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RESEARCH

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Incidence, bacteriological profile and predictors of surgical site infections following limb amputation at Bugando medical centre and Sekou toure referral regional hospital, Mwanza, Tanzania

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Abstract

Background Surgical site infections (SSIs) after limb amputations have been associated with increased patient morbidity, mortality and costs. This study aimed to determine the incidence, bacteriological profile and predictors of SSIs following limb amputation at Bugando Medical Centre (BMC) and Sekou Toure Regional Referral Hospital (SRRH).

Methods The longitudinal study was conducted among patients undergoing limb amputations between March and July 2024 at BMC and SRRH. Pre-tested structured questionnaires were used to collect sociodemographic and clinical data. Clinical diagnosis of SSI was done using CDC criteria followed by collection of wound or pus swab for culture and susceptibility testing. Univariate and multivariate logistic regression modelling was done using STATA version 15.0 to assess associations between clinical variables and odds of SSI.

Results A total of 120 patients with a median (IQR) age of 58 [43.5–66.5] years were enrolled. The indications for limb amputations included diabetic foot ulcers (50.8%,61/120), trauma (8.3%,10/120), malignancy (8.3%,10/120), gangrene (9.2%,11/120), peripheral vascular disease (16.7%,20/120) and congenital malformations (6.7%,8/120). The incidence of SSIs was (30%,36/120), with *Escherichia coli* (36.7%; 11/30) and *Staphylococcus aureus* (23%; 7/30) being the most frequently isolated pathogens. More than half of the Gram-negative isolates were resistant to third and fourth generations cephalosporins which were commonly used as prophylactic antibiotics in the study settings. Age above 65 years (OR = 0.21, 95% CI: 0.05–0.95, $p = 0.043$), smoking (OR = 14.3, 95% CI: 1.33-10.00, $p = 0.027$), ASA Class III (OR = 13.33, 95% CI: 2.82–63.14, $p = 0.001$), longer surgery duration (≥ 2 h) (OR = 4.09, 95% CI: 1.30-12.89, $p = 0.016$) and blood transfusion (OR = 2.4, 95% CI: 0.7-8.00, $p = 0.02$) were independently associated with SSIs.

Conclusion About one third of the patients developed SSIs following limb amputation. Odds of SSIs were increased in patients with low age, smoking, high ASA score, prolonged surgery and who received blood transfusion. This

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highlighted the need to update the management protocol of limb amputation in relation to antibiotics prophylaxis among patients with increased risk of SSIs based on the local antimicrobial surveillance prevalence data.

Keywords Limb amputation, Surgical site infection, Incidence, Bacteriological profile, Tanzania

Background

Limb amputation, defined as the surgical removal of a limb, or part of a limb through the bone, is reported to be a major but preventable public health problem [1–3]. Amputation of a limb has been considered as the last management option when limb salvage is not possible or when the limb is non-functional or the patient's life is in danger due to the limb [4, 5]. Despite its devastating impact on patients and the families, limb amputation remains among the most commonly performed surgeries with approximately 185,000 surgeries performed each year worldwide [2]. Indications for limb amputation include trauma, musculoskeletal malignancies, diabetes, infections, peripheral vascular disease, congenital malformations, sepsis, and burns [6, 7].

Surgical site infections (SSIs) have been reported to be the most common complications following limb amputation [1, 4, 8]. SSIs following limb amputation contribute significantly to patient morbidity and mortality, longer hospital stays, increased risk of readmission, revision surgery, higher treatment costs, and compromised health outcomes [4, 9]. Cumulative incidence of SSIs has been estimated to range from 13 to 48% following amputation, however SSIs rates as high as 57% has also been reported following traumatic limb amputation [7, 10–12]. Previous studies from Tanzania reported different rates of SSIs, ranging from 19% in Kilimanjaro Christian Medical College Centre(KCMC) to 35% in Muhimbili National Hospital(MNH) [13, 14]. This variability, together with limited publications, prompts further research into the magnitude of the problem in various settings as well as trends in SSIs following amputation over time. Previous studies by Chalya et al. in 2012 [4] and Mawalla et al. in 2011 [15] at BMC reported more than ten years ago demonstrated SSIs rates of 21.0% and 12.5% respectively following limb amputations.

