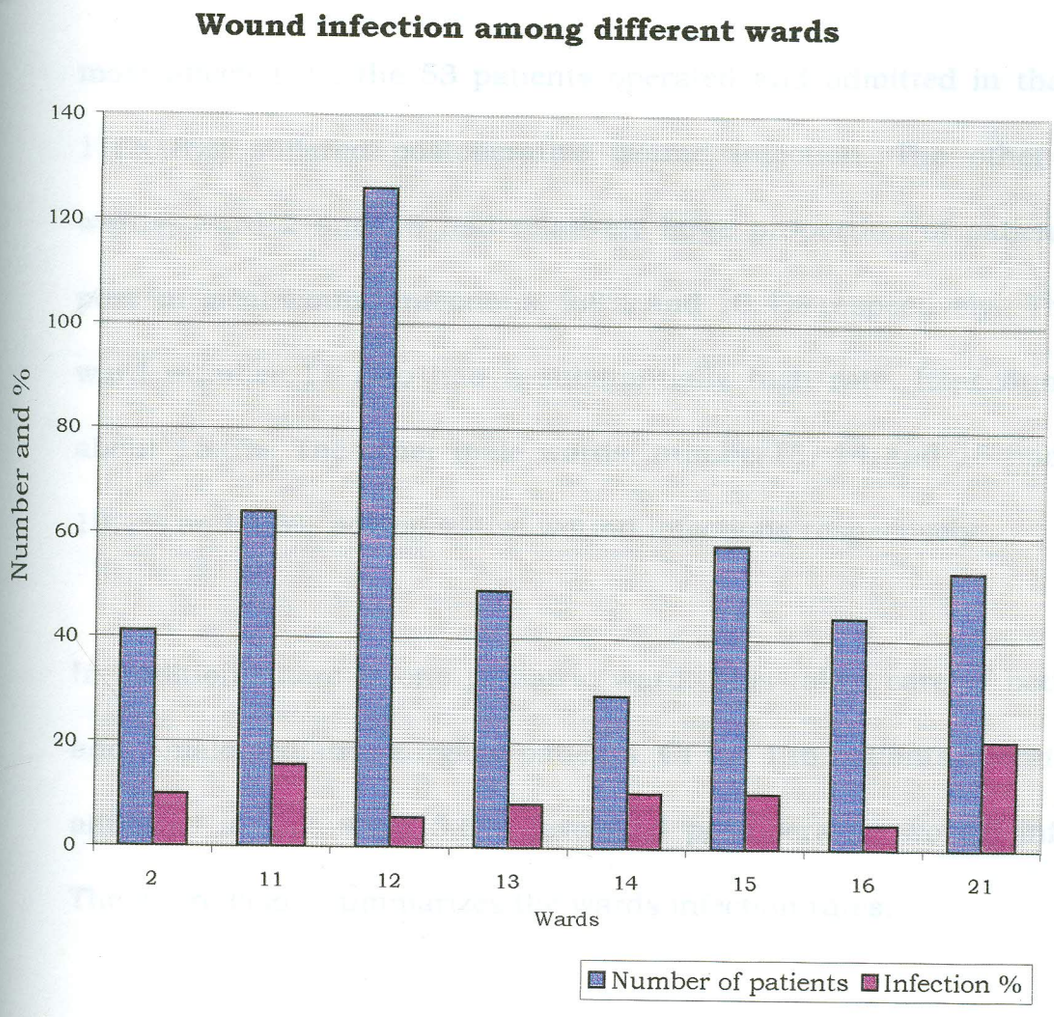


Figure VII: The distribution of clean operations and wound infection rates in different surgical wards

5.9. DURATION OF OPERATION

Majority of the operations done 417(89.9%) lasted less than two hours. Of these, 32(7.7%) turned out to be infected. The rest of the patients 47(10.1%) were operated for more than two hours and 31.9% had

most affected. Of the 53 patients operated and admitted in that ward 11(20.8%) suffered postoperative wound infection. The other female wards, ward 2 and 15 had relatively large proportion of patients with post surgical wound infections, 9.8% and 10.4% respectively. The male ward number 11 also had a substantially high rate. It accounted for about 15.6%. The other male wards, number13, 14 and 16 had 8.2%, 10.4% and 4.6% postoperative wound infections respectively.

In addition, there is one pediatric ward. This takes care of both male and female pediatric surgical patients. Of the 126 patients operated and admitted in this ward 5.6% developed postoperative wound infection. The figure below summarizes the wards infection rates.

wound infection. There were two patients whose operation lasted more than four hours and one ended up with wound infection.

TABLE IX: Duration of operation.

Duration (hours)	Wound infection Status		Total	Percentage
	Yes	No		
<2	32	385	417	7.7
2+	15	32	47	31.9
Total	47	417	464	10.1

P=0.0001

6.0. PREOPERATIVE HOSPITAL STAY

It was found that the majority of the patients stayed in the hospital for less than one week. This accounted for 373(80.4%) patients. There were 32(6.9%) patients who were in the hospital for 7 to 14 days. The remaining 59(12.7%) patients stayed more than two weeks. There was a progressive increase in the wound infection rate the longer the patient stayed in the hospital, that is 5.6%, 18.8%, and 33.9% respectively. The difference was highly statistically significant (p=0.0001)

TABLE X: Wound infection rate by preoperative hospital stay.

Duration#	Wound infection status		Total	Percentage
	Yes	No		
<7	21	352	373	5.6
7-14	6	26	32	18.8
>14	20	39	59	33.9
Total	47	417	464	10.1

Duration#: Duration measured in days

p=0.0001

6.1. SURGICAL SCRUB

Evaluation of scrubbing was made by observing the time spent on scrubbing by the members of the surgical team. These included the surgeon, the nurse and the assistants. The presence or absence of some of the members of the scrub team is also examined.

