SURGICAL SITE INFECTION AT A TERTIARY ACADEMIC HOSPITAL IN JOHANNESBURG: A ONE YEAR AUDIT

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A Research Report (in the format of a "submissible" paper already published in the Journal of Surgery) submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master in Medicine

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Declaration

I, Mohammed Barbakh, declare that this Research Report in the format of a submissible paper is my own, original work. It is submitted for the Degree of Master of Medicine in Surgery at University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at University of the Witwatersrand or at any other university.

13th day of June 2022 (Johannesburg)

Signature:

Dedication

This dissertation work is dedicated to my family, friends and colleagues. To my parents Khaled and Amina your prayers always work for me. A special dedication to my wife Nuha who remains the most selfless person I have ever seen, for her continued motivation and support throughout my studies. Your patience and encouragement are beyond measure. I thank the Almighty for making her part of my life. I would not have achieved this degree without your encouragement.

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Lastly, a special appreciation to my colleagues and friends for unceasingly inspiring and believing in me when I doubted myself, your reassuring words pushed me to keep on going.

Oral presentations arising from this study:

1- 2019 BERT MYBURGH RESEARCH FORUM
2- 48th SURGICAL SOCIETY OF SOUTH AFRICA (SRSSA) ANNUAL VIRTUAL MEETING in 2021.

Abstract

Introduction: Surgical site infection (SSI) occurs during the first 30 days after surgery and affects either the incision or deep tissue at the site of operation. Surgical site infection accounts for approximately 38% of hospital-acquired infections globally and is associated with increased length of hospitalization and mortality, and therefore increased cost of health care. The type of causative organisms in SSI is influenced by among others the type of surgery. Frequently isolated organisms in SSI include *Escherichia coli*, coagulase-negative *Staphylococci*, *Enterococcus species* and *Staphylococcus aureus*.

Aim: The aim of this study was to determine the incidence of SSI, causative organisms and factors which were associated with its occurrence at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH).

Methods: This was a retrospective review of records of patients who were operated over the 12 months and subsequently developed SSI. Data of patients who developed SSI were extracted from records of weekly morbidity and mortality meetings of the Department of Surgery, which are captured on the Research Electronic Data Capture (REDCap). Data retrieved included demographic information, co-morbidities, nature of surgery, class of SSI and microscopy, culture and sensitivity results and overall outcome including the length of hospital stay. Descriptive, bivariate and multivariate analysis of the data was performed.

Results: During the study period 3005 surgical procedures were performed of which 46.8% were elective operations. A total of 147 records of patients who developed SSI were found. The incidence of reported SSI was 4.8% (147/3005) with 72.6% (93/147) occurring in males. The mean age of all the patients who developed SSI was 47.3 ± 17.21 years (range: 16-82 years). *E. coli* and *P. aeruginosa* from 44% (36/82) and 29.3% (24/82), respectively. Of patients who developed SSI, 30.5% (39/128) had diabetes mellitus, 21.9% (28/128) had hypertension and 18.8% (24/128) had both diabetes and hypertension while 15.6% (20) of the patients were known to be HIV positive.

Conclusion: The overall rate of SSI in the surgical patients was 4.8%. Majority of SSI occurred males. The two most commonly cultured organisms in patients who developed SSI were *E. coli* and *P. aeruginosa*. Thirty-one percent of the patient who were diagnosed with SSIs had diabetes mellitus.

Word count: 336

Keywords: Classification, Co-morbidities, Diabetes Mellitus, Gender, HIV, Surgical Site Infection.

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List of Abbreviations

A. baumannii	*Acinetobacter baumannii*
CDC	Centers for Disease Control and Prevention
CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
CRP	C-reactive protein
DCS	Data collection sheet
DM	Diabetes mellitus
E. coli	*Escherichia coli*
K. pneumonia	*Klebsiella pneumonia*
P. aeruginosa	*Pseudomonas aeruginosa*
PCT	Procalcitonin
S. aureus	*Staphylococcus aureus*.
SSI	Surgical site infection
WCC	White cell count

Introduction

Surgical site infection (SSI) is an infection of the skin, soft tissues, organs or anatomical spaces following an invasive procedure. Included are infections, which occur within 30 days following the procedure and even up to a year if the operation included insertion of a prosthetic device if an implant is in place. The definition of SSI does not include burn wounds, circumcision, episiotomies or stitch abscesses.

Surgical site infections (SSIs) account for approximately 38% of all hospital acquired infections globally [1]. Surgical site infection is the most commonly reported type of nosocomial infection globally and accounted for 19.6% of all nosocomial infections in Europe in 2011-2012 and which was higher than the rate of pneumonia and urinary tract infections at 19.4% and 19.0%, respectively [2]. Seventy-five percent of the mortalities in patients who develop SSI are directly related to the SSI [3].

Surgical site infection is classified into incisional and organ or space infections (1). Incisional site infection is further sub-classified into superficial i.e. an infection which limited to skin and subcutaneous tissue (1). Risk factors of SSI are divided into patient-related (preoperative), procedure-related (perioperative), and postoperative categories. The patient-connected risk factors for SSI are categorized as either modifiable or non-modifiable (2). The modifiable factors include diabetes mellitus, obesity, smoking and length of preoperative hospitalization (1). An example of a non-modifiable risk factor for SSI is the age of a patient. Among the risk factors which are related to the operation is the class of a surgical wound, organ site and the length of the surgery. Some of the postoperative risk factors for SSI are blood transfusion and poor glycaemic control (2).

Surgical site infection is frequently associated with increased morbidity, mortality and length of hospital stay. The development of SSI increases the clinical and financial burden of surgery. Surgical site infection increases the work load of the healthcare professionals and has a negative impact on patient's outcome [2]. The economic impact of SSI is mainly due to an increase in the length of hospitalization, additional diagnostic tests, antimicrobial use and dressings (2). Reoperation in necessary in some of the patients who develop SSI (2). Badia and colleagues showed that patients who developed SSIs incurred twice the medical cost compared to patients who did not develop SSIs (2). In the same study by Badia and the team showed that the length of

stay of patients who developed SSI was double the number of days of patients who did not develop SSI.

The reported rate of occurrence of SSIs in sub-Saharan Africa ranges from 6.8% to 26% [4]. The aim of this study was to determine the rate of occurrence of SSI at a tertiary academic hospital in the Gauteng Province of South Africa. Furthermore, the factors which were prevalent in patient who developed SSI were studied.

Methods

Permission to conduct the study permission was obtained from the Human Research Ethics Committee of University of the Witwatersrand (M180945) and the CEO of CMJAH. This was a retrospective observational study based on audit of the records of weekly morbidity and mortality (M+M) meeting of the Department of Surgery. The meeting is run on REDCap. Postoperative complications are classified using the modified Clavien-Dindo classification of postoperative complications (Add reference). Additional information was obtained from theatre records, patients' file and microbiology results. Data retrieved included demographic information, co-morbidities, nature of surgery, class of SSI and microscopy, culture and sensitivity (MC&S) results and overall outcome including the length of hospital stay.