The patient's age, smoking habit, diabetes, HIV infection, jaundice, anemia, Body Mass Index (BMI, bacterial colonization, steroid use, hospitalization, and uremia have all been documented to be associated factors with SSIs [16–18]. Prolonged duration of operation, wound contamination status, prophylactic antibiotics, type of procedure, emergency nature of the surgery, American society of Anesthesiology(ASA) class, contaminated instruments and suture material have also been documented as the most common procedure-related risk factors of SSIs [17, 18]. Furthermore, it should be noted that the bacteriological profile and antimicrobial susceptibility patterns of the bacteria isolates causing SSIs vary between one places to another, different surgeries, surgeons, facilities, wards in the same hospital, and it might even change periodically [17, 18].

Recent data regarding SSIs following limb amputations in our setting are limited, and the few available are outdated [4]. Moreover, there is no evidence-based data to support the preoperative and postoperative care protocols in many health facilities in developing countries. Therefore, this study was carried out to determine the incidence, susceptibility patterns of isolated pathogens and factors associated with SSI among patients undergoing limb amputations at BMC and SRRH. The results of this study are critical in developing an evidence-based treatment protocol for post amputation SSIs.

Materials and methods

Study design, population and setting

This was a longitudinal study that involved all consenting patients who underwent limb amputation at Bugando Medical Centre (BMC) and Sekou Toure Regional Referral Hospital (SRRH) between March and July 2024. BMC is the Lake Zonal referral hospital situated in the city of Mwanza, Northwestern Tanzania. It is a consultant and tertiary care hospital with a bed capacity of 1060. BMC has about 30–45 limb amputations performed every month. SRRH is located in Nyamagana district in the city of Mwanza, it is a public regional facility serving the population of Mwanza Region with 450-bed capacity and about 15–20 limb amputations performed every month.

Exclusion criteria

Patients who previously undergone amputation in other healthcare facilities who were referred for stump revisions were excluded.

Sample size Estimation and sampling procedures

The minimum sample size was 120 patients calculated using Yamane-Taro [19]. Purposive sampling of patients who met the inclusion criteria was performed until the sample size was reached. Patients were recruited from general surgery, pediatric surgery, plastic surgery and orthopedic surgery wards, also from the emergency department and surgical outpatient clinic once the surgeon reached a decision of amputation. The attending surgeon performed limb amputation based on the standard care. The level of amputation was determined in accordance with clinical evaluation and radiographic tests (e.g., plain X-rays of the affected limb, Doppler studies, CT angiography), and histopathological investigations. Standard of care pre operative investigations were performed to assess general fitness for surgery. Patients were screened for HIV using Tanzania HIV Rapid Test Algorithm [3] and CD 4 + count using FACS or FACSCALIBUR from BD Biosciences USA. A determination of CD 4 + count was performed only in HIV positive patients.

After surgery, the surgical wound was examined once for the initial dressing and then once a week for the next 30 days as per CDC protocol [20]. Patients were followed up in the ward from the time of admission until time of the discharge and for 30 days postoperatively in the surgical outpatient clinic or dressing clinic or through telephone interview.

Clinical case definitions

Superficial surgical site infection was diagnosed if any one of the following criteria was fulfilled: purulent drainage from the superficial incision, organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision, at least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat, and superficial incision is deliberately opened by surgeon, and is culture-positive or not cultured.

Deep surgical site infection was diagnosed if any one of the following criteria is fulfilled; purulent drainage from the deep incision but not from the organ/space component of the surgical site, a deep incision spontaneously dehisces or is deliberately opened by a surgeon and is culture-positive or not cultured and the patient has at least one of the following signs or symptoms: fever (> 38 °C), or localized pain or tenderness.

