Incidence, Risk Factors and Bacterial Susceptibility of Surgical Site Infections among Abdominal Surgeries at Kampala International University Teaching Hospital, Uganda

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ABSTRACT

Background: Surgical site infection (SSIs) is a global burden that contributes towards morbidity and mortality of patients undergoing abdominal surgeries. There is paucity of data on SSIs in resource constrained Uganda to guide antibiotic protocols.

Study Objective: To determine the incidence of SSIs, risk factors, common causative bacteria and their susceptibility patterns amongst patients undergoing abdominal surgeries at Kampala International University Teaching Hospital (KIUTH), Uganda.

Methodology: Cross-sectional observational cohort study involving culture and sensitivity of pus swabs from surgical sites of consented consecutive patients. Laboratory tests were performed at the United States Army Research Laboratory on Infectious Diseases (USAMRIID). Data was analyzed using SPSS 20.0. Chi-square and binary logistic regression analyses were performed at 95% confidence interval, regarding $p<0.05$ as significant to determine risk factors for SSIs. Ethical Clearance was obtained from Mbarara University Science and Technology Ethical review committee (IRB N0. 02/01-17).

Results: Of the 138 patients, 17.4% (n=24) developed SSIs. The risk factors for SSIs were comorbidity with diabetes mellitus, cancer without enrollment for anti-cancer treatment, pre-operative white blood cell count >11.0x10^9cells/L, and HB < 14.0g/dl, American Society of Anesthesiologists (ASA) score ≥II, surgery involving entry into the peritoneum. The bacteria responsible for SSIs were *P. aeruginosa* followed by *E.Coli*, *S.aureus,* Methicillin Resistant *S.Aureus, K. pneumonae* and *Proteus* species in that order. These isolates demonstrated multiple drug resistance to gentamycin, amoxicillin-clavulanic acid, ceftriaxone, and ciprofloxacin.

Conclusion(s): The prevalence of SSIs in the present study was higher than previously reported. *P. aeruginosa, E.Coli*, *S. aureus,* MRSA, and *K. pneumonae* were the leading cause of SSIs. These bacteria demonstrated multiple drug resistance.

Key words: Antibiotic resistance, surgical site infection, sepsis, risk-factors, Uganda

INTRODUCTION

Surgical site infections (SSIs) affect the incisions or operative sites (including drains) within 30 days after surgical procedure if no implant is left in place or within one year if an implant is left in place [1]. They are the most frequent type of Hospital Acquired Infections (HAIs) [2, 3] and account for 14-16% of inpatient infectious complications [4]. SSIs increase morbidity [4] and mortality [5] in surgical patients, thus posing a significant economic burden to already constrained healthcare systems [6].

Although there has been an improvement in surgical techniques, infection control practices and universal use of pre-operative antibiotics; wound infection is still a global concern [6]. The National Health safety Network (NHSN) data show that for an overall SSI rate of 1.9%, there is an associated mortality rate of up to 3% [1]. Whereas lower rates of SSI between 2.0% to 5.0% are being reported in developed countries such as USA [6], these more than double in African and other developing countries. For instance, a systemic review by Nejad *et al* [7] reported a 19% SSI rate in Tanzania and Kenya and 10% in Uganda. The presumed risk factors could be patient or operator related, ultimately determining the establishment of a surgical site infection [8].

Various studies (4-8) have identified patient related factors such as co-morbidity with anemia, malnutrition, obesity, diabetes, HIV, cigarette smoking, alcohol consumption and operator related factors such as strictness to implementation of sterile protocol and advancements in surgical techniques as major determinants of SSIs. However the findings have been diverse and inconsistent. Furthermore, although *Staphylococcus Aureus, Escherichia coli* and *Pseudomonas earuginosa* have been identified as common causative bacteria for SSIs [11-13] their exact incidence and patterns of antibiotic

susceptibility has been variable depending on antibiotic prescription practices [1,8], quality of laboratories and tendency for under reporting due to limited diagnostics in low income countries [7].

Surgical Site Infections not only contribute to significant mortality but also economic implications related prolonged hospitalization [5, 9-11]. Patients who develop SSIs require twice more days of hospitalization compared to those without SSIs [12]. Furthermore patients who develop major complications such as deep tissue and organ space infections continue to have a grave impact, increasing their duration of hospitalization as much as 20-fold and the cost of hospitalization fivefold [12, 13]. The extra cost for SSI range from $ 858 to $17,708 per infection, prolonging hospital stay from 1 to 44 days [13].

However, there is paucity of published data on SSIs in Uganda. The last rates of 10% were to World Health Organization (WHO) data base between 1997 and 2011 [7, 14]. The dynamic trends in epidemiology, risks factors and bacterial susceptibility profiles in the present arena of antibiotic stewardship warranties up-to-date data [15]. Such data are mandatory to guide local antibiotic prophylaxis and empirical therapy protocols in remote Ugandan context where culture and sensitivity are not routinely accessible.

Study objective

To determine the incidence of SSIs, risk factors, common causative bacteria and their susceptibility patterns amongst patients undergoing abdominal surgeries at Kampala International University Teaching Hospital (KIUTH), Uganda.

MATERIALS AND METHODS

Study Design

This was a cross-sectional observational cohort study carried out for a period of 6 months from January 2017 to June 2017.