The records of all patients who were operated on and subsequently developed SSI during the study period were reviewed. Although the original plan was to conduct the study over a 2-year period the subjects for the present study were all patients who had an operation at CMJAH between the 1st of July 2017 and 30th of June 2018, and subsequently developed SSI, as defined by the CDC (Appendix D). The patients included in the study were the individuals who were declared to have developed SSI by the surgical units during the M+M meeting. Records of patients who were re-admitted for SSI following an operation before the period of study, patients on immune-suppressants, patients whose records were incomplete and patients with infection of another area not related to the area of operation e.g. urinary tract infection (UTI), were excluded from the study.

Each case was given an individual study number on the DCS without recording any personal identifiers. Information was transcribed from the anonymous patient DCS to an Excel spreadsheet using the patient's study only. A separate list of patient study numbers with patient identifiers recorded was kept in a safe and user name protected

electronic file, only accessible to the principal investigator, to ensure anonymity of the patients.

Data were analysed using the statistical programme Stata v13.1 (College Station, Texas). Continuous data were summarized by using the mean plus standard deviation when data were normally distributed, and the median and inter-quartile range (IQR) when the data were not normally distributed as determined using the Shapiro Wilk test for data distribution. The paired t-test was used for comparison of findings with normally distributed continuous data, and the Wilcoxon signed rank test if not normally distributed. Categorical findings were compared analysed by calculating frequency and percentage and using the chi-square test and the Fisher's exact test. The level of significance was set at a p-value <0.05.

Results

A total of 147 cases of SSI among 3 005 surgeries were recorded in REDCap over a one-year period. Less than half, 1 406 (46.8%) of the operations were elective operations. The rate of SSI was 4.8%. Of these 147 cases, two patients had a kidney transplant and were on immune-suppressants and hospital files for 17 patients could not be traced, thus 19 cases were excluded. Of the remaining 128 patients, 72.7% (96/128) of the reported cases was in male patients and 63.3% (81/128) of the SSIs developed in patients who had emergency surgical procedures. The mean age of the patients who developed SSI was 47.3 ± 17.21 years. Around 44.5% (57/128) the SSIs were superficial SSIs (Table 1).

Table 1: Demography, number of co-morbidities and type of SSIs in patients who developed SSI (n = 128)

Parameter	**Finding**
Emergency to Elective Ratio	81/47.
Male to Female Ratio	93/35.
Mean age in years	47.3 ± 17.21.
Associated co-morbidities (%)	Yes: 111(86.7%). No: 17(13.3%).
Types of SSI (%)	Superficial: 57 (44.5%). Deep: 15 (11.7%). Organ space: 56 (43.8%).

The rate of occurrence of SSI in elective cases was 5.1% (81/1 599) and in emergency patients it was 3.3% (47/1 406) out of the total of 3005 patients. Among the patients who developed SSI, 30.5% (39/128) had diabetes mellitus, 21.9% (28/128) had hypertension and 18.8% (24/128) had both diabetes and hypertension while 15.5% (20/128) were known to be HIV positive. The mean pre-operative body temperature in patients who developed SSI was 37.2 ± 0.36 ^{o}C compared to 37.7 ± 0.35 ^{o}C post-operatively, and the difference was statistically significant (Table 2).

Table 2: Pre-operative and post-operative clinical and laboratory findings in patients who developed SSI (n = 128)

Parameter	**Findings**		
	Pre-operative	Post-operative	p-value
Mean body temperature	37.2 ± 0.36^{o}C	37.7 ± 0.35^{o}C	0.0150
Mean white cell count	11.3 ± 5.9	18.5 ± 8.6	0.0010
Mean CRP	86.1 ± 11.8	229.5 ± 111.1	< 0.00001
Mean blood glucose	9.6 ± 3.1	11.9 ± 3.9	0.0042

Of the patients who developed SSI 45.3% (58/128) had open surgical interventions whereas a percutaneous drainage was done in 10.2% (13 cases), and one patient was treated with intravenous (IV) antibiotics without any other intervention (Table 3).

Table 3: Options used for management of SSI (n = 128)

Intervention	**Number (%)**	**Cumulative %**
Relook procedure	58 (45.3%)	45.3%
Removal of stitches or clips	47 (36.7%)	82.0%
Percutaneous drainage	13 (10.2%)	92.2%
Debridement	5 (3.9%)	96.1%
Wound irrigation	3 (2.3%)	98.4%
Wound dressings	1 (0.8%)	99.2%
Intravenous antibiotics only	1 (0.8%)	100%
TOTAL	128	100%

Sixty-four percent (64.1%: 82/128) of the patients who developed SSI had positive microscopy culture and sensitivity (MC&S) results. In 28.1% (36/128) of the cases culture results showed *E. coli* (Table 4). Thirty-two percent (41/128) of the MC&S results showed more than one organism.

Table 4: Culture results in patients who developed SSI (n = 82)

Organism isolated	**Number (%)**
E.coli	36 (43.9%)
P. aeruginosa	24 (29.3%)
K. pneumoniae	12 (14.6%)
S. aureus	11 (13.4%)
A. baumannii	8 (9.7%)
E. faecum	8 (9.7%)

Colorectal procedures accounted for 37/82 of the positive culture results and 40/82 from other forms of laparotomy. Of the colorectal procedures, 37.8% (14/37) of SSIs cultured, were positive for *E. coli* (Table 5).

Table 5: Breakdown of microorganisms cultured in patients who developed SSI according to type of operation

Original surgical procedure	***E. coli***	***P. aeruginosa***	***S. aureus***	***A. baumannii***	***E. faecium***	***K. pneumonia***	***E. faecalis***	**Total**
Laparotomy	15	8	4	5	2	3	3	40
Colorectal	14	6	1	2	3	7	4	37
Vascular	2	2	1	-	1	-	-	6
Amputation	-	2	-	1	-	1	1	5
Hernia	-	2	1	-	-	1	-	4
Breast	-	1	3	-	-	-	-	4
Appendi-cectomy	2	1	-	-	-	-	-	3
Other	3	1	-	-	-	-	-	4

Around 47.2% (17/36) of the *E. coli* cultured were sensitive to amoxicillin/clavulanic acid (Augmentin) while 22.2% (8/36) were sensitive to 3rd generation cephalosporins (Figure 1).