The primary and secondary outcomes

The primary outcome was to establish the incidence of SSI within 30 days following major amputations with two secondary aims of identifying predictors of SSI as well as bacterial etiology and susceptibility patterns.

Data collection

A pretested, structured questionnaire was used for data collection, including demographic and clinical characteristics, pre-operative investigations, operative and outcome variables.

Specimen collection and laboratory procedures

Two pus swabs: one for microscopy and the other for culture were obtained from the surgical infected wound by sterile cotton swabs and transported in Stuart transport media to the laboratory for processing within an hour of collection. Before sample collection surrounding skin was cleaned with sterile saline or 70% alcohol (Aldrich Sigma; Nairobi). All specimens were processed in accordance with the standard operating procedures of the laboratory. Briefly specimens were inoculated on Blood agar and MacConkey agar (Oxoid; UK) and incubated aerobically for 24–48 h. Identification of bacteria was done using conventional physiological and biochemical methods. Biochemical and physiological methods included; gram stain, catalase reaction, coagulase reaction, hemolytic activity on 5% sheep blood agar plate, hippurate hydrolysis and CAMP test for Gram positive bacteria while for Gram negative; colonies morphology on blood agar and MacConkey agar, triple sugar iron (TSI) reaction, indole, motility, citrate, urease and hydrogen sulphide production (Oxoid, UK) was used [21, 22]. Antimicrobial susceptibility of isolates was determined using disk diffusion method according to Clinical Laboratory Standard Institute [23].

Data management and statistical analysis

Data was entered in the Microsoft excel data sheet and analyzed using STATA version 15 (Collage Station, Texas, the United States). The median (+ IQR)/mean ± standard deviation was calculated for continuous variables depending on the distribution of data whereas proportions, frequency tables, bar and pie charts were used for categorical variables. Univariate logistic regression analysis was done and all factors with p values less than 0.05 were used to build up a multivariate logistic regression to determine predictors of SSI. In all tests, p values of < 0.05 were regarded as statistically significant.

Results

Socio-demographic and clinical characteristics

A total of 120 patients were included in the study. The median [IQR] age was 58[43.5–66.5] years. Most patients had primary education (58.3%, 70/120) and unemployed (83.3%,100/120). Nearly half of the patients had a medical co-morbid (47.5%,57/120) or were underweight (45.8%,55/120) while only (4.2%,5/120) patients reported smoking cigarettes (Table 1).

Pre-operative indications for amputations

The most common indication for surgery was complications of diabetes mellitus (DM), affecting (50.8%,61/120) of patients. Trauma and malignant tumors each accounted for (8.3%,10/120) while gangrene was present in (9.2%,11/120) of cases Table 2.

Post operative outcomes

Out of 120 enrolled and followed patients, 36 developed SSI, therefore the overall incidence of SSI within 3 months of amputation was 30.0% (95% CI 21.8–38). Superficial SSIs were the most common type accounting for 28(77.8%) cases and 8(22.2%) were deep SSIs. Out of 90 patients recruited from BMC, 23(25.5%) developed

Table 1 Socio-demographic and clinical characteristic of study participants($N=120$)

Characteristics	Frequency(n)	Percentage (%)
Age group (years)		
≤45	32	26.7
46–65	57	47.5
>65	31	25.8
Gender		
Male	64	53.3
Female	56	46.7
Education		
Informal	6	5
Primary	70	58.3
Secondary	35	29.2
Tertiary	9	7.5
Occupation		
Employed	20	16.7
Unemployed	100	83.3
Marital Status		
Single	23	19.2
Married	47	39.2
Divorced	50	41.6
Region of residence		
Mwanza	55	45.8
Outside Mwanza	65	54.2
Residence		
Urban	84	70.0
Rural	36	30.0
Hospital centre		
Sekou Toure	30	25.0
BMC	90	75.0
****Comorbidity***		
Yes	57	47.5
No	63	52.5
BMI		
Underweight	55	45.8
Normal	60	50.0
Overweight	5	4.2
Smoking		
Yes	5	4.2
No	115	95.8