Study Setting

The participants were recruited through surgical out patient, accident and emergency unit and surgical ward at Kampala International University Teaching Hospital (KIUTH) (http://ameca.org.uk/directory/listing/kampala-international-university-teaching-hospital-uganda), a private/public partnership and government aided tertiary hospital in Western Uganda, with over 700-bed capacity.

Target population

All patients with surgical abdominal pathologies seeking treatment at Kampala International University Teaching Hospital during the study period.

Inclusion Criteria

i). All patients above 1 year with abdominal pathologies who underwent abdominal surgeries at KIUTH during the study period and were followed-up until the 30th post-operative day.

Exclusion criteria

i) Patients with abdominal wounds not of surgical origin.

ii) Patients who were postoperative referrals to KIUTH.

iii). Patients who did not consent for surgery and or study.

Sample Size determination

The number of participants was calculated using the Kish Leslie (1965) formula. The prevalence of surgical site infection in Uganda was reported to be 10% based on the only available study in the WHO data base [14]. The sample size required, n, was calculated using the formula;

$$n = \frac{pqz^2}{d^2}$$

Where p is the prevalence of surgical site infections 10% ($p = 0.1$); q = 1-p= 0.9 and z is 1.96 (for 5 % alpha error); and d is precision which is 0.05 (permissible margin of error at 5 % level of statistical significance).

$n=0.1\times0.9\times1.96^2/0.05^2$

n= 138

Data collection methods:

A structured questionnaire was used to collect data on demographic, clinical characteristics and baseline investigations such as complete blood count (CBC), blood grouping and cross matching (for those who needed blood transfusion), HIV testing, random blood sugar (RBS) and those requiring radiological investigations like abdominal ultrasound and abdominal x-ray were done. Patients were assessed through Surgical Outpatient Department (SOPD) and Accident and Emergency (A&E) Department at KIUTH. Those who needed emergency surgical intervention were operated following resuscitation, stabilization and diagnostic/baseline investigations. Those who were stable were booked for elective surgery.

The patients were reviewed postoperatively and wounds were examined 48 hours post-operatively. The clinical features that were used for assessment of wound infection included fever with axillary temperature >38^0C, severe pain at the wound, pus discharge from the incision site. For any suspected infected surgical site, a pus swab was taken from the wound and discharge from drains plus a tissue biopsy were taken to the microbiology laboratory for culture and sensitivity. Microorganisms were identified and their resistance profiles to different antibiotics were determined and the regimen of the patients were adjusted appropriately. After discharge patients were reviewed in Surgical Outpatient department after 2 weeks and again on the 30^{th}post operative day. Communication and appointments for review and follow up were through Mobile phone provided at initial admission.

Algorithm for Isolation of Surgical site Pathogens

The algorithm for isolation of SSI pathogens included swab and transport, primary isolation, Confirmation of phenotypic characteristics, Minimal Inhibitory Concentration (MIC) and Polymerase Chain Reaction (PCR) for MRSA. The protocol describing these laboratory processes are detailed in the supplementary files (appendices)

Data Analysis and Presentation

The data was entered into Microsoft excel and checked for errors, then exported into IBM SPSS 20.0. Statistics for windows (Armonk, NY: IBM Corp) for analysis. Proportion, cross-tabulation, Pearson's chi-square, and likelihood ratio tests were used, as appropriate. A binomial logistic regression model was fitted at 95% confidence interval and $P<0.05$ as significant, to ascertain the effects of independent variables on the likelihood that participants will develop surgical site infection. Odds ratios (OR) were

computed for all variables without empty cells, that demonstrated to be potential risk factors for SSIs i.e. for all variables with a p-value ≤0.200 at bivariate analysis. This model was suitable in lieu of dichotomous nature of the dependent variable and categorical or continuous independent variables.

Quality control

All the pre-operative, clinical and postoperative assessments were conducted using standard International units (SI). A professor of microbiology supervised the laboratory work while a senior consultant surgeon supervised the clinical work.

Pilot Study

A pilot study was conducted at Ishaka Adventist Hospital in a similar study population to test the questionnaire and corrections were made accordingly.

Ethical Considerations

Ethical approval was obtained from Institutional Review Committee of Mbarara University of Science and Technology (IRB N0. 02/01-17). The participants were given detailed explanation of the study benefits like free culture and sensitivity test and follow up after discharge at no cost. Informed consent was obtained for participating in the study. For minors, assent was obtained from the legally authorized representatives. Results of culture and sensitivity were immediately shared with the patients and their respective attending surgeons to revise the antibiotics accordingly.

RESULTS

Socio-demographic characteristics of study participants

Of the 138 participants, majority 79% were males and almost 31.9% of the participants were aged above 62 years. Nearly 40% were single and were mainly Christians. About 73% attained only primary education (Table 1).

Prevalence of surgical site infections after abdominal surgery at KIUTH

Of the 138 patients that underwent abdominal surgeries, 17.4% (n=24) developed surgical site infections. The commonest abdominal surgeries were for inguinal hernia 15.9% (n=22), followed by benign prostatic hyperplasia 12.3% (n=17), intestinal obstruction 11.6% (n=16) and gut perforation 11.6% (n=16). The other indications for surgery included acute appendicitis, blunt and penetrating abdominal trauma, cholelithiasis, hemorrhagic necrotic pancreatitis, cryptorchidism, congenital communicating hydrocele, incisional and umbilical hernia, Intra-abdominal mass and malignancies such as gastric, esophageal, prostate cancer.

