

Incidence, Microbiological Agents, and Predictors of Surgical Site Infections Following Open Surgeries at Muhimbili National Hospital in Tanzania, Otorhinolaryngology Department: A Prospective Cohort Study

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Abstract

Background: Surgical site infection (SSI) is the most common complication encountered following surgery across all surgical disciplines, leading to prolonged hospital stays, readmissions, increased hospital-related expenses, re-operations, and even mortality. The incidence, microbial agents involved, and predictors specific to otorhinolaryngology open Surgeries remain largely unidentified. **Methodology:** This was a Prospective Cohort study, involving patients who had undergone open surgeries in the Otorhinolaryngology (ORL) department. Data were gathered using a structured data collection tool. Wound swabs were taken for microbiological analysis from clinical SSI cases after 30 days of follow-up. Analysis was done using STATA version 15.1. The Chi-square/Fisher's exact test was used to determine the statistical significance of SSI occurrence. Modified Poisson regression analysis was employed to assess the strength of the relationship between independent and dependent variables. **Results:** The study enrolled 89 (100%) participants, 20 (22.5%) of whom developed SSI. About 95% (19/20) of the clinical SSI cases yielded culture-positive results, of which 72.2% of the isolated bacterial species were Gram-negatives, among which 1 (8.3%) was ESBL-positive. *Pseudomonas aeruginosa* 7 (38.9%) followed by *Staphylococcus aureus* 3 (16.7%) were the most isolated bacterial species. The majority of *Pseudomonas aeruginosa* species were highly resistant to ceftazidime but least resistant to ciprofloxacin, aztreonam, and

piperacillin-tazobactam. All *Staphylococcus aureus* species isolated were MRSA-positive and multiply resistant to nearly all conventional antibiotics. In multi-variable analysis, having an ASA score III (RR 3.62, 95% CI 1.13 - 11.54, P = 0.03) independently predicted the occurrence of SSI. **Conclusion:** The incidence of SSI in the Otorhinolaryngology department is high (22.5%), chiefly caused by *Pseudomonas aeruginosa* Species, which are sensitive to ciprofloxacin, piperacillin-tazobactam, and aztreonam, followed by *Staphylococcus aureus*, all MRSA-positive and multiply resistant to most conventional antibiotics. It was significantly predicted by a high ASA score (ASA III).

Keywords

Surgical Site Infections, Predictors, Microbiological Agents

1. Introduction

According to the Centers for Disease Control and Prevention (CDC), surgical site infections (SSIs) include all infections occurring at or near the surgical incision within 30 days of follow-up after surgery or after 1 year of follow-up, whenever an implant was put during the surgery [1].

Studies have revealed an alarmingly increased trend of Surgical volume compared to previous years in the world, with >300 million people being operated on annually [2]. Thus, millions of people are at a high risk of getting SSI if preventive measures are not adequately observed.

Some of the open Surgeries commonly performed in the otorhinolaryngology department (ORL) include neck surgeries, such as neck dissection, tracheostomy, thyroidectomy, parotidectomy, and thyroglossal cyst excision. Nasal and paranasal surgeries such as septoplasty, rhinoplasty, and maxillectomy. Otological surgeries such as mastoidectomy, tympanoplasty, and Cochlear implant [3].

The burden of SSI is 20% of all types of nosocomial infections. In the United States of America (USA), the annual incidence of SSI varies from 160,000 to 300,000 of the performed cases [4]. The study in Uganda found the incidence of SSI to be 16.4% [5], whereas in Kenya, one study showed an incidence of 7% [6].

In Tanzania, recent studies on different surgical disciplines, such as obstetrics and gynecology, urology, revealed the rate of SSI to range between 10.9% to 26% [7]-[9]. However, there are no existing data on the magnitude, microbiological agents, and factors associated with SSI among otorhinolaryngology open surgeries.

According to the American College of Surgeons and Surgical Infection Society, surgical site infections are associated with several risk factors, which are grouped into patient-related, such as age, diabetes, obesity, alcohol intake, current smoking, Body Mass Index (BMI) status, immunosuppression, and high American Society of Anaesthesiologist (ASA) score. Preoperative-related, such as emergency versus elective, wound class, proper antibiotic prophylaxis, and Intraoperative-related factors such as longer duration of the procedure, and failure in antibiotics

redosing to patients who take a long procedure time or those who lose >1.5 litres of blood [10].

Studies show that implementing or practicing effectively the above-mentioned factors, such as abstaining from alcohol 4 - 8 weeks before surgery, quitting smoking 2 weeks before surgery, taking precautions among patients with comorbidities such as >350 cells/ μ l of CD4 level among patients with Human immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS), and glucose control among diabetic patients, can reduce surgical site infection by 60% [4] [11] [12].