Key: BMI -Body Mass Index, BMC-Bugando Medical Centre

*Comorbid conditions: HIV = 1, Diabetes Mellitus = 23, Hypertension = 4, Malignancy = 7, Osteomyelitis = 2, Peripheral artery disease = 13, Trauma = 8

Table 2 Indications for limb amputation ($N=120$)

Characteristics	Frequency(n)	Percentage (%)
Indication		
Other complications of DM	61	50.8
Trauma	10	8.3
Malignant tumors	10	8.3
Gangrene	11	9.2
Peripherals vascular diseases	20	16.7
Malformations	8	6.67

SSIs while out of 30 patients recruited from SRRH, 13(43.3%) developed SSIs ($p=0.066$).

Bacteria and their susceptibility patterns

Out of 36 patients clinically diagnosed with SSI, (83.3%,30/36) had positive cultures. Among these 30 patients, (66.7%,20/30) had SSIs due to Gram-negative bacteria while (33.33%,10/30) SSIs were due to Gram-positive bacteria. The predominant bacterial species identified were *E. coli*, found in (36.7%,11/30) of cases, followed by *S. aureus* in (23%,7/30) and *P. aeruginosa* in (13.3%,4/30), Table 3.

The majority of Gram-negative isolates were resistant to third generation cephalosporins, while the majority of Gram-positive bacteria were resistant to ceftriaxone, ampicillin as shown in Table 4.

Distribution of surgical site infections among the study participants

A large number of the participants who developed surgical site infection were of the age below or equal to 45 years, (46.9%,15/32). Most of the study participants underwent were listed for emergency surgeries, (93.3%,112/120) compared to the ones who were listed for elective, (6.7%,8/120), however, SSI occurred more frequent in patients who underwent elective surgeries, compared to those who underwent emergency surgeries (Table 5).

Predictors of surgical site infections following limb amputations

The study analyzed various factors documented to be associated with surgical site infections (SSI). On univariate logistic regression factors found to be associated SSI were: age group between 46 and 65 years (OR = 0.36, 95% CI: 0.15–0.93, $p=0.034$), those over 65 years (OR = 0.33, 95% CI: 0.11–0.98, $p=0.047$), duration of surgery ≥ 2 h (OR = 4.36, 95% CI: 1.80-10.57, $p=0.001$), smoking (OR = 25, 95% CI: 2.85-10, $p=0.003$), ASA class III (OR = 4.36, 95% CI: 1.21–9.79, $p=0.02$) and blood transfusion (OR = 3.33, 95% CI: 1.29–9.09, $p=0.012$).

When these predictors were subjected to multivariate logistic regression analysis the factors that remained statistically significant were, age group 46–65 years (OR = 0.25, 95% CI: 0.07–0.92, $p=0.037$), smoking (OR = 14.3, 95% CI: 1.33-10, $p=0.027$), ASA Class III (OR = 13.33, 95% CI: 2.82–63.14, $p=0.001$), surgery duration (≥ 2 h) (OR = 4.09, 95% CI: 1.30-12.89, $p=0.016$) and blood transfusion (OR = 4.0, 95% CI:1.25–12.5, $p=0.02$) (Table 6).

Table 3 Pathogens isolated from 30 patients with positive growth of wound swabs(*N* = 30)

Gram stain	Bacterial isolates	Frequency (*n*)	Percentage (%)
Gram-positive	*Staphylococcus aureus*	7	23.4
	Enterococcus feacalis	3	10
Gram-negative	*Escherichia coli*	11	36.7
	Pseudomonas aeruginosa	4	13.3
	Klebsiella pneumoniae	1	3.3
	Morganella morganii	2	6.7
	Enterobacter cloacae	1	3.3
	Acinetobacter baumannii	1	3.3