6.1.2. SURGEON

It was found that 27(5.8%) operations were done by surgeons who spent less than two minutes on scrubbing and 406(87.5%) by those who scrubbed for two to five minutes. The remaining operations were done by surgeons who either scrubbed for over five minutes 15(3.2%) or no records could be obtained 16(3.5%). There were 4/27(14.8%) patients

whose wounds became infected among those operated by the surgeons who scrubbed for less than two minutes. This was the highest infection rate among the patients operated. These results however were not statistically significant.

TABLE XI: Surgeons' duration of surgical scrub.

Duration#	wound infection status		Total	Percentage
	Yes	No		
<2	4	23	27	14.8
2-5	42	364	406	10.4
>5	1	14	15	6.7
Total	47	401	448	10.5

Duration#: measured in minutes. **P=0.6**

6.1.3. SCRUB NURSE

Of the 464 operations 399(85.9%) were seen to have the assistance of a scrub nurse. Of these 5 patients were attended by the nurses who scrubbed for less than two minutes. The majority however 365(78.7%) spent between two and five minutes scrubbing. The wound infection rate was relatively low among those attended by the nurses who scrubbed for two to five minutes as compared to those who scrubbed for a longer duration. There were no patients who developed wound infection among those who spent less than two minutes.

TABLE XII: Nurses surgical scrub.

Duration#	wound infection status.		Total	percentage
	Yes	No		
<2	0	5	5	0
2-5	42	323	365	11.5
>5	4	25	29	13.8
Total	46	353	399	11.5

Duration#: measured in minutes

P=0.8

Sixty five patients are not included in the table. Forty-nine patients were operated without the presence of the scrub nurse and with the other 16, no time record was made. These results were not statistically significant.

6.1.4. SCRUB ASSISTANSTS

It was found that, apart from the scrub nurse, the surgical team also comprised of assistants whose number varied from one to three. There was at least one assistant in 412/464(88.8%) operations. The second assistant was present in 111(23.9%) operations and in only 4(0.9%) operations the third assistant was present. Those operations in which the first assistant was present indicate that, 15/412 (3.6%) were attended by assistants who scrubbed for less than two minutes out of whom 4 (26.7%) developed wound infection. There were 385/412

(93.5%) operations, which were attended by assistants who scrubbed for two to five minutes. Only 12 (2.9%) operations were conducted by assistants who spent more than 5 minutes on scrubbing and 2(16.7%) developed wound infection.

Of the 111 operations which were attended by two assistants, 1/111 scrubbed for less than two minutes, 101 for two to five minutes and 9 for over five minutes. Only 4 cases enjoyed the attendance of the third assistant and One ended up infected. The remaining operations were not attended by the third assistant.

TABLE XIII: Scrub assistants and wound infection.

TABLE XIII[a]: First assistant.

Duration	wound infection status		total	percentage
	Yes	No		
<2	4	11	15	26.7
2-5	40	345	385	10.4
>5	2	10	12	16.7
Total	46	366*	412*	11.2

* There are 55 patients who are not included in the table;
10 no recorded time was made and
42 operations were not assisted by the nurse.

P=0.12

TABLE XIII[b]: Second assistant.

Duration	Wound infection status		Total	Percentage
	Yes	No		
<2	0	1	1	0
2-5	17	84	101	16.8
>5	1	8	9	11.1
Total	18	93	111	16.2

[a]5 patients: no time record was made.

[b]348patients: Second assistant was not present.

Evaluation of the presence or absence of the assistant found in 427(92.0%) operations that there was at least one assistant. Two assistants were present in 121(26.1%) operations and the other 4 operations were attended by a third assistant. These results show that there seemed to be a progressive increase in the wound infection rate as the number of assistants increases. The infection rates were 10.8%, 14.9% and 25.0% respectively. However the increase was not statistically significant. ***(P=0.2).***

TABLE XIV: Wound infection and number of surgical scrub assistants.

Assistants No.	Wound infection status		Total	percentage
	Yes	No		
1	46	381	427	10.8
2	18	93	121	14.9
3	1	3	4	25.0

P=0.2

6.2. SHAVING:

Of the 464 patients operated, 125(26.9%) had shaving of the hair at the operation site. Eight percent of these suffered postoperative wound infection. The rate of wound infection was slightly higher 10.9% among those who did not shave prior to surgery.

TABLE XV: Shaving and wound infection.

Shaving	Wound infection status		Total	Percentage
	Yes	No		
Yes	10	115	125	8.0
No	37	302	339	10.9
Total	47	417	464	10.1

P=0.36

6.3. BACTERIOLOGICAL PATTERN

Out of the 464 patients, 60 (12.9%) patients were clinically diagnosed to have wound infection. There were 13 (20.3%) patients whose pus swabs did not grow organisms on culture. The remaining 47(79.9% grew microorganisms. These results are summarized in table IV and their bacteriological pattern and antibiotic susceptibility is shown on table XVI.

TABLE XVI: The bacteriological pattern of the isolates.