Puca *et al.* found that, of all microorganisms causing surgical site infections, Gram-negative bacteria were the most common (57.9%). *Pseudomonas aureginosa* species followed by *Escherichia coli* species were predominant among Gram-negatives. Gram-positive bacteria accounted for 36.6%, with *Staphylococcus aureus* predominating (79.4%) [13]. Moreover, in the study done by Joel Manyahi on the bacteriological spectrum of postoperative wound infections at MNH and Muhimbili Orthopedic Institute (MOI), the three most common isolated organisms were *Pseudomonas aeruginosa* (16.3%), followed by *Staphylococcus aureus* (12.2%), and *Klebsiella pneumoniae* (10.8%) [14].

In ORL head and neck surgeries, one study on post-ear surgery found *Escherichia coli* to be the most common cause of SSI in patients who underwent mastoid surgeries, followed by *Staph aureus* [15]. Whereas a systematic review of 14 articles on cochlear implant surgical site infection prevention, *Staphylococcus*, and *Pseudomonas* species were found to be the most consistently reported isolates in those studies [16].

In a study of bacterial colonization following tracheostomy among patients in the ICU in one of the hospitals in Oman, *Pseudomonas aeruginosa* and *Acinetobacter baumannii* species were the most common isolates identified in that study [17].

2. Materials and Methods

2.1. Study Design and Setting

The study was a prospective cohort study carried out in the otorhinolaryngology (ORL) department of Muhimbili National Hospital (MNH) in Dar es Salaam City. This is a tertiary referral hospital receiving referral cases from all around Tanzania. Muhimbili National Hospital has a total bed capacity of 1500, 25 departments, and 32 specialized clinics, with otolaryngology (ORL) being one of the departments having different specialized clinics. The ORL department has a total of 72 beds divided into male, female, and pediatric surgical wards. The ORL department performs major surgeries five days a week, with an average of 12 patients being operated on.

2.2. Study Population, Sampling Technique, and Sample Size

The study included patients who had undergone open Surgeries in the Otorhinolaryngology department from September 2023 to February 2024, who were sampled conveniently. The sample size was obtained by using Yamane's formula: $n =$

$N/(1 + Ne^2)$.

The letter N denotes the number of open surgeries, which was 100 patients operated on 6 months prior to the index study, as obtained from pilot study, and “e”, the marginal error, approximated to be 5%. Thus $n = 100/(1 + 100 \cdot 0.05^2) = 80$. Considering the non-responders and loss to follow-up, approximately 10% was added to the sample size to compensate, then the sample size was 89.

2.3. Data Collection, Sample Collection, and Laboratory Procedures

The data collection process was divided into three phases. The day before the operation, to obtain pre-operative information such as the patient’s demographics, body mass index (BMI in Kg/m², classified as normal, underweight, overweight, and obese as per CDC classification), comorbidities, patients’ lifestyle (such as alcohol and cigarette smoking), ASA score, and time spent in the ward before surgery. On the day of surgery, intra-operative data such as surgery length, wound class, antibiotic prophylaxis given within 30 to 60 minutes before incision, antibiotics redosing, procedure category (emergency vs elective), and drainage usage were collected through direct observation and patients’ post-op records.

After surgery, patients were evaluated three times, *i.e.*, 48 hours after surgery, on the day of the dressing change, for signs and symptoms of SSI. Surgical site infection case was defined according to CDC standard case definition such as Purulent drainage from the incision site, or from a drain that is placed deep into the organ/space, the surgeon deliberately opening the wound because of the suspected infection, or spontaneous wound dehiscence and the patient who had at least one of the following; fever, pain/tenderness, localized swell, red, and warm. The same was done on day 7, the day of stitch removal, and finally on the 30th day, the patient was interviewed by phone, and the patients with symptoms were asked to come again for further evaluation and swabs collection for culture.

Laboratory procedure: Specimens were obtained using sterile cotton after clinical evidence of SSI according to CDC standards, maintained at room temperature in Amies transport media, and taken immediately to the laboratory for identification of microorganisms by culture, Gram stain, and biochemical methods. The sample was inoculated on the MacConkey number 3 and then on the blood agar, and then incubated at 37°C under aerobic conditions. Analysis of colony morphology characteristics, such as hemolysis on the blood agar, was observed after 24 hours, followed by the Gram stain procedure. Finally, biochemical tests were done, whereby Gram-positive bacteria were subjected to a catalase test to differentiate staphylococci from streptococci species. All the catalase-positive organisms, which are the staphylococci, then underwent a coagulase test to differentiate *Staphylococcus aureus* from coagulase-negative Staphylococci. Analytical profile indexing was done for Gram-negative organisms such as Enterobacteriaceae using biochemical tests such as API 20E and oxidase tests to identify specific Gram-negative bacteria responsible for SSI pathogenesis. The antimicrobial susceptibility pattern of isolated bacterial pathogens was performed by the Kirby-Bauer disc

diffusion method according to the guidelines of the Clinical and Laboratory Standards Institute. Agar plates were uniformly seeded with a suspension of fresh isolates of bacteria of the same colony per plate. Antimicrobial discs of the right potency were then aseptically placed on the plate, which was then incubated in a suitable growth environment overnight. Zones of inhibition were measured in millimeters. The sensitivity was interpreted according to the inhibition zone sizes as sensitive or resistant.

