



RESEARCH ARTICLE

Surgical Site Infections in Digestive Surgery: A Meta-Analysis of Hospitals in BBMCH BALANGIR

Sujeet Kumar Bramha^{1*}, Bhanjan Kumar Meher², Sasmita Meher³

ABSTRACT

Objective: To study the characteristics of surgical site infections (SSI) in digestive surgery in BBMCH BALANGIR.

Patients and Methods: This was an analytical, cross-sectional, and multicenter study conducted from March 1 to September 30, 2024, in the digestive surgery departments of GENERAL SURGERY the BBMCH BALANGIR. All hospitalized patients aged at least 18 years who underwent abdominal surgery were included in the study. Patients were followed up within 30 days of surgery. M

Results: During the study period, 493 patients were included, 73 cases of SSI were recorded, representing a frequency of 14.8%. Was the center with the most cases of SSI were found in the university hospital (58 patients or 79.4%). The median age was 41 years. Male sex was predominant with a sex-ratio of 1.35. Among the SSIs, 74% were superficial; 20.5% deep and 5.5% organ. Acute generalized peritonitis was the most common pathology of infected patients (60.3%). Of the 73 samples analyzed, 70 cultures were positive, representing 95.8%. Escherichia coli were the most identified microorganism (36.5%), followed by non-coagulase Staphylococcus (15%) and Klebsiella pneumoniae (12.2%). Multivariate analysis showed that SSI was statistically associated with ASA score, operative mode, and NNISS score.

Conclusion: SSIs represent a major public health problem. Prevention relies on rigorous epidemiological surveillance and compliance with good perioperative hygiene practices.

Keywords: Infections, Surgical site, Digestive surgery, BBMCH BALANGIR

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INTRODUCTION

Surgical Site Infections (SSIs) in Digestive Surgery

Definition and Impact

- **Rank:** Third most common hospital infection; leading infection in surgical patients.
- **Timeline:** Occurs within 48 hours of admission up to 30 days post-surgery (or 1 year with implants).
- **Mortality:** Carries an overall 3% mortality rate.
- **Consequences:** Prolongs hospital stays, strains medical staff, and increases healthcare costs.

Risk Factors

- **Patient-Specific:** Advanced age, poor general health, and immunosuppression.
- **Procedural:** Urgent surgeries, long operative times, non-absorbable sutures, foreign bodies, and hypothermia.
- **Environmental:** Poor hospital hygiene and inadequate operating room conditions.

Transmission and Diagnosis

- **Diagnosis:** Easy for superficial infections; highly

¹Associate Professor, Department of ENT, Bhima Bhoi, Medical college and Hospital, Balangir, Odisha, India.

²Associate Professor, Department of General Surgery, Bhima Bhoi, Medical college and Hospital, Balangir, Odisha, India

³Associate Professor, Department of Pulmonary Medicine, Bhima Bhoi, Medical college and Hospital, Balangir, Odisha, India

Corresponding Author: Sujeet Kumar Bramha, Associate Professor, Department of ENT, Bhima Bhoi, Medical college and Hospital, Balangir, Odisha, India.

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difficult for deep-tissue infections.

- **Microbiology:** Can be monomicrobial or polymicrobial, primarily driven by bacteria.
- **Sources:** Patient skin/mucosa, surgical staff,

contaminated air, droplets, and unsterile instruments.

- **Complication:** Management is increasingly difficult due to growing antibiotic resistance.

Global Prevalence Rates

- **United States:** 0.5% – 3%
- **Europe:** 1.7%
- **China:** 3.18%
- **Saudi Arabia:** 2.5% (orthopedic) to 12.9% (laparotomies)
- **Sub-Saharan Africa:** 6% – 40%
- **Brazzaville, Congo:** 3.1% (digestive surgery, 2021–2023)

Study Objectives

To expand on preliminary data through a multicenter study to:

- **Determine** exact SSI frequency in digestive surgery.
- **Profile** sociodemographic and clinical characteristics of affected patients.
- **Identify** the primary causative bacterial pathogens.
- **Isolate** key risk factors to build evidence-based mitigation strategies.

METHODOLOGY

Type of study

Cross-sectional, multicenter, prospective data collection analytical study.

Framework of the study

The study was carried out from March 1 to September 30, 2024, in BBMCH BALANGIR in the surgical departments of five hospitals: the digestive surgery department of the BBMCH BALANGIR Hospital and four general surgery departments of these referral hospitals. The choice of these hospitals was based on a reasoned method, due to the attendance of these centers by the population and the existence of surgical services in these centers.

Study population

All patients operated on for digestive pathology in the surgical departments of the above-mentioned hospitals, aged at least 18 years regardless of gender and having consented to the study were included in the study.

Non-inclusion Criteria

Patients who have undergone proctological surgery.