Organism	Number of isolates	Percentage	95%CI*
Staphylococcus aureus	22	36.1	24.16-49.37
Klebsiella spp	19	31.2	19.90-44.29
Escherichia coli	9	14.8	6.97-26.26
Pseudomonas spp	4	6.6	1.81-15.94
Proteus spp	3	4.9	1.02-13.71
β-haemolytic *Streptococcus*	2	3.2	0.39-11.34
Streptococcus spp	1	1.6	0.04-8.78
Unidentified Coliform	1	1.6	0.04-8.79
Total	61	100.0	94.1-100.0

95% CI*= 95% Confidence Interval

The results show that, *Staphylococcus aureus* was the commonest isolate accounting for 36.1% and this was followed by *Klebsiella* spp which accounted for 31.2%. The rest of the microorganisms isolated, their isolation rate and confidence values are indicated in table XVIII.

6.4. ANTIBIOTIC SUSCEPTIBILITY

There was a 100% susceptibility of *Staphylococcus aureus* to methicillin. On the other hand, these microorganisms were 100% resistant to penicillin G, the other commonly used antibiotic. Erythromycin showed 72.7% susceptibility to methicillin. In addition, 6/7(85.7%) isolates of *Staphylococcus aureus* were susceptible to tetracycline. The other gram-positive bacteria showed a variable antibiotic sensitivity.

Klebsiella spp, which were the commonest gram-negative isolates, indicated a variable antibiotic susceptibility. There were 14/15(93.3%) isolates which were found to be susceptible to ceftriaxone, 11/17(64.7%) were susceptible to gentamicin, 13/17(76.5%) to augmentin, 7/19(36.8%) to ampicillin, 2/9(22.2%) to cotrimoxazole, and 3/11(27.3%) were susceptible to chloramphenical. The other bacterial isolates and their antibiotic susceptibility is shown on the table XVIII. Because of lack of constant supply of the antibiotic sensitivity discs, the total number of isolates tested for antimicrobial susceptibility as is indicated in this table vary.

There were 4 isolates of *Pseudomonas* spp all of which were susceptible to ceftriaxone and ¾(75.0%) being susceptible to gentamicin.

TABLE XVII: Gram-negative bacteria and their antibiotic susceptibility pattern

Organism	Ceftriaxone	Gentamicin	Augmentin	Ampicilin	Cotrimoxazole	Chloramphenicol	Tetracycline
	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)
Klebsiella spp	14/15(93.3)	11/17(64.7)	13/17(76.5)	7/19(36.8)	2/9(22.2)	3/11(27.3)	0/2(0)
E. coli	6(100)	9(100)	6/8(75.0)	6/8(75.0)	2/4(50.0)	6/7(85.7)	0/3(0)
Proteus spp	3(100)	3(100)	3(100)	2/3(66.7)	0/2(0)	1(100)	0/1(0)
UDC	1(100)	1(100)	1(100)	1(100)	1(0)	1(100)	

6.5. OVERCROWDING

The average daily number of patients in the ward appears to proportionately fit in the number of beds, which is the reflection of the capacity of each ward. This, however, was not the case in wards 2 and 12. In ward 2, where the bed capacity is 40, there were about 10 to 19 patients more every day.

In ward 12, the actual number of patients was lower than the bed capacity. However, as these patients are normally admitted together with someone to take care of them, the calculated number of patients in table XXI would be twice as much. The rest of the wards on average, had patients corresponding to the available beds daily.

TABLE XVIII: Average admissions in the surgical wards.

Ward	Nº. of Beds	Monthly admissions							
		6	7	8	9	10	11	12	1
2	43	54.5	57.6	59.3	56.4	56.0	57.5	63.5	56.3
11	40	29.3	32.2	29.9	31.2	31.7	30.1	32.5	33.7
12	58	46.0	50.4	55.4	53.4	57.4	58.9	55.4	49.3
13	39	34.2	33.1	31.0	38.7	30.1	34.2	31.3	31.1
14	39	25.3	26.1	26.1	29.8	31.3	33.1	29.7	21.4
15	14	11.8	9.0	9.6	9.1	9.1	12.8	9.5	6.8
16	14	10.4	6.4	9.2	9.9	9.7	8.7	10.5	8.0
21	41	33.0	35.7	38.3	36.6	37.5	40.9	36.3	33.6

6.6. POSTOPERATIVE HOSPITAL STAY

During the follow up period, it was found that a large proportion of patients who developed wound infection stayed longer than the ones without wound infections. There were 21/47(44.7%) who stayed more than two weeks. Fewer patients were discharged within the first week after surgery. For those patients who did not develop wound infection, the majority 335/417(80.3%) were out of the hospital within the first seven days. Table XXII details this information.

TABLE XIX. Postoperative hospital stay

Duration#	Wound infection status		Total
	Yes (%)	No (%)	
<3	2(4.0)	173(41.5)	175
3-7	11(23.4)	162(38.8)	173
8-14	13(27.7)	51(12.2)	64
15-30	21(44.7)	31(7.4)	43
Total	47(100.0)	417(100.0)	464

Duration#: Duration in days

P=0.0001

6. DISCUSSION

In the present study, the prevalence of wound infection is 10.1%. This is significantly higher than in the majority of previously reported studies. Generally it is agreed that, the surgical wound infection for clean wounds ranges between 1% and 5% [4,13,42] In a study done in Nigeria in 1992[8], it was found that the incidence of surgical wound infection after clean operations was 2%. A lower incidence was reported in Mexico where, in 1999, a wound infection rate was found to be 1.3%[46]. In the same study, even the wound infection rates for potentially contaminated and the contaminated surgical wounds were lower, accounting for 1.9% in each category.

The prevalence obtained in this study, however, is as high as the one obtained in another study done in India, in1998 where the incidence was 13% clinical and 12% bacteriological[47]. Clinically, there was a 12.9% wound infection rate in the current study.