2.4. Data Management and Analysis

Data were then entered into STATA version 15.1, and descriptive statistics were reported as the median and interquartile range (IQR) for continuous variables and proportions for categorical variables. Chi-square/Fisher's exact test was used to test the statistical significance of the difference observed in SSI occurrence among different independent categorical variables. Factors with $p < 0.2$ were subsequently analyzed using bivariable and multivariable robust Poisson regression. Bivariable robust Poisson regression analysis was used to identify factors associated with SSI in open surgery patients based on the crude risk ratio (cRR) with a 95% confidence interval (CI), while multivariable Robust Poisson regression analysis was used to investigate the associations between SSI and independent variables after adjusting for other variables. Associations in the multivariable robust Poisson regression analysis models were provided as adjusted risk ratios (aRR) with 95% confidence intervals. A two-sided p -value of <0.05 was judged significant.

3. Results

The study enrolled 89 participants who had undergone open Surgeries, representing a 100% response rate. Their ages ranged from 13 to 78 years of age, and the median age was 44.5 years (IQR 36 - 59). Among all the study participants, those who were in the age group (36 - 53) were the majority, 31 (34.8%). Overall, the female respondents, 47 (52.8%), were the majority in this study, in a female: male 1.12:1 (**Table 1**).

Table 1. Social-demographic characteristics by age and sex.

Age group in Years Median = 44.5, IQR [36 - 59]	Sex		Total n (%)
	Female n (%)	Male n (%)	
≤17	4 (57.1)	3 (42.9)	7 (7.86)
18 - 35	18 (62.1)	11 (37.9)	29 (32.6)
36 - 53	15 (48.4)	16 (51.6)	31 (34.8)
54 - 71	8 (42.1)	11 (57.9)	19 (21.3)
>71	2 (66.7)	1 (33.3)	3 (3.4)
TOTAL n (%)	47 (52.8)	42 (47.2)	89 (100)

IQR = interquartile range.

3.1. Clinical Characteristics of the Study Participants

The study found that 38 (42.7%) of all study participants had an abnormal BMI, with overweight, obese, and undernourished being 26 (29.2%), 10 (11.2%), and 2 (2.3%), respectively. Smoking and alcohol drinking habits were observed in 12 (13.5%) and 18 (20.2%), respectively. In this study, 15 (16.9%) of the study participants had at least one comorbid condition, with HIV/AIDS, diabetes, and hypertension observed in 7 (7.9%), 3 (3.4%), and 5 (5.6%), respectively. Surgery waiting times > 1 day were observed in 17 (19.1%) of them. The majority of the study participants had ASA scores of I and II of 59 (67.1%) and 17 (19.3%), respectively, and only 3 (3.4%) had ASA scores of IV. Head and neck Surgeries were the most performed at 57 (64%), and the least performed were rhinological open surgeries at 10 (11.3%). Among all the open surgeries, 44 (49%) took >1 hour. Of all the open surgeries performed, 75 (84.3%) were elective. Clean-contaminated surgeries were the majority of 64 (71.9%), and only 1 (1.1%) of the participants had dirty wounds before surgery. Among the study participants, 67 (75.3%) received antibiotic prophylaxis. Only 1 (20%) out of 5 patients with the criteria received antibiotic redosing intra-operatively. Drainage was used in 30.3% of all the performed open surgeries (**Table 2**).

Table 2. Clinical characteristics of study participants.

Variable	Frequency(n)	%
BMI in Kg/m ²		
Underweight	2	2.3
Normal	51	57.3
Overweight	26	29.2
Obese	10	11.2
Active cigarette smoking		
No	77	86.5
Yes	12	13.5
Alcohol drinking		
No	71	79.8
Yes	18	20.2
HIV		
No	82	92.1
Yes	7	7.9
DM		
No	86	96.6
Yes	3	3.4
Hypertension		
No	84	94.4
Yes	5	5.6