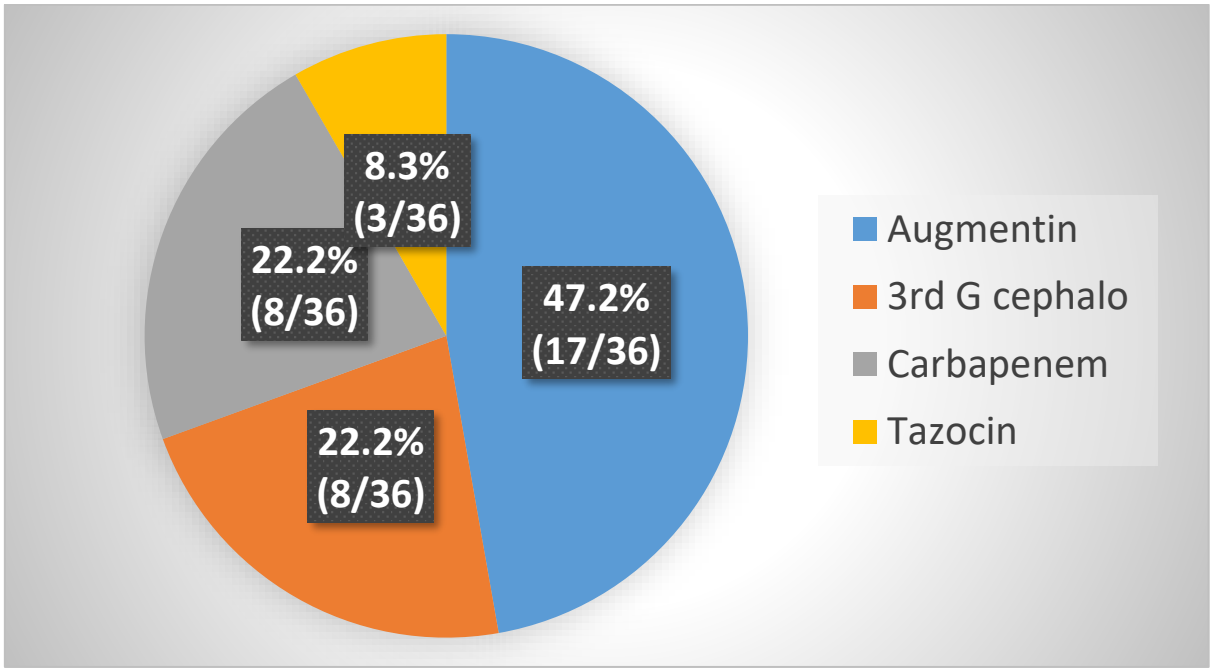

Figure 1: Antimicrobial sensitivity of cultured *E. coli* (n = 36).

*Tazocin = Piperacillin/Tazobactam

Forty-six percent (11 /24) of *P. aeruginosa* were sensitive to piperacillin/tazobactam (Tazocin) (Figure 2).

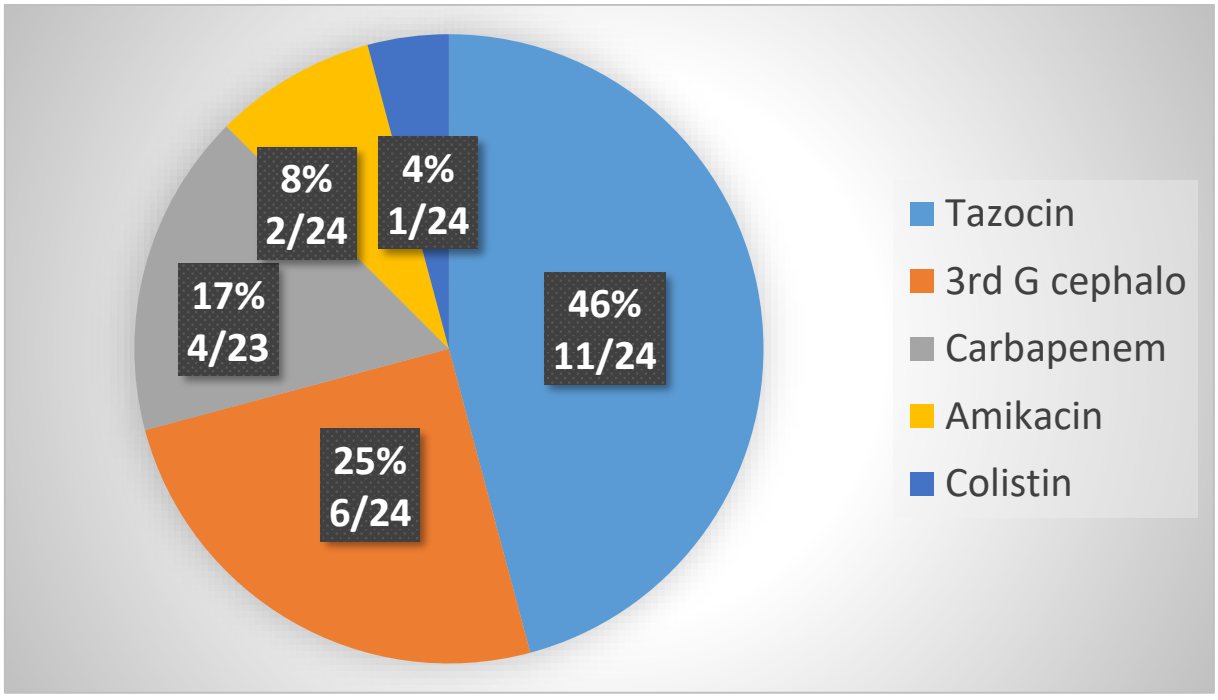

Figure 2: Drug sensitivity profile for *P. aeruginosa*

In the case of *K. pneumoniae,* three strains (25%), showed susceptibility to Amikacin, two strains (16.7%) were sensitive to either Tazocin or to Imipenem and one strain was sensitive to Cefepime, Colistin, Augmentin, Ertapenem and to Ceftriaxone (Figure 3).