The factors that are likely to be associated with the high surgical wound infection rate may include the theatre environment, theatre personnel, the ward environment and some patients' factors.

With the theatre environment, the general layout of the operating theatre seems to predispose to wound infection. Figure III shows the general movements of the personnel from entrance E to the scrub rooms and finally to the operating theatre. One enters operating room III through the anesthetic room which is currently serving as a mini store where anesthetic equipments and infusions are kept. Using this as the storage room prevents adequate cleaning and disinfection resulting into the risk of contamination of the operating room. To enter the other operating room one passes through the sluice room. A definite contamination is therefore likely to occur when this entry point is used.

The other possible reason that may explain this high infection rate is the breakdown of the ventilators. With this, excessive contamination of the operating room environment is likely to occur as the result of lack of guided direction of the air movement and exchange. Air exchange, which is supposed to maintain air under positive pressure (plenum) has also been reported to be important in the reduction of the microbes[33]. In this operating theatre plenum is not maintained as well as the exchange of air that is required to be maintained at the rate of not less than 20 times per hour[33].

Contamination of the operating theatre environment as a result of the breakdown of the ventilators is compounded by the presence of the swinging doors that regularly causes air turbulence into the operating rooms when opened. The risk is even more when this happens with an operation taking place because turbulence occurs with air movements between less clean rooms and the operating rooms, which are "sterile" rooms. It is therefore apparent that, movements of both personnel and air are not directed from less clean to cleaner areas.

It was also found that, the operating rooms are used for both emergency as well as elective surgical procedures. This poses a risk of contamination of the operating rooms from emergency operations and hence increasing the likelihood of post surgical infection of clean surgical wounds. The results in this study indicate that, more emergency operations were done in operating room III. Similarly patients from operating room III had a higher postoperative wound infection rate (though not statistically significant), than those from the other operating room. As it will be discussed in the later sections, the ward environment also may be having a role to play in the development of surgical wound infections.

There also seems to exist laxity in the adherence to the norms and rituals in the operating theatres. Scrubbing practices as will be discussed below is taken as an example.

6.1. POSTOPERATIVE MORBIDITY

The morbidity was higher among patients with surgical wound infection. This is demonstrated by a much longer hospital stay rate among patients with surgical wound infection as compared with those without. Though some patients who did not develop wound infection appeared to stay a little longer, they represent a small group of patients from up country who stayed in the hospital for social reasons. As such they could not be discharged early as they were to wait for transport arrangements back home.

6.2. SURVEILLANCE

Surveillance is a major component for the prevention and control of infection in hospitals[6,48]. Like other nosocomial infections, surgical wound infection remains to be a significant source of postoperative morbidity[49]. Its surveillance therefore would be equally important in the

prevention and control of postoperative morbidity, which occur as a result of postoperative wound infection.

Previous studies have emphasized the importance of surveillance of surgical wound infection. Without surveillance, most of the post discharge surgical wound infection will be missed and hence under reporting of the problem of surgical wound infection. A study done in the United States of America, (University of Minnesota), reported that, 53.9% of surgical site infections were identified after hospital discharge [50]. Another study indicated an even higher post-discharge surgical wound infection diagnosis rate. It was found in Australia in 1999 that 68.1% of post surgical patients developed wound infection and were detected on follow-up through a surveillance program[51].

In the present study, the post discharge surgical wound infection rate was low. Only 13.3% of the infected cases were detected on follow-up. The discrepancy that is surfacing here between the current results and the previous reports may be due to a number of reasons.

The method that was used to follow-up the registered patients was that of requesting the patients to come back to a special clinic. They were

either requested to come for suture removal and wound review or only re-examination of their wounds.

Results show a progressive decrease in the number of cases attending on follow-up to only a quarter at the end. This is probably one reason as to why there were few patients diagnosed after discharge.

It was also realized that, some patients missed the opportunity for petty reasons. Either they missed their appointment dates, as no examiner was there or they came on the day of appointment but they lost direction, as this clinic was not a regular one. With this some were seen on subsequent follow up days reporting to have correctly attended the clinic but the examiners were not there.

Low socioeconomic status of the patients was another drawback. There were some patients who categorically emphasized on their unfortunate inability to abide to the follow-up plan because of high traveling costs. It is likely that, some patients disappeared from follow-up because they could not understand the importance of the follow-up. This could be coupled with the lack of awareness of the role of the follow-up.

On the other hand, the previous reports may be having large numbers of post discharge diagnosis of surgical wound infection because of large numbers of daycare cases in their centers[37]. In the present study only 10 patients were treated as day care cases and were not included.

More important is the high standard medical care services in developed countries where the reported researches were conducted. Probably also the patients involved were of high social economic status. In one study, the follow-up plan required the patients to just make a telephone call for their follow-up. In addition there were general practitioners and district nurse liaisons who enabled detection of the problem[52] by making close follow-up of the patient close to where they stay.

Surveillance of surgical wound infection is advantageous in that, there is close, continuous follow-up of the patients postoperatively. Out of the 60 patients who were clinically found to have surgical wound infection, 58.3% were diagnosed within the first seven days. All these were diagnosed before discharge. The remaining 41.7% were diagnosed during the remaining follow-up period. Out of these, 8/25(32.0%) patients had already been discharged.

Most previous studies outline the effect of surveillance on the prevention of surgical wound infection. There is a reported decrease in the clean wound infection rate in UK subsequent to the institution of the surveillance programs since 1991[6,48]. From this study, it is hard to draw up any conclusion with regard to the impact of surveillance on the prevention of surgical wound infection. There are no previous records to compare and hence, what we have here is the background information.