Continued

Pre op (days)		
≤1	72	80.9
>1	17	19.1
ASA score		
I	60	67.1
II	17	19.3
III	9	10.2
IV	3	3.4
The performed surgeries by site		
Head and neck	57	64.0
Otology	22	24.7
Rhinology	10	11.3
Procedure duration (hours)		
≤1	45	50.6
>1	44	49.4
Procedure category		
Elective	75	84.3
Emergency	14	15.7
Wound class		
Clean	15	16.9
Clean-contaminated	64	71.9
Contaminated	9	10.1
Dirty	1	1.1
Antibiotic prophylaxis		
No	22	24.7
Yes	67	75.3
Antibiotic redosing		
No	4	80
Yes	1	20
Drainage use		
No	62	69.7
Yes	27	30.3
TOTAL	89	100

3.2. Incidence of Surgical Site Infections per Site of Surgery

According to this study, the overall incidence of surgical site infections (SSIs) among patients who underwent open surgeries was found to be 22.5%. The incidence of SSI was highest among open surgeries done in rhinology 6 (60%), and

the smallest incidence was observed among open surgeries done in otology 1 (4.6%), and that difference was statistically significant ($p = 0.002$) (Table 3).

Table 3. Incidence of surgical site infection by site of operation.

Site of operation	Surgical Site Infection		Total n (%)	p-value
	Yes n (%)	No n (%)		
Head and neck	13 (22.8)	44 (77.2)	57 (65.0)	0.002
Otological	1 (4.6)	21 (95.4)	22 (24.7)	
Rhinological	6 (60.0)	4 (40.0)	10 (11.3)	
Total n (%)	20 (22.5)	69 (77.5)	89 (100)	

3.3. Microbiological Agents

A total of 20 specimens from clinically diagnosed SSI were collected for microbiological study. About 19 (95%) specimens showed culture-positive results, which made a total of 20 isolates; one specimen had two bacterial species in it. Out of the 20 isolates, 16 (80%) were pathogenic organisms, 2 (10%) were coagulase-negative *Staphylococcus aureus* (CONS), and 2 (10%) were contaminants.

Figure 1: Among all the bacterial species isolated, gram-negative bacteria were the most common, accounting for 72.2%, among which only *Klebsiella pneumoniae* was an ESBL-producing organism. Of all the bacterial species, *Pseudomonas aeruginosa* was the most isolated bacterial species (38.9%), followed by *Staphylococcus aureus* (16.7%), which were all MRSA positive (Figure 1, Table 4).

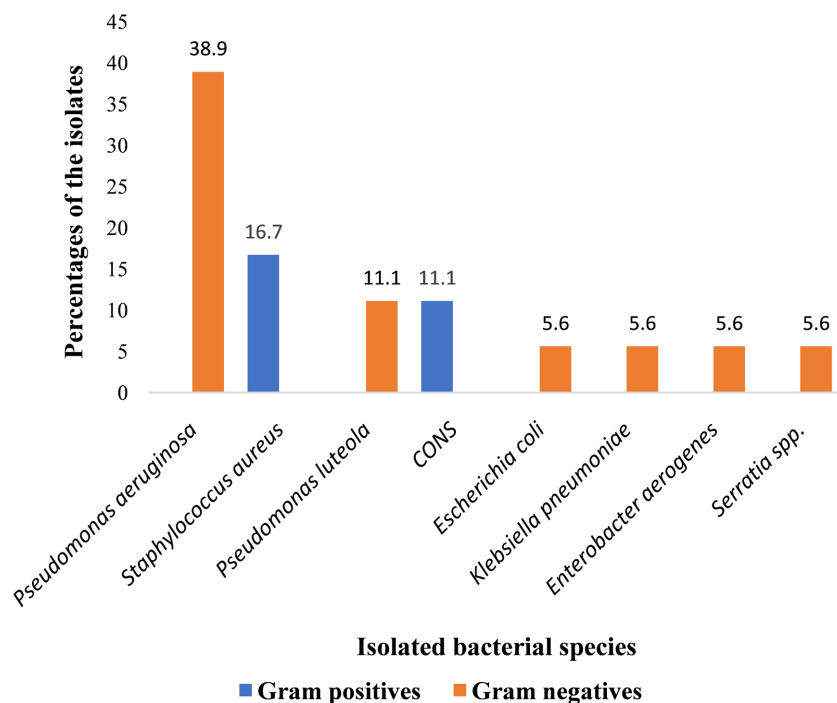
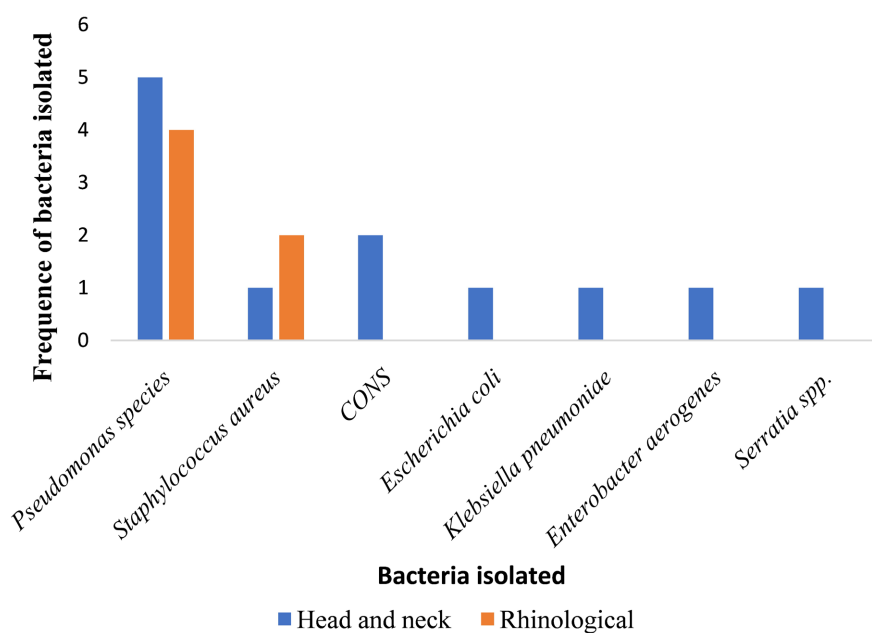