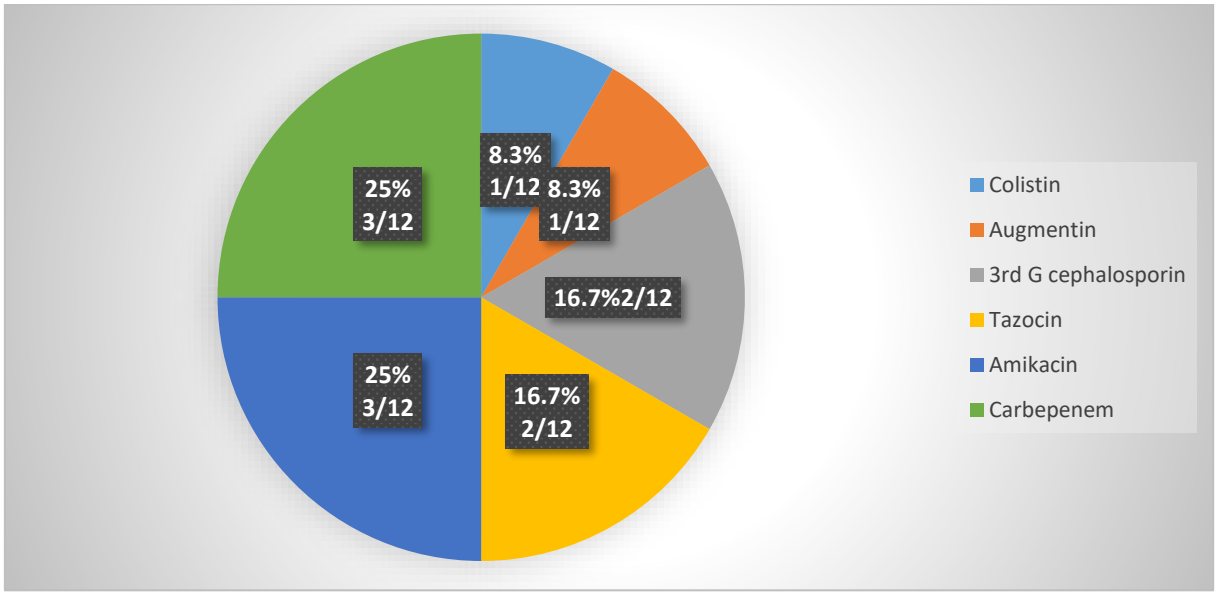

Figure 3: Sensitivity profile for *K. pneumoniae*

In the case of *S. aureus,* eight strains (72.7%), showed susceptibility to Cloxacillin, and three strains (27.3%) were sensitive to Vancomycin (Figure 4).

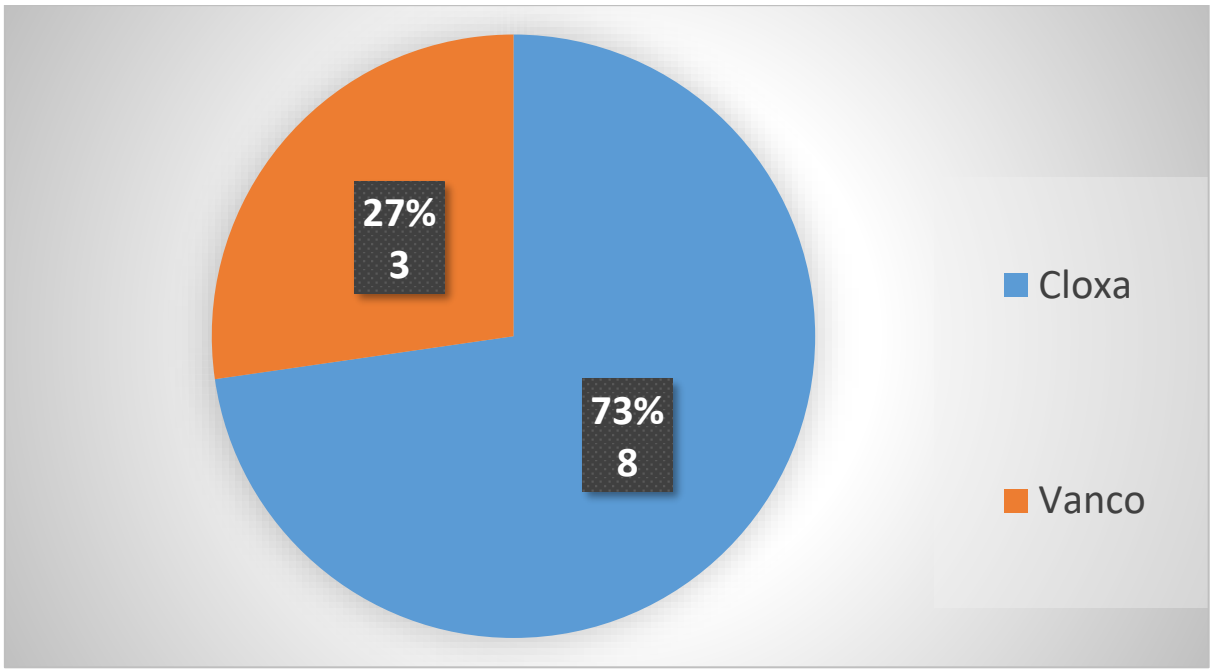

Figure 4: Sensitivity profile for *S. aureus.*

The *A. baumannii* strains showed sensitivity to colistin in two strains (25%) and 12.5% (1/8) showed sensitivity to either ciprofloxacin, ceftazidime, amikacin, Augmentin, ceftriaxone and gentamicin.

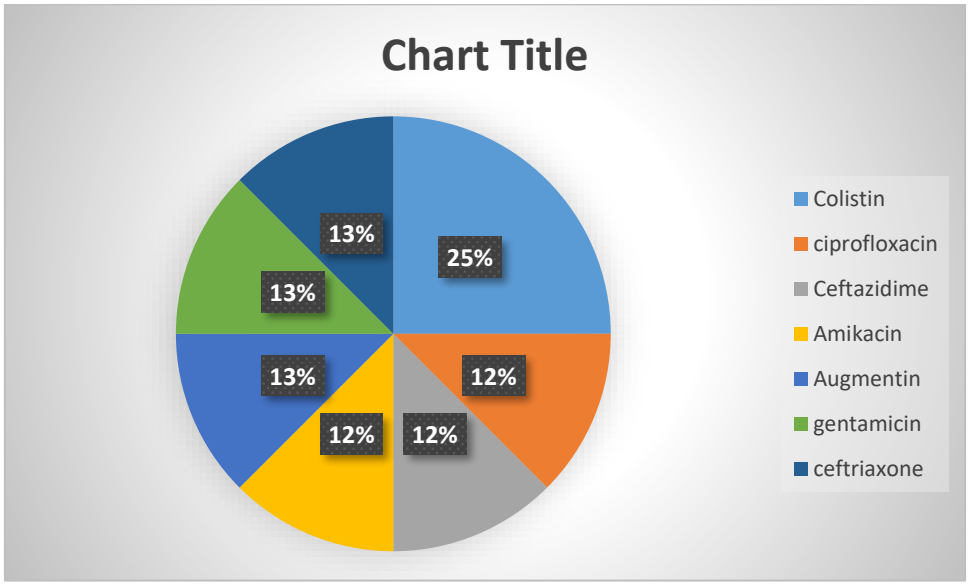

Figure 5: Sensitivity profile for *A baumannii*

Among SSIs patients there were two mortalities, 49.2% (63/128) of the patients needed at least one surgical intervention, 10% (13/128) had a pigtail for intra-abdominal collections. The median of the length of hospital stay was 18 days, with no difference between different types of wounds. The length of stay was 22 days among the patients who developed organ/space SSI. Two patients (1.6%: 2/128) who developed SSI died. Twenty-eight percent (36/128) required re-admission.