6.3. DEMOGRAPHIC CHARACTERISITICS

(a) AGE

There were patients of all age groups with the youngest being two months and the oldest being 88 years. The largest proportion of patients aged between 1 month and 10 years accounting for 141/464 (30.4%). The other extreme however, ie those older than 70 years accounted for the smallest number of patients.

The wound infection rate was highest among those aged 41-50 years. Generally the results show a progressive increase in the wound infection rate with advancing age. These findings are not unusual. In most studies the extremes of age are the commonest reported risk group[3,4].

Cruse and Foord in 1980 [53], demonstrated that wound infection rate increases with advancing age. This was also the case in the Foothills study [4] which indicated an increase in wound infection rate with advancing age.

The trend that is reported in the current study seems to agree with these findings though statistically not significant (p=1.96). Also the elderly patients aged more than 50 years were found to have a relatively lower wound infection rate, although this was significantly higher than the generally accepted wound infection rate of at most 5%. It is hard to explain these differences; probably chance findings. But again a small sample size could be another reason for this deviation.

With the younger age groups, similar results were obtained in one study in the USA. Horwitz et al[49] reported a 4.4% wound infection rate in his prospective multicenter study in 1998. The current study demonstrated a 4.9% surgical wound infection rate for under fives and 5.7% surgical wound infection rate for all children i.e. those aged 10 years and below.

(b) SEX

The surgical wound infection rate was slightly higher among female patients, though the difference was not statistically significant (p=0.12). This agrees with other reports that, clean wound infection rate is the same in male and female patients [4]

The slight increase that is seen in this report is probably a result of other factors. Ward differences for example may have a bearing on this variation. There was a relatively high surgical wound infection rate of about 20.8% patients in ward 21, which is one of the female wards.

The observed tendency for high surgical wound infection rate was not seen in the other female wards. Probably therefore, this is only the reflection of the increased infection rate in ward 21.

6.4. DURATION OF OPERATION

The duration of operation has been found to have a direct relationship with the rate of infection in different studies [4,13,52]. Clean wound infection roughly doubles with every hour spent during operation[4]. In

the current study, a significant increase in surgical wound infection rate was found ($p < 0.0001$). Patients operated for less than two hours, had wound infection rate of about 7.7%. The rate was more than four times this rate i.e. 31.9% for those operations which lasted more than two hours.

Several factors may explain this association. With increasing operation duration, the exposed tissue will suffer prolonged exposure to bacterial contamination[4]. Previous studies have noted that there is continuous dispersal of microorganisms from the skin[13,27,33]. Therefore the patient's own normal skin flora as well as those from members of the surgical team both scrubbed and unscrubbed disperse microorganisms that may land on the wound.

Continuous dispersal of microorganisms also takes place from the mucous membranes of surgical team (oral or nasal). The use of masks is therefore recommended to prevent this risk. There is a divided thinking and experience as to whether face masks are useful or not. Some researchers asset that there is no difference in the surgical wound infection rates between patients operated by surgeons with masks and

those without[33]. Some, however, emphasize on their use especially in implant surgery[13].

The effectiveness of facemasks in the prevention of droplets from entering the wound is doubtful. Some are made of materials that are pervious but even with those which are impervious to microorganisms, it is practically not possible to have these fit tightly on the lateral aspect. There is therefore a risk of lateral dispersal of microorganisms. Reports also indicate a risk of these becoming wet with time and thus losing their potency as barriers.

The second possible explanation is the associated blood loss and shock that may be associated with the prolonged operation. When these occur, they have been reported to depress the patient's body resistance to infection.

Prolonged operations are also likely to cause more tissue damage as a result of prolonged handling, dissection, electro coagulation, retraction and drying. As a result of these, the damaged tissues become devitalized forming an area that is suitable for bacterial proliferation. It was noted earlier on that, there is also a risk of excessive contamination

with prolonged operations. It would seem, therefore, that these factors compound each other.

Apart from the complexity of the operation, prolongation of the operation duration may also be a result of poor surgical technique and inexperience. As such inadvertent contamination of the wound may occur. Further still, undue tissue desiccation, retraction, electro coagulation, inappropriate suture choice and use by mass ligation predisposes further to wound infection.

6.5. PREOPERATIVE HOSPITAL STAY

As the patient stays long in hospital before operation, chances for surgical wound infection increases. There was a significant ($p < 0.0001$) and progressive increase in wound infection rate the longer the patient stayed in hospital. Many studies have demonstrated this effect [4,49,52].

Patients who are kept on the waiting list in this hospital include those referred from upcountry as well as those residing within or near Dar-es-salaam region. For the patients from upcountry, they are normally retained in the hospital for social reasons. However, because of the

failed treatment from where they come from and hence their referral, it could therefore mean that these patients suffer from rather complex problems that may require prolonged operation duration and extensive dissection which are also risks that predispose to surgical wound infection.

It has been argued that longer hospitalization exposes patients to hospital based microorganisms that are resistant to antibiotics. As a result, therefore, patients suffer infections that are antibiotic resistant. However, the role of antibiotics in clean operations is questionable. These are operations in which endogenous contamination is at a minimum[4]. If there is adherence to aseptic technique, exogenous contamination will also be to the minimum and hence there is a minimal infection risk. The role of prophylactic antibiotics would therefore be doubtful. Taylor outlined the indications of prophylactic antibiotics in clean surgery in which he included implant surgery and immunocompromised patients and this has been the traditional teaching[54].