Figure 1. Proportions of isolated bacterial species in all patients who developed surgical site infections.

Table 4. Proportions of MRSA and ESBL among *Staphylococcus aureus* and Enterobacteriaceae.

Resistant group	Isolated bacterial species	Total	Frequency	Percent (%)
MRSA (100%)	<i>Staphylococcus aureus</i>	3	3	100
	<i>Pseudomonas aeruginosa</i>	7	0	0
	<i>Pseudomonas luteola</i>	2	0	0
ESBL (8.3%)	<i>Escherichia coli</i>	1	0	0
	<i>Klebsiella pneumoniae</i>	1	1	100
	<i>Enterobacter aerogenes</i>	1	0	0
	<i>Serratia spp.</i>	1	0	0

Figure 2 shows that the *Pseudomonas aeruginosa* species was most frequently isolated among those with SSI who had undergone open head and neck surgeries, 5 (55.6%), whereas the *Staphylococcus aureus* species was most frequently isolated among those with SSI who had undergone open rhinological surgeries, 2 (66.7%). In one case with surgical site infections from otology, culture results revealed no microbiological agent growth.

**Figure 2.** Frequency of bacterial species isolated as per site of surgery.

3.4. Resistance Pattern of the Most Isolated Bacterial Species

The *Pseudomonas aureginosa* species displayed significant resistance to ceftazidime 5 (71.4), while showing the least resistance to ciprofloxacin, aztreonam, and piperacillin-tazobactam, 0 (0%). Whereas *Staphylococcus aureus* species were resistant to almost all the conventional antibiotics tested, such as ciprofloxacin, penicillin, clindamycin, and trimethoprim-sulfamethoxazole 3 (100). Resistance to gentamycin was noted in all isolates (**Table 5**).

Table 5. Antimicrobial resistance patterns of the isolated bacterial species.

Antibiotic	Resistance pattern n (%)			
	<i>Pseudomonas aeruginosa</i> (N= 7)	<i>Pseudomonas luteola</i> (N= 2)	<i>Staphylococcus aureus</i> (N= 3)	CONS (N= 2)
Ciprofloxacin	0 (0)	0 (0)	3 (100)	0 (0)
Meropenem	3 (42.9)	1 (50)	-	-
Gentamycin	1 (14.3)	1 (50)	1 (33.3)	1 (50)
Amikacin	-	-	-	-
Trimethoprim-Sulphamixazole	-	-	3 (100)	1 (50)
Piperacillin Tazobactam	0 (0)	1 (50)	-	-
Ceftazidime	5 (71.4)	2 (100)	-	-
Erythromycin	-	-	3 (100)	1 (50)
Chloramphenicol	-	-	-	-
Penicillin	-	-	3 (100)	1 (50)
Clindamycin	-	-	3 (100)	1 (50)
Cefepime	2 (28.6)	1 (50)	-	-
Cefoxitin	-	-	3 (100)	1 (50)
Aztreonam	0 (0)	0 (0)	-	-
Ceftriaxone	-	-	-	-
Cefotaxime	-	-	-	-
Amox Clavunate	-	-	-	-
Ampicillin	-	-	-	-