Of the 24 patients who developed SSIs, majority 29.2% (n=7) had a preoperative diagnosis of gut perforation for laparotomy, benign prostatic hyperplasia (BPH) for open prostatectomy 16.7% (n=7), acute urine retention for supra-pubic cystostomy 12.5% (n=3) and intestinal obstruction for laparotomy 12.5% (n=3) (Table 2).

Of those who developed SSIs (n=24), half 50.0% (n=12) had pre-operative leukocytosis of equal or more than 11.0 x10^9 cells/L. Table 3 summaries the incidence of surgical site infections by clinical characteristics.

Risk factors for surgical site infections following abdominal surgeries at KIUTH

Results of bivariate analysis showed that there is a statistically significant relationship; ($p<0.05$); between development of SSIs following abdominal surgeries and: comorbidity with diabetes, whether or not the patient is enrolled for treatment for diabetes, nature of treatment for diabetes (oral hypoglycemic versus insulin), history of enrollment for cancer treatment, pre-operative white blood cell count, hemoglobin concentration, pre-operative diagnosis, ASA score, Nature of surgery and WHO/CDC wound classification.

The predictors for the development of SSIs included, post-operative temperature of equal or greater than 38.0^0C and post-operative pain and pus discharge at the surgical site (Table 4). There was no statistically significant association between SSIs and social demographic variables such as: gender, age category, level of education and occupation, history of cigarette smoking and or alcohol consumption; as well as body mass index, blood pressure and random blood sugar at admission, urgency of surgery (elective vs. emergency), antibiotic exposure prior surgery, duration of surgery; HIV status, enrollment for HIV treatment, CD4 count, carrying a diagnosis of cancer ($p>0.05$).

The logistic regression model was statistically significant ($X^2= 38.402$ $p<0.001$). The model explained 68.0% (Nagelkerke R^2) of variance in occurrence of SSIs and correctly classified 89.0% of cases (positive predictive value). Those who were more likely to develop SSIs following abdominal surgery were: patients once diagnosed by some form of cancer but were not on any cancer treatment [OR=3.800; 95% CI (1.101-13.117)], pre-operatively anemic [OR=1.691; 955CI (1.339-2.134)] and those whose surgery involved entry into the peritoneum [OR=1.75; 95% CI (1.352-2.290)]. Presence of pus discharge from the surgical site [OR=21.850; 95% CI (9.236-51.694)], pain at the surgical site

[OR=14.929; 95% CI (7.210-30.909)] and history of post-operative fever [OR=11.400; 95% CI (6.307-20.606)], with post-operative temperature≥38.0^{0}C [OR=7.917; 95% CI (3.934-15.933)], remained significant predictors for SSIs (Table 5). There was no statistically significant association between SSIs and HIV status, carrying a diagnosis of cancer, urgency and duration of surgery (p>0.05).

Bacteria causing surgical site infections after abdominal surgery at KIUTH

The commonest bacterial isolate for surgical site infection was Pseudomonas aeruginosa, accounting for 26.7% followed by Escherichia coli 23.3% (Fig.1). Of the 5 *Staphylococcus aureus* bacterial isolates, 40% (n=2) were methicillin resistant (MRSA).

Bacterial susceptibility profiles to common antibiotics at KIUTH.

Bacterial isolates were more sensitive to imipenem followed by ceftaroline as shown in (Table 6).

Bacterial resistance profile to common antibiotics at KIUTH

Majority of the bacterial isolates demonstrated multiple drug resistance to first line antibiotics used in our settings that includes: gentamycin, cotrimoxazole, ampicillin, amoxicillin-clavulanic acid, cefotaxime, chloramphenicol, and ciplofloxacin herein being referred to as category (1) (Table 7).

Of the 8 patients who had *Pseudomonas aeruginosa*, 3 patients were found to have co-infections with *Proteus mirabilis, Citrobacter freundii,* and *Pasteurella pneumotropica* that demonstrated multiple drug resistance to category (1) antibiotics as shown in (Table 8).

DISCUSSION

Incidence of SSIs amongst patients undergoing abdominal surgeries at KIUTH

The study revealed that of the 138 patients who underwent abdominal surgeries, 17.4% developed surgical site infections. This finding is comparable to 17% reported in Egypt and Nigeria by the World Health Organization worldwide report [16] and to rates reported in India [17] and United Arab Emirates [18]. However, it was higher than 10% reported in Uganda during a multi-country systematic review in 2011 [7], which might depict increasing incidence. It is slightly lower than the 19% reported in the neighborhoods of Kenya, Tanzania and Central African Republic [7]. The SSIs incidence in our study is far much higher than 1.9% expected international standards by Centre for Disease Control [1]. This probably due to inclusion of contaminated and dirty wounds in our settings whose infection complication rates are expected to be high.

Risk factors for SSIs amongst patients undergoing abdominal surgeries at KIUTH

There is a statistically significant relationship , between development of SSIs following abdominal surgeries and: comorbidity with diabetes, whether or not the patient is enrolled for treatment for diabetes, nature of treatment for diabetes (oral hypoglycemic versus insulin), history of enrollment for cancer treatment pre-operative white blood cell count and hemoglobin concentration , pre-operative diagnosis , ASA score, Nature of surgery (extra-peritoneal vs. intra-peritoneal) and WHO wound classification. .