Table 4 The resistance pattens of the 30 isolates from patient with SSI

ANTOBIOTICS	BACTERIA ISOLATED				
	Enterobacterales(*N* = 15)	*P. aeruginosa*(*N* = 4)	*A. baumannii*(*N* = 1)	S. aureus (*N* = 7)	E. faecalis (*N* = 3)
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Ampicillin	13(86.7)	3(75)	1(100)	4(57.14)	1(33.33)
Trimethoprim/sulphamethoxazole	12(80.0)	3(75)	1(100)	4(57.14)	1 (33.33)
Cefepime	9(60.0)	0(0)	0(0)	NA	NA
Ceftazidime	11(73.3)	1(25)	0(0)	NA	NA
Ceftriaxone	12(80.0)	2(50)	0(0)	NA	NA
Ceftriaxone/sulbactam	10(66.7)	3(75)	0(0)	NA	NA
Ciprofloxacin	9(60.0)	0(0)	1(100)	2(28.57)	0(0)
Gentamycin	11(73.33)	1(25)	1(100)	1(14.29)	0(0)
Amikacin	5(33.3)	1(25)	0(0)	1(14.29)	0(0)
Meropenem	0(0.0)	0(0)	0(0)	NA	NA
Piperacillin/tazobactam	8(53.3)	2(50)	0(0)	NA	NA
Vancomycin	NA	NA	NA	0(0.0)	0(0)

KEY: Enterobacterales group comprise of the following bacteria species: -*Escherichia coli*, *Morganella morganii*, *Klebsiella pneumoniae* and *Enterobacter cloacae*

Discussion

The overall incidence of surgical site infections following limb amputations was found to be 30% in two referral hospitals in Mwanza, Tanzania. The current observed prevalence is higher than 21% and 12.5% that were previously reported more than a decade ago by Chalya et al. [4] and Mawalla et al. [15] at the same center following limb amputations, respectively. However, it was lower than what was reported in a Nigerian study which presented an SSI incidence of 58.8% after major limb amputation, however contrary to our study the Nigerian study was a five year retrospective [1].

In the present study, the majority of patients were in their fourth and fifth decades of life, which is consistent with Chalya et al. [4] at BMC and other studies [14, 24], but unlike with a Ghanaian study which reported high median age incidence in the 7th decade [9]. Other studies reported even lower peak age incidence [25]. In this study, age above 65 years was found to be protective factor of development of SSIs following limb amputation with young age group being more likely to develop SSI. This was due to the reason explained above of the majority young age groups having amputation due to trauma (road traffic accidents). Previous studies have documented increased SSI among patients with trauma [11, 14, 26].However, this association is weak due to a p value of 0.043 and wide confidence intervals.

Also, in this study young age were shown to be at high risk of SSIs due to the fact that majority had trauma as indication of amputation.

In keeping with other studies done elsewhere [2, 15], complication of diabetic foot ulcers was the most common indication for limb amputation. These findings are not in agreement with other studies which reported trauma as the most common indication for limb amputation [7, 23]. It has been documented in several studies that approximately 80–90% of limb amputations in developed countries are performed as a result of vascular problems [24, 27]. These differences in the pattern of indications reflect differences in incidences of different pathologies leading to limb amputation which tend to vary from one place to the other. The increased incidence of diabetic foot complications requiring limb amputation may reflect the level of effectiveness of the early detection of diabetes mellitus and the foot at risk, medical education, patient compliance and overall control of diabetes mellitus in this population.

In this study Gram-negative bacteria predominantly *Escherichia coli*(36.7%) and *Pseudomonas aeruginosa* (13.3%) were the most frequently isolated bacteria