3.5. Incidence of Surgical Infections by Social-Demographic Characteristics and Clinical Characteristics

Among all the study participants who had SSI, those with HIV/AIDS comorbidity had a higher proportion of SSI cases of about 57.1% compared to 19.5% who were HIV/AIDS negative, and that difference was statistically significant ($p = 0.022$). Among all the SSI cases, those who had alcohol drinking habits had a higher proportion of 55.6% compared to 14.1% who never drank, and that difference observed was statistically significant ($p < 0.0001$). Of all the SSI cases, a higher proportion was observed in those patients who stayed in the hospital for >1 day before their surgeries at 52.9% compared to 15.3% whose surgeries were done in <1 day, and the difference was statistically significant ($p = 0.001$). Among all the SSI cases, the highest proportion was observed in those who had ASA III and IV, about 66.7% each, compared to 10.2% who had ASA I class, and that difference was statistically significant. Of all the observed SSI cases, a higher proportion was observed in those who didn't receive antibiotic prophylaxis 45.5% compared to 14.9% who received prophylaxis within 30 to 60 minutes before incision, and that difference was statistically significant ($p = 0.003$). Social demographic (such as

age, sex), comorbidities such as DM, hypertension, BMI, smoking habit, duration of surgery >1 hr, procedure category, wound class, antibiotic redosing, and drainage usage predictors were not found to be associated with SSI in this study ($p > 0.05$) (Table 6).

Table 6. Incidence of surgical site infections by social-demographic and clinical characteristics among patients who underwent open surgeries.

Social-demographic predictors	Surgical Site Infection		Total, <i>N</i>	p-value
	Yes, <i>n</i> (%)	No, <i>n</i> (%)		
Age group in Years				
Median = 44.5, IQR [36 - 59]				0.447
≤17	1 (14.3)	6 (85.7)	7	
18 - 35	6 (20.7)	23 (79.3)	29	
36 - 53	7 (22.6)	24 (77.4)	31	
54 - 71	4 (21.0)	15 (79.0)	19	
>71	2 (66.7)	1 (33.3)	3	
Sex				
Female	8 (17.0)	39 (83.0)	47	0.193
Male	12 (28.6)	30 (71.4)	42	
Comorbid and lifestyle predictors				
<i>Body mass index</i>				
Underweight	0 (0)	2 (100)	2	0.778
Normal	12 (23.5)	39 (76.5)	51	
Overweight	5 (19.2)	21 (80.8)	26	
Obese	3 (30.0)	7 (70.0)	10	
<i>Cigarette smoking</i>				
No	15 (19.5)	62 (80.5)	77	0.087
Yes	5 (41.7)	7 (58.3)	12	
<i>Alcohol drinking</i>				
No	10 (14.1)	61 (85.9)	71	<0.0001
Yes	10 (55.6)	8 (44.4)	18	
<i>HIV</i>				
No	16 (19.5)	66 (80.5)	82	0.022
Yes	4 (57.1)	3 (42.9)	7	
<i>DM</i>				
No	18 (20.9)	68 (79.1)	86	0.062
Yes	2 (66.7)	1 (33.3)	3	
<i>Hypertension</i>				
No	18 (21.4)	66 (78.6)	84	0.334
Yes	2 (40.0)	3 (60.0)	5	

Continued

Peri-operative predictors

<i>Pre-OP hospital stays (days)</i>				0.001
≤1	11 (15.3)	61 (84.7)	72	
>1	9 (52.9)	8 (47.1)	17	
<i>ASA score</i>				<0.0001
I	6 (10.2)	53 (89.8)	59	
II	6 (35.3)	11 (64.7)	17	
III	6 (66.7)	3 (33.3)	9	
IV	2 (66.7)	1 (33.3)	3	
<i>Procedure duration (hours)</i>				0.283
≤1	8 (17.8)	37 (82.2)	45	
>1	12 (27.3)	32 (72.7)	44	
<i>Procedure category</i>				0.551
Elective	16 (21.3)	59 (78.7)	75	
Emergency	4 (28.6)	10 (71.4)	14	
<i>Wound class</i>				0.350
Clean	1 (6.7)	14 (93.3)	15	
Clean-contaminated	16 (25.0)	48 (75.0)	64	
Contaminated	3 (33.3)	6 (66.7)	9	
Dirty	0 (0)	1 (100)	1	
<i>Antibiotic prophylaxis</i>				0.003
No	10 (45.5)	12 (54.5)	22	
Yes	10 (14.9)	57 (85.1)	67	
<i>Antibiotic redosing</i>				0.400
No	3 (75.0)	1 (25.0)	4	
Yes	0 (0)	1 (100)	1	
<i>Drainage use</i>				0.970
No	14 (22.6)	48 (77.4)	62	
Yes	6 (22.2)	21 (77.8)	27	
TOTAL	20 (22.5)	69 (77.5)	89	

After bivariable robust Poisson regression analysis, SSI was found to be significantly associated with alcohol drinking habits (cRR 3.94, 95% CI 1.94 - 8.00, $p < 0.001$), having HIV/AIDS (cRR 2.93, 95% CI 1.35 - 6.37, $p = 0.007$), having >1-day pre-op hospital stay (cRR 3.47, 95% CI 1.71 - 7.04, $p = 0.01$), higher ASA score such as ASA III and IV (cRR 6.67, 95% CI 2.21 - 20.9, $p < 0.001$), having diabetes mellitus (cRR 3.19, 95% CI 1.30 - 7.83, $p = 0.012$) and those who didn't receive antibiotics prophylaxis (cRR 3.05, 95% CI 1.46 - 6.33, $p = 0.003$).