Discussion

This study revealed a rate of SSIs of 4.8%, which is comparable to the incidence of SSIs reported by Nair *et al.,* in the Northern Cape Province of South Africa [5]. The relatively low rate of SSI in South Africa are similar to figures reported in Norway (4.6%) [6] and Switzerland (4%) [7]. In contrast the rate of occurrence of SSI across the African continent is high, For example the rate of SSI which was reported from Nigeria ranged from 15 to 27% [8,9] while from Ethiopia 19.1% [10,11] and in Tanzania 26.0% [12]. However, the SSI reported rates from countries across the world may not be

comparable as patients' attributes, wound classifications and diagnostic approach could have been different.

A higher rate of occurrence of SSI in patients who were younger than 40 years is not different to findings from prior studies [13]. Two-thirds of the patients in our study developed SSI after elective surgical interventions, which might have influenced the results. The rate of occurrence of SSI is also influenced by nutritional status of a patient, the level of immunity and comorbid illnesses such as HIV/AIDS or diabetes mellitus [14-17].

Patients with SSIs are much more likely to spend extra days in the clinic/hospital in contrast to patients without SSIs. This observation is in line with a number of other reports [2,18–20]. The mean of the length of stay in this study was 18 days, which is within the ranges found in other studies (3 to 23 days), and similar to the Whitehouse et al*.,* study (19 days) [21].

The present study retrospectively analysed the plasma concentration of the white cell count (WCC) and C-reactive protein (CRP) regarding their sensitivity and specificity for detecting perioperative infections. Regardless of the type of operation or the type of SSI that developed, the study showed a 100% increase in CRP, and in 85.1% of the patients the WCC was high. Similar findings were reported in two other studies [22,23].

Although, the procalcitonin test (PCT) is commonly used as a diagnostic marker of sepsis [24], and has been confirmed to be a more accurate marker for the recognition of early postoperative infection after cardiac and intestinal surgeries when compared with standard laboratory parameters, such as CRP and WBC [25], in this current study the WCC and CRP were still used as indicators of infection.

In this current study approximately 44% of SSIs were classified either as superficial or organ/space SSIs, while most other studies revealed that superficial SSIs are the most frequently occurring type [26]. In contrast, results found by Poulsen *et al.*, indicated that more than 30% of SSIs are organ/space SSIs [27].

The most common microorganisms cultured in this study were gram-negative bacteria and these results are similar to a study done by Golzarri and colleagues in a 7-year retrospective review [28], while most of the other studies revealed a predominance of gram-positive microorganisms as the main cause of SSI [28-31].

Of importance is that this study provides standard information on the event of SSIs at the hospital and it may serve as a helpful tool in decision making and in assigning restricted funds in addressing SSIs and hospital acquired infections in general.

Conclusions

The overall rate of SSI in the surgical patients was 4.8%. Majority of SSI occurred males. The two most commonly cultured organisms in patients who developed SSI were *E. coli* and *P. aeruginosa*. Thirty-one percent of the patient who were diagnosed with SSIs had diabetes mellitus.

Limitations of the study

As a retrospective study, it lacked the comparison of a control group. A cause-and-effect relationship could not be determined. The study relied on the quality of documentation, and sometimes doctors and/or nurses do not report the incidence. Furthermore, complications sometimes occur on discharge and are not noticed at the Out Patients Department. Patients not returning to our hospital but going to another hospital for whatever reason may also have impacted on our study. Another but substantial limitation was that it was only a one-year study at one hospital only.

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Appendix 1: Approved research protocol

Corrected protocol with list of corrections attached as the 2nd last page, and the plagiarism declaration as the last page.

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DEGREE FOR WHICH PROTOCOL IS BEING SUBMITTED: MMed		
PART-TIME OR FULL-TIME: Full-time		
FIRST REGISTERED FOR THIS DEGREE:	TERM : January	YEAR:2016
DEPARTMENT: General surgery		
TITLE OF PROPOSED RESEARCH: Surgical site infection at a tertiary academic hospital in Johannesburg: 2 year audit		
CANDIDATE'S SIGNATURE:		DATE:
SPERVISOR 1(NAME& SURNAME): Prof. Adelin Muganza		30 % Supervision
SUPERVISOR'S QUALIFICATIONS: MD, FRCSI, FCS (SA)		
SUPERVISOR'S DEPARTMENT: General surgery		
SUPERVISOR'S ADDRESS / TEL / E-MAIL: amuganza@gmail.com		
SUPERVISOR 2(NAME& SURMANE): Dr. Marietha Nel		30 % Supervision
SUPERVISOR'S QUALIFICATIONS: MSc, BSc, PhD		
SUPERVISOR'S ADDRESS / TEL / E-MAIL: marietha.nel@wits.ac.za		

SUPERVISOR 3(NAME& SURNAME): Prof. Thifhelimbilu Luvhengo	40 % Supervision
SUPERVISOR'S QUALIFICATIONS: MBChB, FCS (SA)	
SUPERVISOR'S ADDRESS / TEL / E-MAIL: Thifhelimbilu.Luvhengo@wits.ac.za	
SYNOPSIS OF RESEARCH: A retrospective study based on audit of Morbidity and Mortality and RedCap records To determine the incidence and associated factors in patients who develop surgical site infections (SSIs) at CMJAH, and to determine the demographic and clinical pathology findings in patients who developed SSIs at CMJAH.	
ETHICS PENDING: Y ETHICS APPROVED: Y (circle appropriate symbol)	IF Y SUPPLY ETHICS CLEARANCE No:
SIGNATURE OF SUPERVISOR/S:	.....
SIGNATURE PG OFFICE STAFF	REGISTERED YES..... NO.....
	STAMP

Protocol

Surgical Site Infection at a Tertiary Academic Hospital in Johannesburg: a 2 -ear Audit

Candidate: Dr. Mohammed Barbakh

Student Number: 1578236

Course: MMed (Surg)

Supervisors

1. Prof. Muganza A: 30%
2. Dr. Nel M: 30%:
3. Prof. Luvhengo TE: 40%

Introduction

Definition: Surgical site infections (SSIs) are infections of the skin, tissues, organs, or spaces exposed by surgeons during performance of an invasive procedure, occurring within 30 days of the operation if no implant is left in place or within 1 year if an implant is in place. The definition of SSI does not include burn wounds, circumcision, episiotomies or stitch abscesses[1].