Table 5 Distribution of surgical site infections among the study participants

Variables	Surgical Site Infections	
	Yes	No
	n (%)	*n* (%)
Age group (years)		
≤ 45	15(46.9)	17(53.1)
46–65	14(24.6)	43(75.4)
> 65	7(22.6)	24(77.4)
Gender		
Male	16(25.0)	48(75.0)
Female	20(35.7)	36(64.3)
BMI		
< 18.5	19(34.6)	36(65.4)
18.5–24.9	16(26.7)	44(73.3)
≥ 25.0	1(20.0)	4(80.0)
Comorbidity		
No	16(25.4)	47(74.6)
Yes	20(35.09)	37(64.91)
Smoking		
No	28(25.23)	83(74.8)
Yes	8(88.89)	1(11.1)
ASA class score		
I &II	5(14.29)	30(85.7)
III	31(36.47)	54(63.5)
Timing of Surgery		
Emergency	33(29.46)	79(70.54)
Elective	3(37.5)	5(62.5)
Prophylactic antibiotics		
Yes	33(28.95)	81(71.05)
No	3(50)	3(50)
Duration of surgery (hours)		
< 2	20(22.0)	71(78.0)
≥ 2	16(55.2)	13(44.8)
Limb involved		
Upper	5(55.6)	4(44.4)
Lower	31(27.9)	80(72.1)
Amputation type		
Closed	23(30.3)	53(69.7)
Open	13(29.5)	31(70.5)
Blood Transfusion		
No	20(20.6)	77(79.4)
Yes	16(69.6)	7(30.4)

contrary to previous studies done at BMC which demonstrated *Staphylococcus aureus* as the most common organism isolated in SSIs following limb amputation [2, 15]. Findings from this study concurs with a recent study [28] which observed a shifting towards Gram negative bacteria as the commonest pathogens isolated from wound swabs. The predominance of Gram-negative organisms in the postoperative wound infections can be attributed to transmission from health care environment [29].

In line with previous studies [4, 15] done at BMC, the majority of bacteria isolates in this study demonstrated multi drugs resistance phenotypes to commonly prescribed antibiotics such as ciprofloxacin, ampicillin, trimethoprim/sulphamethoxazole, gentamicin, erythromycin and ceftriaxone.

As reported in other reports done elsewhere [2, 14, 15], majority of Gram-negative isolates in this study were sensitive to meropenem while Gram positive bacteria were uniformly sensitive to vancomycin.

In agreement with other studies conducted elsewhere [15, 30], this study observed association between cigarette smoking and increased odds of SSIs development. Cigarette smoking has been reported to have an impact on wound healing through impairment of tissue oxygenation and local hypoxia via vasoconstriction [15, 31]. Additionally, tobacco smoke has high concentrations of carbon monoxide, which binds hemoglobin, forming carboxyhemoglobin which in turn binds to oxygen with high affinity and thereby interferes with normal oxygen delivery to hypoxic tissues [31].

As in the current studies, several studies have shown a strong association between ASA status and SSIs following surgery [15, 27, 32]. ASA classification is a standardized, reproducible numeric determination that has been used to routinely stratify severity of illness for surgical patients and is known to be a good indicator of host susceptibility to infection [15, 33]. The overall poor general health of the study subjects with higher ASA class could be the reason for this association.

In agreement with other studies, this study found that length of surgery > 2 h was associated with increased risk of developing SSI [27]. The increasing length of surgery can lead to higher risk of SSI due to desiccation of tissues, increased bacterial exposure and decreased level of prophylactic antibiotic in the tissues [15, 34]. This finding supports the notion that the administration of an additional dose of antibiotic in lengthy procedures (e.g.>2 h) might be effective in reducing the overall SSI rate [15, 27, 34].

Blood transfusion has been reported in the literature to be associated with SSIs following surgery [3, 35]. Studies have shown that blood transfusion leads to immunomodulation, increased serum iron, and microcirculatory dysfunction, which can cause bacterial overgrowth [3, 36]. Allogeneic blood transfusion induces immunosuppression and predisposes to postoperative infection [36]. In this study, perioperative blood transfusion was significantly associated with SSI following limb amputation. However, potential of contamination due hospital surfaces(settings) surpasses the potential of SSI due to blood infection [29].