After Multivariable robust Poisson regression analysis, a higher ASA score, *i.e.*, ASA III (aRR 3.62, 95% CI 1.13 - 11.54, P = 0.03), was the only independent predictor found to be significantly associated with the development of surgical site infections (SSI) in this study (**Table 7**).

Table 7. Bivariable and multivariable analysis of the factors associated with SSI.

Variable	Category	SSI (%)	Bivariable analysis			Multivariable analysis		
			cRR	95% CI	p-value	aRR	95% CI	p-value
Gender	Male	12 (28.6)	1.68	0.76 - 3.1	0.200	0.85	0.38 - 1.90	0.687
	Female	8 (17.0)	Ref					
Cigarette	Yes	5 (41.7)	2.14	0.95 - 4.80	0.065	0.96	0.42 - 2.21	0.932
	No	15 (19.5)	Ref					
Alcohol	Yes	10 (55.6)	3.94	1.94 - 8.00	<0.001	2.12	0.86 - 5.22	0.104
	No	10 (14.1)	Ref					
HIV	Yes	4 (57.1)	2.93	1.35 - 6.37	0.007	2.41	0.93 - 6.21	0.070
	No	16 (19.5)	Ref					
DM	Yes	2 (66.7)	3.19	1.30 - 7.83	0.012	0.89	0.15 - 5.48	0.901
	No	18 (20.9)	Ref					
Pre-Op (days)	>1	9 (52.9)	3.47	1.71 - 7.01	< 0.001	1.75	0.67 - 4.60	0.256
	≤ 1	11 (15.3)	Ref					
ASA score	IV	2 (66.7)	6.67	2.21 - 20.09	<0.001	2.82	0.56 - 14.19	0.210
	III	6 (66.7)	6.67	2.74 - 16.21	<0.001	3.62	1.13 - 11.54	0.030
	II	6 (35.3)	3.53	1.31 - 9.55	0.013	2.07	0.71 - 6.02	0.183
	I	6 (10.0)	Ref					
Antibiotic prophylaxis	No	10 (45.5)	3.05	1.46 - 6.33	0.003	1.47	0.63 - 3.43	0.369
	Yes	10 (14.9)	Ref					

Key: SSI: Surgical Site Infection, cRR: crude Relative Risk, aRR: adjusted Relative Risk, Ref: Reference group.

4. Discussion

Among the postoperative complications, SSI is still a major problem in its entirety, more so in developing countries, which has led to prolonged hospital stays, unnecessary healthcare-associated costs, readmission, reoperation, and death among patients who undergo Surgeries [4].

The index study found an SSI incidence of up to 22.5%, consistent with the study done by Kibwana *et al.* at MNH, whose findings revealed a 22% rate of SSI [8]. These comparable findings can be best explained by the shared predictors, such as the same environmental setting, inadequate infection control policy enforcement, and limited resource supply for infection control strategies. Our findings were slightly higher compared to those found in the recent study done in Uganda, which showed incidences of SSI of 16.4% [5]. This can best be explained

by sample size differences (110 study participants in the study in Uganda vs 89 in the index study). The incidence of SSI in this study is strikingly higher than that observed in Latin America and Asia, showing incidences of 7% and 4%, respectively [18]. This may be attributed to well-made preoperative plans, adequate use of antibiotics, adherence to preventive measures, and sufficient infrastructure to contain potential pathogens. The index study was conducted in a low-resource area.

In the study, which was done by Joel Manyahi on the bacteriological spectrum of postoperative wound infections in general surgery, obstetrics and gynecology, and orthopedics at MNH and MOI, the three most common isolated organisms were *Pseudomonas aeruginosa* (16.3%), followed by *Staphylococcus aureus* (12.2%), and *Klebsiella pneumoniae* (10.8%) [14], which is in agreement with the findings of the index study, which revealed *Pseudomonas aeruginosa* (38.9%), followed by *Staphylococcus aureus* (16.7%), and coagulase-negative Staphylococcus (11.1%) to be the commonest isolates, which were all multidrug resistant, in keeping with the findings by Manyahi *et al.* [14]. This can best be explained by the same environmental setting, which acts as a potential exogenous source of microorganisms in surgical wounds.