Stressing on the importance of wound contamination, Raahave[18] pointed out that the Median infective dose was $4.6X10^5$ cfu cm^{-2} of wound and

Robson had reported a similar finding prior to this observation[54]. The role of hospital based bacterial contaminants like other bacterial, the community acquired in particular may be considered in a similar circumstance ie if the surgical site is well prepared before making the incision so that it remains with a much lower infecting dose chances for developing wound infection would be low.

It has been reported that even the MRSA which are the commonest causes of hospital infections are neither more virulent nor do they spread rapidly [55]. Had it been the case, these could be ways that explain the high infection rate that occurs to patients that are hospitalized for a long time before surgery.

Overall, therefore, the high surgical wound infection rate among patients who are hospitalized for a long period may be related to the reasons that cause the prolonged hospitalization rather than their being contaminated with antibiotic resistant strains.

6.6. SHAVING

It is common practice to shave all the hairs from the operation site. This is one of the rituals in surgical practice, whose importance is declining.

Currently, it is advisable not to shave at all unless the hairs are coarse much so that, they will interfere with the surgery. Otherwise, the long hairs may be clipped off from the operation site.

Shaving has been found to predispose to surgical wound infection particularly if done a long time before surgery using razor blades, the reason being contamination of the surgical wound from septic spots that develop as a result of multiple trivial injuries that occur to the skin during shaving. When these occur, they subsequently end up being infected, and therefore surgery that is done later at that particular site will in fact not be a clean one.

In the current study, shaving was not found to predispose to wound infection (P=0.36). This may have been the case because there is at the moment wide knowledge among surgeons and nurses about the effect of shaving. As a result, the current practice is to shave the planned patients on the day of operation. Under such a situation both shaved and unshaved patients had a similar surgical wound infection risk.

6.7. SURGICAL SCRUBBING

Surgical scrubbing forms the single most important aspect in the prevention of surgical contamination[34]. When done correctly, even with bar or liquid soap or detergent, it will remove most, if not all, of the transient skin flora [13,35]. It was found in this study that there was a higher wound infection rate though not stastistically significant, with shorter scrub duration among surgeons and assistants, the first assistant in particular.

Whether this was due to a direct contamination through improperly scrubbed hands by some of the surgical team members or not remains difficult to prove. This is because, after scrubbing it is routine to put on sterile gloves[13]. These act as additional barrier to transfer of microorganisms to the wound. If these are used properly chances of contamination will be low.

On the other hand, it is understood that, bacteria multiply rapidly under gloves[13]. Contamination therefore can occur through punctures in the gloves that occur frequently[13,33]. Emmerson reported a rate of about 11

to 11.5% intraoperative gloves puncture that may lead to wound contamination[33].

With the possibility of glove puncture, which is coupled with the high multiplication rate of the bacteria under gloves, one therefore would expect to have high microorganism load if he was not properly scrubbed.

6.8. SURGEON

The findings in this study indicate that the surgeon's rank is not a risk to surgical wound infection (p=0.32). In previous reports, it was shown that, individual surgeons were responsible for their own surgical wound infection. This was reported by Cruse in Canada[4] in 1992. As a result, therefore, surveillance programs adopted an idea of reporting back to the surgeon the infection rate[13,48,56]. The CDC SENIC project, for example, showed that establishing an infection surveillance and control program which include reporting surgeon-specific rates led to a reduction in hospitals overall surgical wound infection rates of approximately 35%[13]. This, therefore, shows that there is a direct relationship between surgical wound infection and the surgeon.

The role of the surgeon in the causation of surgical wound infection is probably multifactorial. He or she may cause contamination to the wound by breaking the sterile technique. Equally important is the use of poor surgical technique that may lead into bleeding and shock, haematoma formation, leaving dead spaces, undue dissections with extensive devitalization of tissues and many other factors. Overall none of these was investigated in this study.

In part, however, a look was made in assessing the operation duration, which may be associated with wound contamination when this procedure is either prolonged for over a very long time or is carried on for a very short time. Prolonged scrub duration may expose resident flora posing a risk of wound contamination. Likewise, brief scrubbing may leave large numbers of normal flora which as well may subsequently cause wound contamination or infection.

The surgeon-specific wound infection rate reporting, however, has been criticized. Scheckler in 1988 pointed out that reporting of surgeon-specific wound infection rate is a potentially dangerous and misleading strategy[57].

Despite this criticism, it seems reasonable to have each surgeon being given a feedback of the surgical outcome and complications such as wound infections. This will aid in reducing the surgical wound infection rate by keeping the surgeons alert of their resulting wound infection. It will also sensitize them to the search of the causes of the resulting infections and hence the initiation of the prevention of such wound infection.

6.9. OPERATING THEATRES

There was no statistical difference in the rate of surgical wound infection in the two operating theatres used, (P=0.15). In the operating theatre III the wound infection rate was found to be 12.6% while in the operating room IV, it was 8.4%. Taking the two theatres individually, the incidence of surgical wound infection in each was higher than normal. Some factors may be associated with this high surgical wound infection rate.

The theatre layout essentially does not conform to the recommended standards. Figure III depicts the arrangement of the two operating theatres. From this figure, the arrangement that requires movements of the personnel from a "sterile zone" to the "unsterile" one is not present,.

In the operating room IV, one enters the theatre through a sluice room. To the other operating room as well, one enters it through the anesthetic equipments and infusions storeroom. These are not sterile rooms and because of movements that occur during the operations contamination of the operating room environment does occur.

The doors of both operating theatres are of the swinging type. They pose a risk of causing air turbulence in the operating rooms allowing entry of microorganisms from the external environment.