Exclusion Criteria

Patient sampling technique was exhaustive and consecutive sampling during the study period. In the general and

digestive surgery departments of the different centers involved in the study, all patients included were divided into two groups: group 1: patients operated on for a digestive condition during the study period and experiencing an SSI; group 2, patients operated on for a digestive pathology during the study period, who did not experience an SSI.

Sample Study

Patients not meeting the inclusion criteria and those lost to follow-up during follow-up.

Data Collection

Patients hospitalized in the surgical department each have a medical record in which all administrative, clinical, paraclinical, diagnostic and therapeutic data are recorded, as well as data from the examination during the checkup. Electronic forms have reduced bias in data entry and facilitated data collection. Information concerning the intraoperative period was taken from the surgical report register and anesthesia sheets.

Study Variables

The dependent variable of the study was SSI. The independent variables included sociodemographic (age, sex, occupation, socioeconomic level), anamnestic, clinical and biological data.

Data Process

The diagnosis of SSI was mentioned by general practitioners and confirmed by surgeons who performed the surgical procedures in the 5 hospitals. The diagnosis of SSI was based on a sample for bacteriological examination with antibiogram. The criteria for judging SSI were those of the CDC ATLANTA of 1992/1999 describing the criteria for the diagnosis of SSI [3]. Patients were seen and examined in hospital and reviewed after discharge, in outpatient consultations on the 15th and 30th day following surgery. Anamnestic and clinical investigation Preoperative data collected were: administrative data, clinical and laboratory information, preoperative diagnosis and treatment, ASA score and NNIS score. Intraoperatively, these were: type of surgery, duration of the procedure, surgical technique used, and treatment received by the patient and the number of people in the operating room. Postoperative data consisted of clinical data on postoperative infection, treatment, length of hospital stay, other complications and patient outcome. Regarding biological data, they were based on cytobacteriological examination of pus and antibiogram of positive results. Pus samples were taken between 8 a.m. and 12 p.m.

Ethical Considerations

The study adhered to rigorous standards throughout. Ethical approval was obtained from the Health Sciences Research Ethics Committee of the General Delegation for Scientific and Technological Research of the Republic of Congo

Data processing and analysis

Data entry was performed using Epi-data software, version 3.0. The database was cleaned on an Excel page (xls) and analyzed using PASW Statistic 18.0 software. Categorical variables are presented as frequencies and percentages. Statistical analyses, including the Sokal and Rohlf S test and the Chi-square test, were used to determine the association between qualitative variables. To establish the association between SSIs and environmental, clinical, and personal factors, simple and adjusted odds ratios (OR) (logistic regression) were calculated. Factors associated with SSI were considered as: risk factors when $OR > 1$ and the 95% confidence interval did not include 1; protective factors when $OR < 1$ and the 95% confidence interval did not include 1; there was no association when $OR = 1$. Furthermore, a multivariate logistic regression was also considered when at least three (03) factors were statistically associated with SSI in the context of a crossover with two variables using the Chi2 test. Logistic regression made it possible to eliminate confounding factors and establish a parsimonious model where all explanatory variables (x) explain the model (y). The test was statistically significant when the p-value was strictly less than 0.05 ($p < 0.05$).

RESULTS

Epidemiological Aspects

During our study, we found 73 cases of SSI in 493 surgical procedures, representing a frequency of 14.8%. These were 42 men (57.5%) and 31 women (42.5%) (sex ratio, 1.35). Sociodemographic aspects The distribution of SSIs by center is shown in Figure 1. Their median age was 41 years ($Q1 = 29$ years; $Q3 = 55$ years) (range: 18-78 years). Among the 73 patients with SSI, 35 (48%) were from the informal sector, 21 (28.7%) were from the formal sector and 17 (23.3%) were unemployed. Regarding the economic level, 40 (55%) of them had a medium economic level, 22 (30%) a high economic level and 11 (15%) a low economic level. Clinical aspects The preoperative clinical picture of infected patients was generalized acute peritonitis in 60.3% of cases (Table 1). Among the 73 patients presenting with SSI, we found 60 cases of emergency surgical interventions, i.e. 82.2%, and 13 cases of scheduled surgical interventions (scheduled surgery) (17.8%).

As for the duration of preoperative hospitalization, in 75% of cases patients were operated on the same day, 15% between 2-7 days and 10% for durations greater than or equal to 8 days.

Regarding the preoperative bath, 61 (83.6%) did not take one compared to 12 (16.4%) who did. The duration of surgical intervention in infected patients was more than one hour in 66 cases (90.4%), and at most one hour in 7 cases (9.6%). As for drainage, sixty-eight infected patients (93.2%) had a drain, while 5 patients (6.8%) had not had one.

Figure 2 shows the distribution of infected patients according to ASA score.