Limitations of the study includes failure to perform anaerobic culture that led to inability to establish the

Table 6 Predictors of SSI following major limb amputations

Predictors	Surgical Site Infections		Univariate		Multivariate	
	Yes	No				
	n (%)	n (%)	OR [95% CI]	p-value	OR [95% CI]	p-value
Age group (years)						
≤45	15(46.9)	17(53.1)	Ref			
46–65	14(24.6)	43(75.4)	0.36(0.15–0.93)	**0.034**	0.25(0.06–0.91)	**0.037**
>65	7(22.6)	24(77.4)	0.33(0.11–0.98)	**0.047**	0.21(0.04–0.95)	**0.043**
Gender						
Male	16(25.0)	48(75.0)	Ref			
Female	20(35.7)	36(64.3)	1.6(0.75–3.66)	0.203		
BMI						
<18.5	19(34.6)	36(65.4)	Ref			
18.5–24.9	16(26.7)	44(73.3)	0.68(0.31–1.52)	0.360		
≥25.0	1(20.0)	4(80.0)	0.47(0.04–4.54)	0.517		
Comorbidity						
No	16(25.4)	47(74.6)	Ref			
Yes	20(35.09)	37(64.91)	1.58(0.72–3.48)	0.249		
Smoking						
No	28(25.23)	83(74.8)	Ref			
Yes	8(88.89)	1(11.1)	25(2.85-10.00)	**0.003**	14.3(1.33-10.0)	**0.027**
ASA class score						
I &II	5(14.29)	30(85.7)	Ref			
III	31(36.47)	54(63.5)	3.44(1.21–9.79)	**0.020**	13.3(2.81–63.1)	**0.001**
Timing of Surgery						
Emergency	33(29.46)	79(70.54)				
Elective	3(37.5)	5(62.5)	1.43(0.32–6.35)	0.633		
Prophylactic antibiotics						
Yes	33(28.95)	81(71.05)	Ref			
No	3(50)	3(50)	2.45(0.47–12.78)	0.286		
Duration of surgery (hours)						
<2	20(22.0)	71(78.0)	Ref			
≥2	16(55.2)	13(44.8)	4.36(1.80-10.57)	**0.001**	4.08(1.29–12.9)	**0.016**
Limb involved						
Upper	5(55.6)	4(44.4)	Ref			
Lower	31(27.9)	80(72.1)	0.31(0.07–1.23)	0.096		
Amputation type						
Closed	23(30.3)	53(69.7)	Ref			
Open	13(29.5)	31(70.5)	1.14(0.51–2.56)	0.741		
Blood Transfusion						
No	20(20.6)	77(79.4)	Ref			
Yes	16(69.6)	7(30.4)	3.0(1.10–7.70)	**0.012**	4.0(1.25–12.5)	**0.020**

presence of anaerobic organisms hence underestimate the patterns of the bacteria and the yield of the culture of wound swab. However, the positive rate of the swabs was within the range of previously reported rates. The superficial swab culture results may not always represent the organism's causing infection, particularly in deep wounds. Another limitation is lack of reporting of resistance mechanism proportions in gram negatives (e.g. ampC, ESBL) and Gram-positive organisms (MRSA).

Conclusion and recommendations

This study has demonstrated an increased trend of SSI amongst patients who underwent limb amputation underscoring the need to improve infection prevention and control (IPC) programs in these hospitals. The observed predominance of multi drug resistant (MDR) Gram negative bacteria causing SSI requires strengthening of antimicrobial stewardship and IPC programs in these hospitals and other hospitals in low- and middle-income countries to control emergence and spread of MDR Enterobacterales which have been classified by WHO as critical priority pathogens. Patients with history of cigarette smoking and those with high ASA status, prolonged duration of surgery and blood transfusion should be carefully prepared and managed to ensure the risk of SSI are minimized.

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Author contributions
HH, PLC and conceived and designed the study. HH, VS and HN performed data collection and laboratory procedures. HH, VS and HN analyzed the data. HH and HN drafted the manuscript. MMM, PLC and SEM critically reviewed the manuscripts and responsible for validation. All authors read and approved the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethical approval and consent to participate
Ethical approval for this study was sought was sought from the Joint CUHAS/BMC Research, Ethics and Review Committee (CREC/796/2024). Permission to carry out the study was obtained from the hospital authority (BMC) and Sekou-Toure Regional Referral Hospital.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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