The corridor C that appears on figure III is used as a passage for operating theatre staff as well as other non-operating theatre personnel to the recovery room as well as to other operating theatres. It is also used by some as access to another changing room. This space communicates directly with the external environment, as the windows are always open. Because of this, there is a direct communication between the operating theatres and the external environment.

The uses of the two operating theatres are also slightly different; overall more operations are done in operating room III as compared to operating room IV. During the whole study period, 699 operations were done in

operating theatre III, out of which 421 were emergencies. This is about 8.5 times the number of emergency operations done in operating room IV, which were only 49. This very large number of emergencies done in operating theatre III may explain the associated relative high wound infection rate as they are the potentially contaminated, contaminated, or dirty operations, and thus cause contamination of the operating theatre making it a wound infection risk.

7.0. MICROBIOLOGY OF WOUND INFECTION

The bacterial isolates obtained in this study are not uncommon. Murthy, et al found in India in1998 that *Staphylococcus aureus* accounted for about 32% and *Pseudomonas* spp were 21%[47]. In England, *Staphylococcus aureus* isolate accounted for about 29%[20]. Many other studies also have reported S*taphylococcus aureus* as the commonest isolate[3, 4,13,50,53,58].

Rangel- Frasto MS[46] et al, however, reported *Escherichia coli* as the commonest isolate in their series. Twenty eight percent of the isolates were *Escherichia coli*, 11.1% *Staphylococcus aureus* and *Pseudomonas aeruginosa* 8.6%. Shija[7] in his preliminary report of 1973 had gram-

negative bacteria dominating in Dar es Salaam. There were 34.8% *Proteus* spp 17.4% *Klebsiella* spp and *Staphylococcus pyogenes* 13% in that order. The observation that *Klebsiella* spp isolates were the second commonest is striking. In many reports, with the exception of the one done in Dar-es-Salaam in 1973 where it was also the second commonest, this microorganism is rather rare. Other reports [13,58] have found it among the least common causes of surgical wound infection. It is even less common as compared to *Escherichia coli*, *Pseudomonas* spp and *Proteus mirabilis*. Whether this is coincidental or real, is hard to explain, the speculation made by Shija in 1973 may be real[7]. Probably the pathogenicity of this microorganism in this hospital is rather high.

The other isolates were similar to reports made elsewhere. In the United Kingdom Jacobson reported 10% isolates as being *Escherichia coli*, 8% *Pseudomonas aeruginosa*, 4% *Proteus mirabilis*, and 3% *Streptococcus* spp[20]. In another report, the isolates included *Staphylococcus aureus*, *Pseudomonas* spp, and *Klebsiella* spp in that order. Therefore the bacteriological pattern in this study is generally similar to other reports elsewhere though with a more frequent isolation of *Klebsiella* spp.

7.1. ANTIBIOTIC SUSCEPTIBILITY

In the present study variable antibiotic susceptibility patterns were demonstrated. The gram-positive bacteria were generally found to have a significant susceptibility. *Staphylococcus aureus*, which was the commonest isolate, was 100% susceptible to methicillin. But the same microorganism was also found to be 100% resistant to penicillin G and 15-28% resistant when it was tested to erythromycin and tetracycline.

Whether there has been a less effect of the frequently reported abuse of antibiotics or not is hard to explain. In 1973, Shija[7] pointed out the existence of general abuse of the antibiotics at dispensaries and elsewhere. As such, this was the suspected reason of the high rates of antibiotic resistance that resulted in his series. Seven years later a similar inference was made in Dar-es-salaam[59].

The trend towards a progressive increase in resistance to commonly used antimicrobial agents could be anticipated. Following the trade liberalization in the latter half of the 1980's a number of pharmaceutical shops were established from which the antibiotics could be easily dispensed. Reported incidences where antibiotics were dispensed without prescriptions have been made. Before the trade liberalization,

antibiotics and other antimicrobial agents could be obtained from dispensaries, health centers and hospitals under a relatively supervised prescription procedure.

The emergence of MRSA and VRS were reported in the early 1980[5,37]. In 1997, and 1999 there were reports from Kenya and USA respectively which came up with respective MRSA rates of about 39.8% and 1.8%. These were reported to be attributed by the antibiotic abuse[50,60]. Whether the problem of MSRA does not exist here is hard to say from the data obtained in this study, probably a chance finding.

With gram-negative bacteria, different researchers have reported a mixed picture. The current study has shown antibiotic resistance rates that range between 25 and 100% to commonly used antibiotics such as augmentin, ampicillin, cotrimoxazole, chloramphenicol, tetracycline and gentamicin. Resistance was less marked with ceftriaxone with which, only *Klebisiella* spp demonstrated a 6.7% resistance.

In 1979/80, between 50-90% of all coliforms isolated were found to be resistant to ampicillin, tetracycline, and sulphonamide in Dar-es-salaam[59].

Otukunefor and Datubo-Brown also reported multidrug resistance in Nigeria in 1990[61]. In 1997 a Kenyan study also reported a similar finding[60]. While previous reports have shown a less than 100% resistance to the tested antimicrobial agents, the present study recorded 100% resistance with some commonly used antimicrobial agents (though small numbers of the isolates in some cases may be responsible with the high antibiotic resistance). Therefore, It seems the problem of multidrug resistance is worsening. Previous speculations that abuse of the commonly used antibiotics is the root cause of resistance can still remain plausible especially after trade liberalization.

Overall therefore, the problem of multidrug resistance is significantly large, such that some other drugs like penicillin G seem useless especially when one is faced with a patient suspected to have the risk or is already infected with Staphylococcus aureus.