The increased risk of SSIs in this category of patients is consistent with those of an Indian study in a government hospital conducted during 2014 [5], emphasizing the need for pre-operative and post-operative glycemic control in this patient category.

The study showed that 50% of patients who developed SSIs had pre-operative leukocytosis and the risk nearly doubled if the patient was pre-operatively anemic; which remained significant even on regression analysis. Moral García et al demonstrate that anemic patients bleed into the dead space [19] and suffer sepsis due to transfusion [5]. Furthermore, the associated malnutrition in anemia compromise wound healing [20], particularly in Ugandan context where pre-operative under nutrition is common [21].

We found that patients who developed SSIs were mainly those who underwent open prostatectomy for benign prostatic hyperplasia and exploratory laparotomy for gut perforation or bowel obstruction. Our findings conform to Centre for Disease Control risk stratification, where clean wounds carry a lower infection complication rate (1-5%) compared to clean-contaminated (3-11%), contaminated (10-17%) and dirty wounds such as gut perforations (up to 27%) [1]. Mainly these patients belonged to ASA classification II and III respectively, in contrast to Pear et al., who demonstrated ASA IV and V as most at risk of SSIs [22]. However in the present study, whether the surgery involved entry into the peritoneal cavity was a major determinant of SSIs as opposed to pre-operative diagnosis, ASA score or duration of surgery which were demonstrated to be the main risk factors by Ansari et al [23].

We also found that those who developed SSIs following abdominal surgery were patients once diagnosed by some form of cancer for example cancer of the prostate or esophagus who were currently being admitted for a different indication for abdominal surgery but were not on any cancer treatment. This could depict low immunity as a result of the co-existing cancer or for reasons the patient was deemed unsuitable for anti-cancer drugs, which either case would impair wound healing [8]. Presence of pus discharge from the

surgical site, pain at the surgical and history of post-operative fever, with post-operative temperature ≥38.0^{0}C, remained significant predictors for SSIs.

Patients who were HIV positive, those who underwent emergence surgery and those whose surgery took longer than 2 hours had slightly higher odds for SSIs but these did not reach statistical significance as opposed to previous studies [24-26]. This could due to the fact that majority of our HIV positive patients had CD4 count>250cells/mm^3 and our cut off time for prolonged surgery of 2 hours was shorter than 2.5 hours used in previous studies [23].

Although previous studies had correlated SSIs with extremes of age [27], obesity [9], hypertension [5] and smoking [28], there was no relationship between these variables and development of SSIs in the present study, the difference of which could be attributed to patient selection and different inclusion criteria. Also the present study demonstrated no statistically significant relationship between prophylactic antibiotic exposure and SSIs as opposed to earlier studies [8]. Our findings could be confounded by the fact that our study was conducted in a tertiary hospital where majority of our patients had received antibiotics from referring hospitals as prophylaxis or treatment for other underlying condition such as urinary tract infections for patients with indwelling catheters for urinary retention due to benign prostatic hyperplasia and variability in antiseptics for hand scrubbing and patients' skin preparation [29].

Epidemiology of bacteria causing SSIs at KIUTH

We found that *Pseudomonas aeruginosa* was the number one cause of SSIs following abdominal surgeries, *Escherichia Coli* and *Staphylococcus aureus* of which 6.7% were *Methicillin Resistant Staphylococcus Aureus* (MRSA). The incidence of *pseudomonas*

aeruginosa (27.7%) in the present study is much higher than (20%) reported in India [28], (12.8%) in Egypt [10] and (3.2%) in Saudi Arabia [18]. Our findings of E.coli being prevalent at 23.3% slightly deviate from routine known that *E.coli* is the leading cause of SSIs followed by *Staphylococcus Aureus* [10, 18, 28, 30]. The difference could be attributed to the fact that some of our patients underwent extra-peritoneal surgery such as herniorrhaphy and open prostatectomy where *E.coli* is not as common as surgery involving extensive entry into the peritoneal cavity such bowel surgery [28].

However the prevalence of *Staphylococcus* Aureus in the present study is comparable to 20.4% reported previously in a Ugandan study, although there were lower rates of MRSA (6.7%) in our study compared to (37.5%) previously reported in Uganda [31], 18.8% in Tanzania [32], 17.2% in Egypt [10]. The difference in epidemiology of causative bacteria for SSIs emphasizes the need for routine surveillance studies to keep up-to-date knowledge of local variations in prevalence and susceptibility patterns to guide antibiotic protocols.

Antibiotic susceptibility and resistance profiles of bacteria causing SSIs at KIUTH

The study revealed that majority of the bacterial isolates demonstrated multiple drug resistance to our first line antibiotics. While 100% of *Staphylococcus Aureus* and *Proteus Valgaris* in our study were sensitive to ceftriaxone and imipenem, only 50% of Pseudomonas aeruginosa and MRSA and 28.8% of *E.coli* were sensitive to ceftriaxone and imipenem. Half of MRSA and *Klebsiella pneumonae* were sensitive to ceftaroline. These findings were comparable to those of Janugade et al in their Indian study at the Krishna Institute of Medical Sciences [17]. On the contrary, a study in Saudi Arabia found that *Staphylococcus Aureus* was resistant to more than 23 antibiotics excluding oxacillin

and vancomycin [18] whereas a Nigerian study demonstrated resistance to B-lactam antibiotics of more than 98% including 70% to cotrimoxazole [33].