Incidence: Surgical site infection accounts for around 38% of hospital acquired infections globally[2.] It is the most commonly reported type of nosocomial infections and accounted for up to 19.6% of all nosocomial infections in Europe in 2011-2012, followed by pneumonia and urinary tract infections at rates of 19.4% and 19.0%, respectively[3]. In more than 75% of patients who develop SSI and die in the postoperative period, the mortality is directly related to the SSI[4].

Although no incidence/prevalence data on SSIs in general surgery are available for South Africa, the impact of SSIs in sub-Saharan Africa ranges from 6.8% to 26% with predominance in general surgery. This is in part the reason for embarking on this study although it will only be over a 2-year period and at one hospital, the study will give some insight regarding the incidence of SSI in South Africa.

Classifications: Surgical site infection is classified into incisional and organ or space infections. Incisional site infection is further sub-classified into superficial i.e. infections limited to skin and subcutaneous tissue[5].

Risk factors: Risk factors of SSI may be systemic or local. Advanced age (generally ≥ 65years) is a distinct risk factor for adverse outcomes of infection[6] related to immune senescence and an increased incidence of nosocomial infection.

Furthermore, hyperglycemia in the setting of diabetes mellitus and temporary hyperglycemia induced by stress response, are also associated with an increased risk of surgical site infection [7,8,9,10]. Other systemic host factors which contribute significantly to the risk of surgical site infection include obesity, malnutrition, HIV, AIDS[11], advanced malignancies, organ system failure, hypocholesterolaemia and patients on immunosuppressive drugs[12].

Local factors which influence the development of SSI include poor skin preparation, prolonged operation time, improper surgical technique such as leaving a large dead space, haematoma, overuse of cautery or rough tissue handling and the presence of a foreign body[13].

Perioperative strategies such as shaving and choice of solution for skin preparation also influence the incidence of SSI. Darouiche *et al.,* (2010), have recommended chlorhexidine for surgical skin preparation to prevent SSI[14]. Supporting this recommendation is a study done by Milestone which showed that chlorhexidine is superior to povidone-iodine solution for skin preparation for vascular catheter insertion[15].

Skin closure of a contaminated incision is believed to increase the risk of SSI. Unfortunately, no large enough studies are available to determine if SSI rate is influenced by the choice of wound closure techniques available to surgeons. Interestingly, Chantip *et al.,* (2017) found that early primary closure of the surgical wound in complicated appendicitis cases have a lower incidence of superficial SSI than delayed primary closure, however, this finding did not reach statistical significance[16]. Minimal invasive surgery is associated with a decreased incidence of SSI[17].

As incorporated in the National Nosocomial Infections Surveillance System (NNIS), and its successor program, the National Healthcare Safety Network (NHSN), the most predictable factors for the development of SSI is the American Society of Anesthesiologists Class 3 procedures or higher and prolonged operative times [18,19,20].

The type of surgical procedure affects the rate of SSI. As such, abdominal surgery has the highest risk for SSI even following 'clean' surgery[4]. Even endovascular procedures are not immune to SSI as it was found by Aziz *et al*., (2017) that SSI is indeed one of the causes for readmission of patients who underwent endovascular aortic repair [21]. Although the use of antibiotic prophylaxis lowers the incidence of SSI for surgical procedures including breast reduction and hernia repair[22,23], the different causal organisms need to be recognised and treated appropriately. Furthermore, because of the huge importance of prevention of SSIs many recommendations were made by various health organizations and these recommendations are still undergoing modulations by adding and deleting some of the components[23].

Signs and symptoms: As per The Centers for Disease Control and Prevention (CDC) the signs of SSI are general and local. They include pain, tenderness, fever, increase heart rate, localized swelling, redness in the wound area and discharge from the

wound[24]. In spreading necrotizing infection crepitus may be elicited. In blood tests we will find an increase in septic markers such as C- reactive protein and white cell count[24].

Causative organisms: The normal skin flora that is introduced through the incision during surgery cause most of the SSIs. Therefore, the most common pathogens in SSI are gram-positive cocci (*Staphylococcus epidermidis, S. aureus,* and *Enterococcus* spp)[25] which are the three most common organisms found normal skin.

Treatment: The basic treatment of wound infection is to re-open the wound and allow it to drain. In a mild infection, a simple dressing change will be adequate, without any antibiotics needed, whereas for a clean wound, 1st generation cephalosporin may be given. However, if the infection is severe, 3rd generation cephalosporin or a quinolone plus clindamycin or metronidazole, or piperacillin – tazobactam alone is recommended[26]. Importantly, antimicrobials alone are not sufficient for severe SSI. Invasive and necrotizing infection requires aggressive debridement as well. Antibiotics are stopped as soon as local inflammation and systemic signs of infection have resolved and there is no gross evidence of necrotic tissue [26].

For organ or space SSI, treatment consists of IV fluids for resuscitation, elimination of the source of infection, e.g. laparotomy and closure of perforated viscus, removal of necrotic material and appropriate antibiotic therapy[26].

Financial impact: Surgical site infection is frequently associated with increased morbidity, mortality and hospitalization. In addition, the development of SSI increases the clinical and financial burden of surgery. Indeed, SSI causes an increase in the already overburdened economic load of the health system especially in South Africa. It increases the work load of the health care professionals and has a negative impact on patient's outcome [3].

The economic load of SSI is mainly due to an increase in the length of hospitalization, additional diagnostic tests, antibiotics, dressings and reoperation in some cases[3,27]. More specifically, a study by Badia *et al.*, (2017) showed that patients who developed SSIs incurred double the medical cost compared to patients who did not develop SSIs. The same study showed that the hospitalization days of the patients with SSI were double the number of days of patients who did not develop SSI[3]. Therefore, the economic impact of SSIs alone makes my study on the patient outcomes, survival and the incidence of SSI's relevant and valuable.

In the aim of this study to compare the total number of general surgery patients with the number of SSI patients over the same 2-year period to determine the rate/incidence of SSI. By comparing the data to be collected on the SSI patients, such as associated factors, outcomes etc. as depicted in the Data Collection Sheet it may be possible to determine the cause of the SSI and the patient survival percentage.

The data of patients who developed SSI in the 2-year period of the study, recording septic markers and vital signs such as temperature, heart rate, white cell count and blood sugar levels before and after the surgical intervention will be collected. As well as record any comorbidities which may have affected the development of SSI in any of these patients. The type of operation, type of perioperative antibiotics and the type of SSI intervention and the patient outcomes will be recorded.

All this data will assist in determining the incidence and outcomes of SSI at the Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), and possibly shed light on the comorbidities affecting the development of SSI as well as the effectiveness of the patient skin disinfection in theatre and the effectiveness of the antibiotics used peri-operatively at the Charlotte Maxeke Johannesburg Academic Hospital.

Methods

Study type: This is a retrospective study based on morbidity and mortality records on REDCap, hospital files and laboratory results patients of patients who were declared to have had SSI during a 2-year period.