7. CONCLUSIONS

The magnitude of wound infection after clean operations as seen in this study is five times higher than the acceptable standards of 1-2%. Though there are no previous records to compare locally, studies done

elsewhere indicate a much lower incidence. As noted earlier on, a Nigerian study reported a 2% wound infection rate. Generally most researchers have recorded incidence rates ranging between 1 and 5%. More recently, reports in the United Kingdom came up with an incidence rate of less than 1%. The finding in this study of 10.1% therefore is exceedingly high, and could be even higher than what is reported because there was a large number of dropouts from the follow up.

The surveillance program instituted, though not very efficient, it indicated the role of providing post-surgical patients with close follow-up. There were about 7/47(14.9%) patients who would have been missed if the follow-up would be restricted only to hospitalized patients.

The bacteriological pattern of surgical wound infections obtained did not differ greatly with the findings elsewhere. Staphylococcal predominance, which has been the commonest isolate in most series was also the case in the present study, however a slight deviation was noted with *Klebsiella* spp isolates being the second commonest. Studies done elsewhere report this (*Klebsiella* spp) microorganism less frequently. Otherwise, the rest of the isolates were similar to previous findings

Significant factors leading to wound infection were prolonged hospital stay before surgery and prolonged operation duration. Though not significant, laxity in adherence to the norms of the conduct in the operating theatre was apparent. Shorter surgical scrub durations were recorded with some members of the surgical team. Other factors investigated such as the ward environment, the operating theatres, the surgeons and technique need further review.

8. RECOMMENDATIONS

As the problem of surgical wound infection in this hospital is large, the following are recommended.

1. A more extensive study is required. This needs to be long term with coverage of all areas that work in association in the provision of surgical care. Such areas as the CSD, the operating theatres, the surgical wards and personnel need to be studied so as to establish the most important risk areas at which preventive measures can be focused.

2. The operating theatre needs modifications that can suit the

requirements of a standard operating theatre. Areas that need restructuring include, the movement patterns both for air and personnel, ventilators, air extractors, conditioners and the general structure that eventually will be that of the "ideal" operating theatre. The minimum that is required to be done is to resume the initial plan and functions of the different parts of the operating theatre. The currently closed doors as indicated in figure III need to be opened. As a result the movement pattern of the personnel will, for example, avoid entrance of the operating theatre IV through the sluice room. To effect this, a different room can be used for endoscopy such as one of the side rooms in the surgical wards or the room that was designed as the sterilization room(STR). Also a closed door number 4 needs to be opened so that, one enters operating room III after having scrubbed. The storage function of the room which provides access to the operating theatre III should stop and other alternatives be used, such as the then STR which is currently not functioning.

3. A surveillance program needs to be put in place. This should cover the patients' continuous follow-up after surgery so as to identify those who suffer complications and particularly the nosocomial infections. It should also involve surveillance of the environment,

such as that in operating theatre, with which, routine air sampling needs be done so as to establish the level of contamination of the theatre environment, identify the contaminating microorganisms and their susceptibility patterns. This together with the regular check-up of the personnel for their bacterial flora and potentially transmissible infections is important in establishing the possible sources of infections should they occur on surgical wounds.

4. As we are currently in the science and technology era, it is high time that a computerized data management be adopted. This should be not only for surgical wound infections or nosocomial infections but also for other hospital patients' related information. On the aspect of surgical wound infection, this can be made possible if a hospital infection control team is formed. The presence of such a team will make possible the collection of the necessary information that is required with regard to the magnitude of the problem, outbreaks, possible risk factors etc. The team is also important, as it will aid interdepartmental, multidisplinary and inter-hospital collaboration, which is vital in the surveillance and control of hospital infections.

It is therefore being recommended that a hospital infection control

team (HICT), be formed that will consist of the following.

- Infection control Doctor (ICD) and
- Infection control Nurse (ICN).

Together with this, a hospital infection committee be formed that will consist of the,

- Hospital infection control team.
- Consultant in communicable disease control
- Infectious disease physicians
- Microbiologist
- Hospital director
- Hospital matron.
- Occupational health specialist
- Representatives from other allied hospitals, some private hospitals, District hospitals, and Referral hospitals.

The hospital infection committee is important. Because of its composition, it will be capable of providing the infection control team with expert advice on the infection control. Furthermore, it can draw infection control programmes and assist in the administrative aspect and their implementation by supporting the infection control team.

5. There is a need for continuous re-education among hospital personnel with regard to the aspects of infections. For the operating theatre personnel, continuing education on the rituals in the surgical practice is needed. Aspects like surgical scrub, sterility, use of masks, theatre wears etc need emphasis every now and then.

6. Continuous monitoring and reviewing of policies regarding the use of antimicrobial agents in the hospital, dispensaries, health centers, pharmaceutical shops, and the country at large needs to be enforced. With these, the reversible antibiotic resistance can be restored and on the other hand prevention or marked reduction of the developed antibiotic resistance can be achieved.

7 An operating room that is reserved for emergency operations is required. This will avoid the possible contamination risk that may occur if elective operations are done in the same operating room as the emergency ones.

9. LIMITATIONS

1. Lack of funds was the limiting factor in several aspects. The

required investigation materials were not made available due to lack of funds. As a result, the required investigations were conducted depending on the availability of the hospital supplies. At times some tests could not be done, such as bacterial sensitivity. Also there were not enough funds to employ or recruit specific personnel for the conduct of the research. As a result, those recruited were merely on temporary basis leading to some missed opportunities. At times, they were not available as required as they were attending to their regular routine.

2. There were no modifications and preparations done to the laboratory that could suit the research conditions. All the investigations were conducted under conditions similar to routine investigations done in the hospital.

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