We also found that resistance to category (1) drugs [gentamycin, cotrimoxazole, ampicillin, amoxicillin-clavulanic acid, cefotaxime, chloramphenicol, and ciplofloxacin] was 100% by *Staphylococcus Aureus, Proteus Valgaris* and *Morganella Morgagni*, 62.5% by Pseudomonas Aeruginosa, 50% by Klebsiella pneumonae, 42.9% by *E.coli* and 50% by MRSA. Our findings are in conformity with an earlier Ugandan study [31] in which 100% of Staphylococcus Aureus, E.coli and Klebsiella species were resistant to penicillin. The resistance profile demonstrated by *S. Aureus* in the present study is higher than 91% reported in India [15], probably due to self-prescription and miss use of penicillin as an-over-the-counter drug in Ugandan settings [34].

Over 25% of *Pseudomonas Aeruginosa* was resistant to vancomycin and amikacin in addition to category (1) and 12.5% to ofloxacin and azithromycin in addition to category (1). An earlier Ugandan study by Seni et al during 2013, among hospitalized surgical patients at Mulago National Referral Hospital demonstrated that 100% of Pseudomonas aeruginosa were resistant to tetracycline, even though authors included gynaecological surgical cases [31].This clearly shows that antibiotic resistance of *Pseudomonas Aeruginosa* is a growing public health concern in Uganda that needs antibiotic stewardship.

Over 50% of Klebsiella pneumonae was resistant to imipenem in addition to category (1). This proportion of resistance to carbapenems is far much higher than 7.9% reported by Sievert *et al* [30]. We found that over 50% of MRSA was resistant to ofloxacin and azithromycin in addition to category (1) whereas 28.6% of *E.coli* was resistant to

tetracycline, clindamycin, and vancomycin in addition to category (1). These resistant patterns of MRSA and *E.coli* are much higher than (2.2%) and (11.9%) respectively reported in a Spanish study of critically ill patients with secondary and tertiary peritonitis [35], although consistent with a Ugandan study at the National Referral Hospital, Mulago [36]. Overall, all the resistance profiles depicted in our settings is higher than that reported in the National Health Care Safety Network report [30], which calls for scaling up of antibiotic stewardship and rational prescriptions based on local antibiotic susceptibility profiles.

Limitations of the study

It was difficult to obtain all previous medical documents detailing risk factors due to the condition of the patient in emergency operations. For patients who were re-admitted following am initial discharge against medical advice, it was difficult to determine the exact onset and probable source of infection outside hospital settings.

Conclusion(s)

We found a high incidence of SSIs amongst patients undergoing abdominal surgeries at KIUTH compared to earlier reports in the country. The main risk factors for SSIs in our study population were comorbidity with diabetes mellitus and cancer without enrollment for anti-cancer treatment, pre-operative Leukocytosis , pre-operative low hemoglobin concentration, ASA score ≥ II, having a clean contaminated wound and undergoing surgery involving entry into the peritoneal cavity. The commonest bacteria responsible for SSIs were *Pseudomonas aeruginosa* followed by *Escherichia Coli* and *Staphylococcus*

aureus. We found that majority of the bacterial isolates demonstrated multiple drug resistance to commonly available antibiotics in our settings.

Recommendation(s)

There is need to curtail SSIs with more emphasis on control of comorbidities such as diabetes mellitus, malignancies and anemia prior to surgery, particularly for elective procedures involving entry into the peritoneal cavity. The current study findings could be used to update the antibiotic prescription protocol amongst surgical patients at KIUTH. Further studies should be tailored towards understanding the molecular basis underlying multiple drug resistance to keep clinicians informed of the dynamically changing bacterial susceptibility patterns to augment antibiotic stewardship.