Study setting: Department of Surgery, University of the Witwatersrand circuit at CMJAH.

Study period: Data will be obtained from SSI patient files from the end of June 2018, working backwards to 01 June 2016, which is a 2-year period.

Study population: Records of all patients who were diagnosed with SSIs in the proposed 2-year study period at the Charlotte Maxeke Johannesburg Academic Hospital.

Sample type: The total number of Charlotte Maxeke Johannesburg Academic Hospital, Department of Surgery patients *versus* all Department of Surgery, Charlotte Maxeke Johannesburg Academic Hospital patients who developed SSI over the same period.

Inclusion criteria: Patients who were 18 years and older who developed SSIs.

Exclusion criteria

a) SSI patients on immunosuppressants.
b) Incomplete patient records.

Sample size: The study sample size will be approximately 150 to 250 SSI patient records, since approximately 75 to 125 SSI patients are treated at the Charlotte Maxeke Johannesburg Academic Hospital per year.

Research Questions

What is the incidence and what are the associated factors of SSIs at CMJAH?

Aim and Objectives

Study aim: To determine the rate of occurrence and factors associated with the development of SSI at CMJAH in a 2-year period.

Study objectives

i. To determine the outcomes of the SSI patients, if the patient needed readmission, relook(s), discharged or demised.
ii. To determine the survival rates of patients who developed SSIs.
iii. To determine the rate of occurrence of SSI following surgery at CMJAH.
iv. To determine the demographics and comorbidities of patients who developed SSI.
v. To determine the prevalence of the various types of SSI.
vi. To determine the type of intervention required in patients who developed SSI.

Data Collection and Analysis

Data collection: A ready prepared data collection Excel spread sheet will be used for data entry after extraction from M&M on Research Electronic Data Capture (REDCap) records and patient hospital file records (see attached spread sheet document).

Data analysis: The data will be collected from the REDCap system and from patient hospital file records. A de-identified (anonymous) dataset will be used for data analysis. Data will be summarized and described in the form of tables and graphs, using means, standard deviation, median (range) or frequency. Comparative analysis will be carried out in Stata v13.1 (College Station, Texas) or a similar statistical package using T-tests and Chi-square tests with the level of significance set at $p<0.05$.

Limitations of the Study

Missing data in patient files.
Unavailable biopsy results.

Funding

The project will be funded by the PI personally and the costs to be considered include only stationary such as pens, paper and photocopying.

Ethical Considerations

Ethical approval for this study will be sought from the Human Research Ethics Committee (Medical) in the Faculty of Health Sciences, University of the Witwatersrand.

All data will be kept strictly confidential and will only be released by the laboratory to investigators (the PI and the 3 MMed study supervisors) involved in the study. Data collection will be anonymous. Each patient will be given a unique study number corresponding to the hospital file number which will be recorded on a separate sheet kept separate from the data collection sheets, in a safe locked place only accessible by me. The data collection sheet will not contain any patient identifiers apart from the patient's unique study number.

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Appendix A: Data collection sheet

Data Sheet: "Surgical site infection at a tertiary academic hospital in Johannesburg: a 2 year audit."

Patient Study Number:

Criteria at presentation

Age (years): .....

Gender: Male ☐ Female ☐

Date of admission:

Co-morbidities:

Date of operation:

Type of operation:

Type of SSI:

Blood test results

Parameter	Pre-operative	Post-operative
i. Highest WCC:		
ii. Highest CRP:		
iii. Highest blood sugar:		
iv. Worst pH:		

Management:

Number of relooks:

Outcome:

Appendix B: CEO Letter of approval

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL

Enquiries:
Ms. N. Mzila
Office of the Clinical Director
Email:Nolwazi.Mzila@gauteng.gov.za
Tell: (011): 488-4812
16th April 2018

Dear Dr. M. Barbakh

STUDY TITTLE: Surgical Infection at a Tertiary Academic Hospital in Johannesburg: An 8 Year Audit

Permission to conduct the above mentioned study is provisional approved. Your study can only commence once Ethics approval is obtained. Please forward a copy of your Ethics Clearance Certificate as soon as the study is approved by the Ethics Committee for the CEO's office to give you the final approval to conduct the study.

Supported / not supported

Dr. M.I. Mofokeng
Clinical Director
DATE: 17/04/2018

Approved / not approved

Ms G. Bogoshi
Chief Executive Officer
DATE: 18.04.2018

Appendix C: Ethics approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Mohammed Barbakh

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M180945

NAME: (Principal Investigator)	Dr Mohammed Barbakh
DEPARTMENT:	General Surgery Charlotte Maxeke Johannesburg Academic Hospital
PROJECT TITLE:	Surgical site infection at a tertiary academic hospital: a 2 year audit
DATE CONSIDERED:	28/09/2018
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof TE Luvengo
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	15/02/2019

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **September** and will therefore be due in the month of **September** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix D: CDC definition of SSI

Table 1. Summary of CDC definition of SSI.

Superficial Incisional SSI

- Infection occurs within 30 days after the operation;
- infection involves only the skin or subcutaneous tissue; and
- at least 1 of the following:
  - purulent drainage (culture documentation not required);
  - organisms isolated from fluid/tissue of superficial incision;
  - at least 1 sign of inflammation (eg, pain or tenderness, induration, erythema, local warmth of the wound);
  - wound is deliberately opened by the surgeon; or
  - surgeon or attending physician declares the wound infected.

A wound is not considered a superficial site infection if there is:

- a stitch abscess present;
- infection of episiotomy or circumcision site;
- infection of a burn wound; or
- incisional SSI that extends into the fascia or muscle.

Deep Incisional SSI

- Infection occurs within 30 days of operation or within 1 year if an implant is present;
- infection involves deep soft tissues (eg, fascia and/or muscle) of the incision; and
- at least 1 of the following:
  - purulent drainage from the deep incision but without organ/space involvement;
  - fascial dehiscence or fascia is deliberately separated by the surgeon due to signs of inflammation;
  - deep abscess is identified by direct examination, during reoperation, by histopathology, or by radiologic examination; or
  - surgeon or attending declares deep incisional infection is present.

Organ/Space SSI

- Infection occurs within 30 days of operation or within 1 year if an implant is present;
- infection involves anatomic structures not opened or manipulated by the operation; and
- at least 1 of the following:
  - purulent drainage from a drain placed by a stab wound into the organ/space;
  - organisms isolated from organ/space by aseptic culturing technique;
  - identification of abscess in the organ/space by direct examination, during reoperation, or by histopathological or radiological examination; or
  - diagnosis of organ/space SSI by surgeon or attending physician.

Adapted from[16] Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. *Infect Control Hosp Epidemiol*. 1992;13(10):606-608.