Moreover, the index study had one culture-negative result, which was one SSI case from otology, unlike the previous study on microbiological patterns after mastoid surgeries that revealed *Escherichia coli* followed by *Staphylococcus aureus* as the common isolated bacterial species [15], that culture-negative results can be due to the difficulty of culturing anaerobes in our setting.

In this study, though the p-value was >0.05 , most surgical site infections were in the age group >71 years. This finding is supported by many other previous studies [19] [20], and it is theoretically true that elderly patients are at risk of infections due to low immunity levels, comorbidities, smoking, and alcohol intake being prevalent in this age group [21].

In the same vein, although the P-value was >0.05 , male patients were found to have a higher incidence of surgical site infection compared to females, which also displays the likeness of the findings of 10 years of surveillance in Germany [22]. Theoretically, this is true because of the impaired cell-mediated immunity in males due to the effects of testosterone [23].

Furthermore, as previous research shows [9] [24] [25], In those patients whose operation had taken a duration of >1 hour, SSI cases were proportionally higher compared to those without. The recommendation from the Surgical Care Improvement Project [26] (SCIP) is that antibiotic redosing must be given in addition to the first prophylaxis provided within 30 to 60 minutes before skin incision, for surgeries that take 1 - 2 times the half-lives of the first antibiotic prophylaxis given, or 1.5 liters of blood loss, or the procedure that lasts > 4 hours. In the index study, five patients met the criteria to receive antibiotic redosing; only one received antibiotic intra-op, and among the four who didn't receive, 3 (75%) developed SSI. This may be because the longer the surgery lasts, the greater the danger

of contamination and blood loss in those patients, resulting in an increased risk of SSI.

Bivariable analysis of this study showed that Patients who had alcohol drinking habits had a 3.94-fold increased risk of developing surgical site infections compared to those who didn't. This finding is consistent with many other previous studies [19] [27] This is because alcohol tends to impair cell migration to fight offending micro-organisms, and also, in the initial stages of wound healing, debris is not cleared up owing to the absence of macrophages on the incision site, hence harboring the nidus for infections.

Like the previous studies [9] [28], patients who had HIV/AIDS had a risk of developing SSI 2.93 times higher than those who did not as shown by the bivariable analysis of the index study. This is because patients with HIV/AIDS usually have impaired cell-mediated immunity to tackle the offending pathogens, impaired immunological processes toward wound healing, and malnutrition [12].

Furthermore, bivariable analysis of the index study revealed those who didn't receive antibiotic prophylaxis to have 3.05 times increased risk of developing SSI compared to those who received prophylaxis 30 to 60 minutes before surgery, in keeping with previous studies [29]-[32]. The truth of the matter is, absence of bacteriostatic or bactericidal activity offered by appropriate prophylactic antibiotics might lead to the proliferation of potential micro-organisms from either endogenous or exogenous sources in the surgical wound leading to SSI [33].

Multivariable analysis of the index study revealed an increased likelihood of developing surgical site infection among those with an American Society of Anaesthesiologists (ASA) score III, 3.65 times more than those with an ASA score I, similar to previous studies [20] [24]. Patients with Higher ASA scores are physically constrained due to systemic diseases such as heart failure, hypertension, and diabetes mellitus, which impair immunological functions important for wound healing and the fight against infections.

5. Limitation

This was a single-center study with a small sample size, making it difficult to generalize the study's findings.

The study methodology used had a risk of selection bias.

Surgical expertise among surgeons and the ability of patients to comply to post operative care package of wounds could have influenced the results.

6. Conclusion

The incidence of SSI among open surgeries in the Otorhinolaryngology department is high (22.5%) and is chiefly caused by *Pseudomonas aeruginosa* species, which are sensitive to ciprofloxacin, piperacillin-tazobactam, and aztreonam, as well as *Staphylococcus aureus* species, all MRSA-positive and multiply resistant to nearly all the conventional antibiotics. It was significantly predicted by having an ASA score of III.

7. Recommendation

Patients who are planned for elective surgery should stop alcohol intake at least 4 to 8 weeks before surgery. Antibiotic prophylaxis is strongly recommended in most ORL open surgeries. Surgical patients with HIV/AIDS should be assessed thoroughly, including CD4 levels over 350 cells/ μ l. Antibiotic redosing among open surgeries that take >4 hours or >2 half-lives of the given first dose of antibiotics, or with blood loss of 1.5 L, is highly recommended. Patients with high ASA scores should be optimized before and after the operation according to CDC recommendations. Further research with a large sample size and a long study period is strongly recommended.

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Ethical Approval

The MUHAS institutional review board (IRB) provided ethical clearance for my study.

Conflicts of Interest

The authors declare absence of competing interests.

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