CONFLICT OF INTEREST

The authors declare no conflict of interest

LIST OF FIGURES

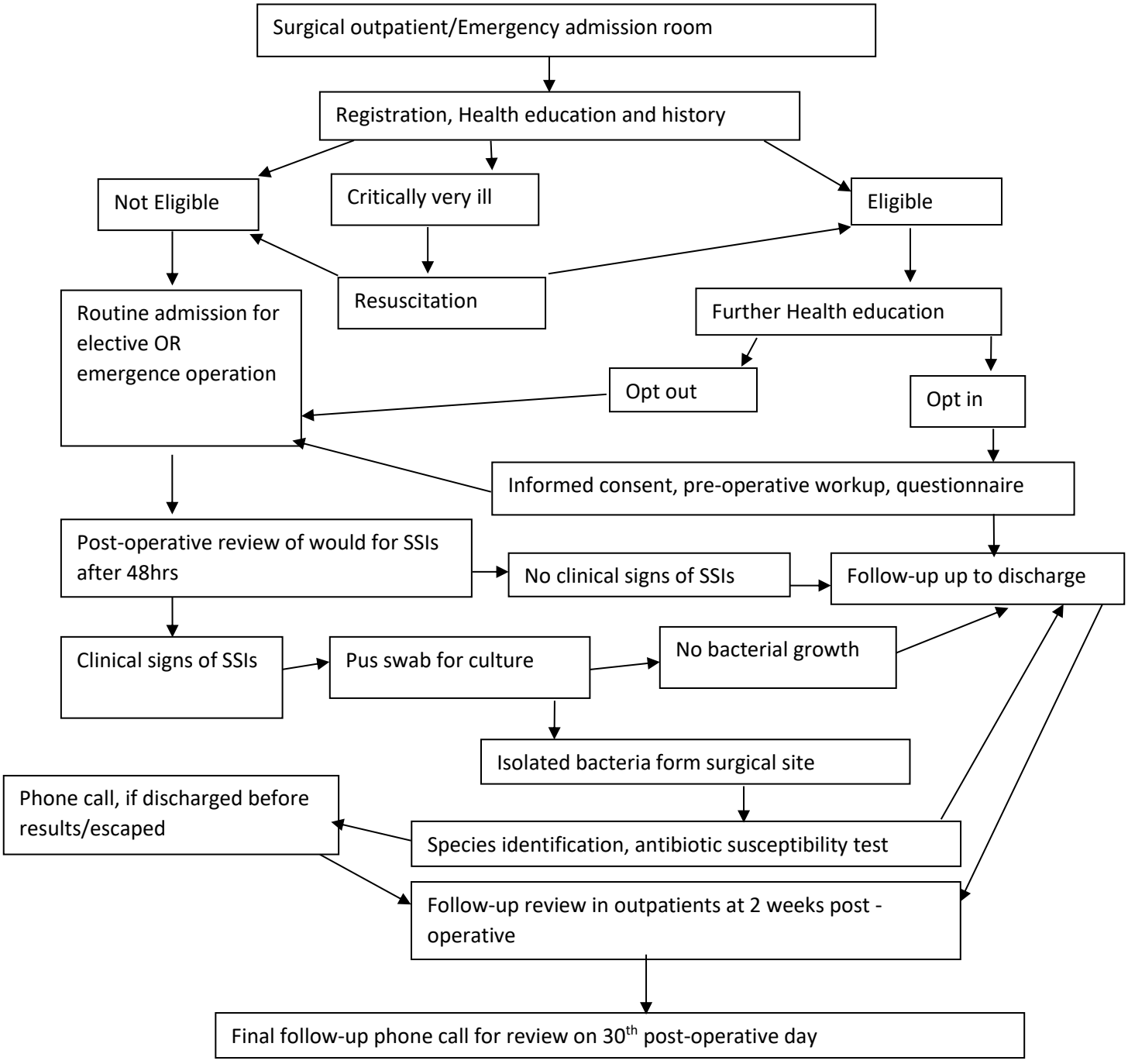

Figure 1: Flow Chart Showing Study Procedure and Flow of Participants

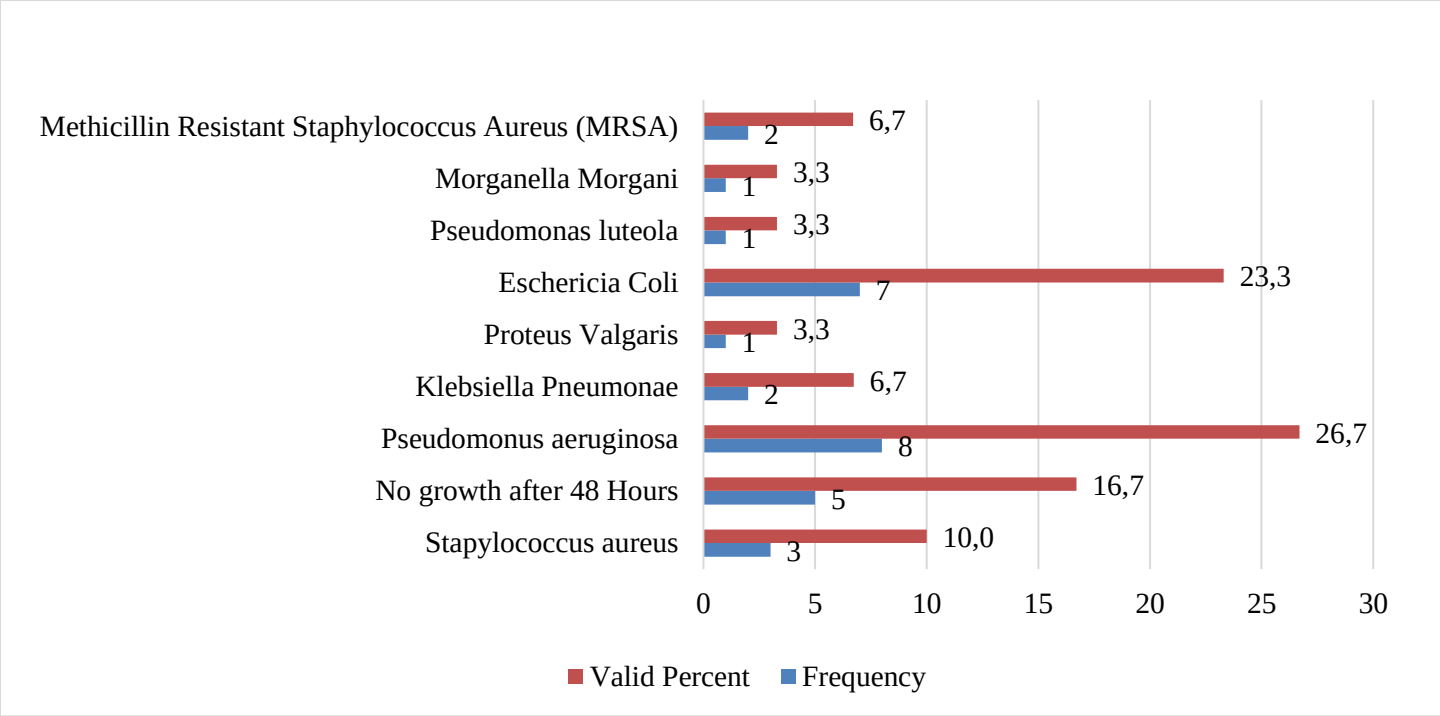

Figure 2: Showing epidemiology of bacteria responsible for surgical site infections following abdominal surgeries at KIUTH

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Table 1: Showing socio-demographic characteristics of study participants who underwent abdominal surgeries at KIUTH

Study Variables	Frequency(N=138)	Percent (%)
Sex		
Male	109	79.0
Female	29	21.0
Age (Years)		
0-20	38	27.5
21-41	37	26.8
42-62	19	13.8
Above 62	44	31.9
Marital Status		
Single	55	39.9
Married	70	50.7
Divorced	02	1.4
Separated	02	1.4
Widowed	09	6.5
Religion		
Christian	131	94.9
Muslim	07	5.1
Education Level		
Primary	101	73.2
Secondary	19	13.8
Tertiary/University	06	4.3
No formal education	12	8.7
Occupation		
Peasant farmer	**83**	**60.1**
Formal employment	**08**	**5.8**
Business	**16**	**11.6**
Student	**27**	**19.6**
Unemployed	**04**	**2.9**

Table 2: Showing prevalence of SSIs by pre-operative diagnosis

Pre-operative diagnosis	**Presence of surgical site infection (N=24)**	
	Count (n)	Percentage (%)
Penetrating abdominal injury	01	4.2
Foreign body in the abdomen	01	4.2
Gastric cancer	01	4.2
Intra-abdominal abscess	02	8.3
Intestinal obstruction	03	12.5
Esophageal cancer	01	4.2
Gut perforation with peritonitis	07	29.2
Intra-abdominal mass	01	4.2
Acute urine retention due to urethral stricture	03	12.5
Benign prostatic hyperplasia	04	16.7

Table 3: Showing prevalence of SSIs by clinical characteristics