Appendix E: Turn-it-in report

08901071:Barbakh_for_Turnitin_17_Feb_2020.docx

by Marietha Nel

Submission date: 17-Feb-2020 10:15AM (UTC+0200)
Submission ID: 1258823512
File name: db9-447f-972e-3a19836efc22_Barbakh_for_Turnitin_17_Feb_2020.docx (55.01K)
Word count: 2205
Character count: 11385

08901071:Barbakh_for_Turnitin_17_Feb_2020.docx

ORIGINALITY REPORT

8%	2%	1%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Cape Town Student Paper	4%
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[2]

Surgery in Low and Middle Income Countries: *WJS* seeks high quality manuscripts describing the unique problems and unique solutions facing surgeons in rural and impoverished settings, globally. *WJS* requires that manuscripts that use primary data from a low- or middle-income country should include one or more local co-authors. A local co-author is defined as a national of that country who is living and working in their home country. All other author requirements need to be met for the author(s) from the low and middle income country. The editors understand that there may be extenuating circumstances in which this requirement cannot be met. In such cases, a cover letter should explain why a local co-author is not included. Further details on this editorial policy can be found at:

World J Surg (2011) 35:2367–2368.

Cost-effectiveness research is especially valuable for the field of global surgery. However, unless the methods are sound, findings can sometimes be erroneous. *WJS* calls upon authors who undertake cost-effectiveness research in global surgery to review the methodologic points brought out by the following article when they

develop, conduct, and write up their studies: World J Surg. 2017 Jan 19. DOI: 10.1007/s00268-017-3875-0 PMID: 28105528.

WJS also requires completion of the checklist contained in the above article at the time of submission of cost effectiveness studies. The checklist is available at: https://scholar.harvard.edu/shrime/cost-effectiveness-analysischecklist.

If the authors feel another checklist is more suitable for their particular study, they may use that checklist. In all cases of cost-effectiveness studies, the checklist used should be stated in the cover letter and the completed checklist attached to the cover letter.

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Increasing problems of duplicate and fraudulent submissions and publications have prompted the editors of surgical journals, including *World Journal of Surgery*, to support these overall principles of publication:

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In general, if a manuscript has been peer-reviewed and published, any subsequent publication is duplication. Exceptions to this general rule may be:

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For example, any submission duplicating material previously published in full in "Proceedings" or book chapters is considered duplicate unless the exceptions in (a) above apply. Similarly, manuscripts dealing with subgroups of [11] data (i.e., patients) that have previously been analyzed, discussed and published as a larger group are considered duplicate unless (b) above applies.

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h) Falsification of any item on the copyright form.

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While not intended as an all-inclusive document, these examples and guidelines should alert authors to potential

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Surgery Journal Editors Group Consensus Statement on the Adoption of the COPE Guidelines

We, the undersigned member journals of the Surgery Journal Editors Group (SJEG), in the furtherance of integrity in surgical and scientific publication, agree to adopt the guidelines established by the Committee on Publication Ethics (COPE)[1]. The COPE guidelines represent a means of addressing a variety of ethical concerns, including duplicate publication and authorship misconduct issues, which have, unfortunately, become more prevalent.

[1]*COPE Committee on Publication Ethics. https://publicationethics.org/resources/guidelines*

In the majority of clinical and research studies submitted to surgery journals for possible publication, many individuals participate in the conception, execution, and documentation of each of those works. However, recognition of work in the form of authorship has varied widely. This consensus statement is being issued to clarify and define the criteria for surgical journal authorship.

The following guidelines should be used to identify individuals whose work qualifies them as authors as distinct from those who are contributors to the work under consideration. All persons designated as authors should qualify for authorship, and all those who qualify should be so credited.

A. Authorship Criteria

Individuals claiming authorship should meet all of the following 3 conditions:

1. Authors make substantial contributions to conception and design, and/or acquisition of data, and/or analysis and interpretation of data;
2. Authors participate in drafting the article or revising it critically for important intellectual content; and [12]
3. Authors give final approval of the version to be submitted and any revised version to be published.

Each author should have participated sufficiently in the work to take public responsibility for appropriate portion of the content. Allowing one's name to appear as an author without having contributed significantly to the study or adding the name of an individual who has not contributed or who has not agreed to the work in its current form is considered a breach of appropriate authorship.

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E. In Conclusion

This consensus statement is intended as a basic guide for authors. In the interest of promoting the highest ethics in surgical publishing and the surgical sciences, we ask that authors take these criteria into careful consideration when submitting a manuscript to a peer-reviewed surgical journal.

F
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22 February 2022

Letter to the Editor,

Please find attached our manuscript entitled: “Surgical site infection at a tertiary academic hospital in Johannesburg: A one-year audit” for consideration of publication in the prestigious World Journal of Surgery.

This article has not been submitted for consideration of publication elsewhere.

The study was done in order to address a gap in the knowledge on surgical site infection type and prevalence in a big public hospital. The Charlotte Maxeke Johannesburg Academic Hospital is situated in the Gauteng Province of South Africa. The healthcare system in South Africa (a third world country) is financially greatly under resourced and surgical site infections increases this burden. Other prevalent comorbidities such as hypertension, diabetes mellitus, HIV/AIDS impact negatively on patient morbidity, increasing the medical costs even more.

This study revealed a low incidence of surgical site infections at 4.8% comparable to Norway and Switzerland but in contrast to other African countries. A high infection rate was seen in this study in patients younger than 40 years, which could be due to the high number of emergency cases often driven by violence injuries.

In contrast to most studies reported in the literature, gram-negative organisms were found to be the most common cause of surgical site infections in this hospital. Although postoperative

surgical site infections are associated with longer hospital stay (19 days) and readmission cases from home are common, the mortality rate is low.

Kindly contact the corresponding author if there are further questions or comments.

With kindest regards,

Corresponding author:

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Cell: +27767707548

Author Contribution Statement and Agreement of Co-authors

Title of manuscript: Surgical site infection at a tertiary academic hospital in Johannesburg: A one-year audit

Name of corresponding author: Dr Mohammed K E Barbakh

Herewith all 4 authors declare that each author had made a significant contribution to this manuscript as detailed below, have seen and approved the final manuscript and have agreed to its submission to World Journal of Surgery.

None of the authors have any conflict of interest.

Dr Mohammed K E Barbakh

Execution of research work, collection and analysis of data, drafting the manuscript, final corrections and approval of the final manuscript.

22 Feb 2022

Professor Thifheli Luvhengo

Original study idea, conceptual design, clinical supervision and final approval of the manuscript.

22 Feb 2022

Professor Adelin Muganza

Clinical supervision of project and final approval of the manuscript.

22 Feb 2022

Dr Marietha Nel

Research design, academic supervision, final writing, proofreading and editing of the manuscript.

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