Clinical variable	Bacteria isolated from surgical site (n=24)	No bacteria isolated from surgical site (n=114)
White blood cell count (WBC)		
Leucopenia (<4.0x10^9cells/L)	03 (2.2%)	08 (5.8%)
Normal range (4.0-11x10^9cells/L)	09 (6.5%)	79 (57.2%)
Leukocytosis (>11.0x10^9 cells/L)	12 (8.7%)	27 (19.6%)
ASA score		
ASA I	02 (1.4%)	59 (42.8%)
ASA II	13 (9.4%)	42 (30.4%)
ASA III	08 (5.8%)	11 (8.0%)
ASA IV	01 (0.7%)	02 (1.4%)
Urgency of surgical intervention		
Emergency	14 (10.1%)	50 (36.2%)
Elective	10 (7.2%)	64 (46.4%)
Nature of surgery		
Intra-peritoneal	20 (14.5%)	54 (39.1%)
Extra-peritoneal	4 (2.9%)	60 (43.5%)

Table 4: Bivariate analysis of factors associated with SSIs after abdominal surgery at KIUTH

Variable	Chi-square (X^2)	Degrees of freedom (Df)	Asymptotic Significance (2-sided); (*p<0.05; **p<0.01)	Likelihood Ratio
Comorbidity with Diabetes	9.750	2	0.008**	7.249
Treatment enrollment status for diabetes	59.939	2	0.000**	48.642
Type of current treatment for diabetes	9.640	2	0.008**	7.139
Status of enrollment for cancer treatment	4.905	1	0.027*	3.868
White blood Cell count (WBC)	8.750	2	0.013*	8.398
Hemoglobin concentration	10.397	1	0.001**	11.804
Surgical Diagnosis (Indication for surgery)	44.436	24	0.007**	48.372
ASA score	19.212	3	0.000**	21.072
Nature of surgery (intra-peritoneal vs. extra-peritoneal	10.312	1	0.001*	8.916
Wound classification	29.508	3	0.000**	26.308
Presence of self-reported post-operative fever	88.867	1	0.000**	86.328
Post-operative Temperature≥38.0	41.148	1	0.000**	32.796
Post-operative pain on the wound	87.372	1	0.000**	75.512
Presence of pus discharge from the wound	102.515	1	0.000**	89.854
Post-operative day when pus discharge began	15.985	7	0.025*	15.375

Table 5: Logistic regression analysis of factors associated with SSIs at KIUTH

Risk Estimate (N=138) Odds Ratio for Presence of surgical site infection (Yes / No)	**Value (OR)**	**95% Confidence Interval (CI)**		**P-value**
		Lower	Upper	
Status of enrolment for a cancer treatment (If carrying a diagnosis of any cancer)				
Are you on Anticancer treatment? = Yes	.872	.726	1.047	0.027
Are you on Anticancer treatment? = No	3.800	1.101	13.117	
Haemoglobin (Hb) level				
(<14.0g/dl)	1.691	1.339	2.134	0.001
Normal (14.0-16.0g/dl)	.259	.088	.759	
Nature of operation				
Exploratory Laparotomy (surgery involving entry into peritoneum)	1.759	1.352	2.290	0.001
Extra-peritoneal surgery e.g elective herniorraphy	.317	.127	.788	
Predictors of SSIs Fever				
Presence of post-operative fever = Yes	11.400	6.307	20.606	<0.001
Presence of post-operative fever=No	-	-	-	
Body (Axillary)Temperature				
Day 3 Post-operative Temperature = 36-37.9^{0}C	.407	.242	.684	<0.001
Day 3 Post-operative Temperature ≥Equal to 38.0^{0}C	7.917	3.934	15.933	
Pain				
Presence of post-operative wound pain = Yes	14.929	7.210	30.909	<0.001
Presence of post-operative wound pain = No	.089	.024	.335	
Pus discharge				
Presence of pus discharge from the wound = Yes	21.850	9.236	51.694	<0.001
Presence of pus discharge from the wound = No	.044	.006	.297	

Table 6: Showing percentage of sensitivity profile of each isolated bacterial species to commonly available antibiotics at KIUTH

Antibiotic group(s)	Bacterial isolates (N=25)							
	S.aureus (n=3)	*P. aeruginosa* (n=8)	*Klebsiella pneumonae* (n=2)	*Proteus valgaris* (n=1)	*E. coli* (n=7)	*Pseudomonas luteola* (n=1)	*Morganella Morganii* (n=1)	*Methicillin resistant Staph aureus* (n=2)
Imipenem & Ofloxacin	0.0%	12.5%	0.0%	0.0%	0.0 %	0.0%	0.0%	0.0%
Ceftaroline	100.0 %	0.0%	50.0%	100.0 %	14.3 %	NA	NA	50.0%
Imipenem, Amikacin & Streptomycin	0.0%	37.5%	0.0%	NA	42.9 %	NA	NA	0.0%
Amikacin & Streptomycin	NA	0.0%	NA	NA	14.3 %	NA	NA	NA
Imipenem alone	NA	50.0%	50.0%	NA	28.6 %	100.0%	100.0%	NA
Imipenem, ceftriaxone and Gentamycin	NA	0.0%	0.0%	0.0%	0.0 %	0.0%	0.0%	50.0%

NA=Not applicable (Susceptibility profile of the bacterial species was not tested for that antibiotic)

Table 7: Showing percentage bacterial resistance profile of each isolated bacterial species to commonly used antibiotics at KIUTH

Antibiotic group(s)	**Bacterial isolates (N=25)**						
	S.aureus (n=3)	*P. aeruginosa* (n=8)	*Klebsiella pneumonae* (n=2)	*Proteus valgaris* (n=1)	*E. coli* (n=7)	*Morganella Morganii* (n=1)	*Methicillin resistant Staph aureus* (n=2)
Category (1)	100.0%	62.5%	50.0%	NA	42.9%	100.0%	50.0%
Ofloxacin, Azithromycin in addition to category (1)	NA	12.5%	0.0%	0.0%	0.0%	0.0%	50.0%
Vancomycin, Ceftriaxone in addition to category (1)	0.0%	0.0%	NA	NA	14.3%	NA	0.0%
Tetracycline, Clindamycin, Ofloxacin, Vancomycin in addition to category (1)	NA	NA	NA	NA	14.3%	NA	NA
Imipenem in addition to category (1)	NA	NA	50.0%	100.0%	28.6% %	NA	NA
Vancomycin, Amikacin in addition to category (1)	NA	25.0%	0.0%	0.0%	0.0%	NA	NA

NA = Not applicable (Resistance profile of the bacteria was not tested for that antibiotic); Category (1) = gentamycin, cotrimoxazole, ampicillin, amoxicillin-clavulanic acid, cefotaxime, chloramphenicol, and ciplofloxacin.

Table 8: Showing susceptibility and resistance profiles of miscellaneous co-infections isolated from patients with pseudomonas aeruginosa

Test name: Kirby Bauer; API 20E: 4202200		**Microorganism**					
		Proteus mirablis		***Citrobacter freundii***		***Pasteurella pneumotropica***	
Antibiotic name	*Disc content (µg)*	Diameter of ZOI (mm)	Interpretation (R,I,S)	Diameter of ZOI (mm)	Interpretation (R,I,S)	Diameter of ZOI (mm)	Interpretation (R,I,S)
Ampicillin	10	11	R	11	R	11	R
Amoxicillin – clavunate	20/10	8	R	18	S	14	R
Cefotaxime	30	0	R	0	R	17	R
Chloramphenicol	*30*	9	R	17	I	18	I
Ciprofloxacin	5	14	R	28	I	23	S
Erythromycin	15	0	R	0	R	10	R
Imipenem	10	32	S	22	I	28	S
Gentamicin	10	0	R	0	R	18	I
Trim/sulfamethoxazole	1.25/23.75	0	R	11	I	0	R

ZOI=Zone of Inhibition, R=Resistant, I=Intermediate, S=Sensitive

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