Regarding the type of digestive surgery, it was considered dirty in 71.2% of infected patients. Regarding the NNISS

score, among the 73 infected patients, 10 of them (13.7%) presented an NNISS score of 3 (Figure 3). The median time to onset of SSI was 4 days ($Q1 = 4$ days; $Q3 = 5$ days) (range: 3-18 days). Regarding the location of SSI onset, 67 patients (91.8%) experienced SSI during hospitalization, 6 (8.2%) after hospital discharge. Table 2 highlights the mode of diagnosis of SSI. SSIs were superficial in 74% of infected patients (Figure 4a), deep in 20.5% (Figure 4b) and organ-related in 5.5%. Bacteriological aspects Bacteriological analysis, which resulted in 70 positive cultures and 3 sterile cultures, identified 74 germs (Table 3). Polymicrobial associations included: *Escherichia coli* + *Staphylococcus aureus*; *Klebsiella pneumoniae* + non-coagulase *Staphylococcus*; *Proteus vulgaris* + non-coagulase *Staphylococcus*. The antibiogram identified eleven SSIIlated germs (Table 4). In addition, we identified a non-albicans candida fungus. It was sensitive to econazole and miconazole and resistant to itraconazole. Therapeutic aspects All patients with an SSI received local care (daily or twice-daily dressing)

Table 1: Distribution of patients with SSI according to the preoperative clinical picture.

Clinical picture	Effective	Percentage (%)
Acute generalized peritonitis	44	60.3
Tumor pathologies	8	11
Intestinal obstructions	7	9.6
Abdominal trauma	5	6.8
Acute appendicitis	4	5.5
Eversionation	3	4.1
Hernias	2	2.7
Total	73	100

: $p < 0.05$

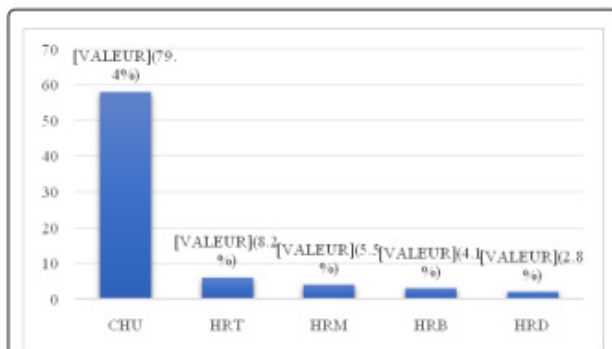


Figure 1: Distribution of SSIs by center.

CHU: University Hospital Center; TRH: Talangai Reference Hospital; MRH: Makélékélé Reference Hospital; BRH: Baongo Reference Hospital; DRH: Djiri Reference Hospital

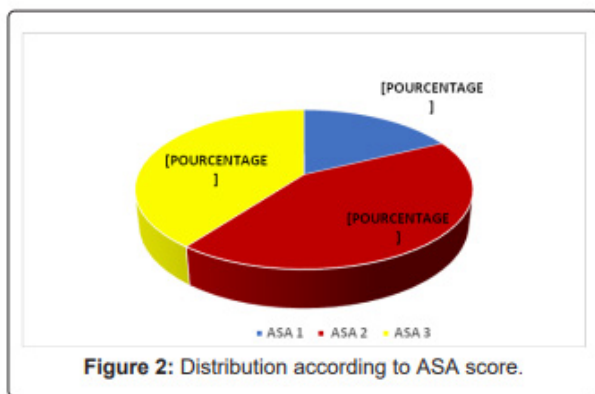


Figure 2: Distribution according to ASA score.

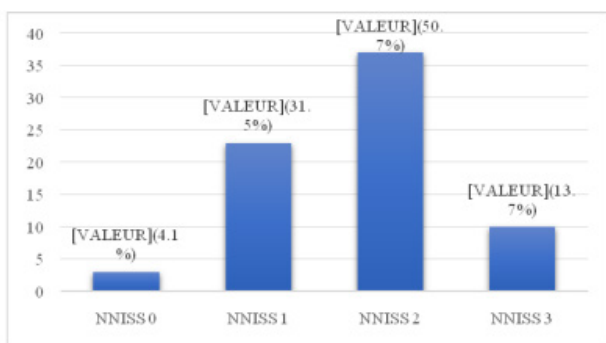


Figure 3: Distribution according to NNIS score.

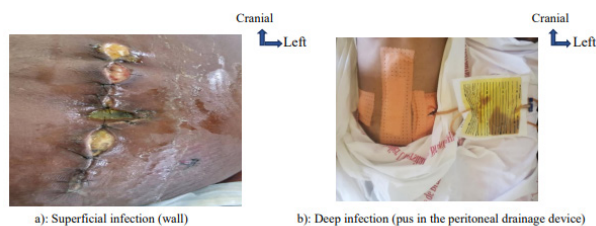


Figure 4: Type of infection.

Table 2: Distribution according to the method of diagnosis of SSIs.

Diagnostic mode	Effective	Percentage (%)
Discharge of pus	49	67.1
Discharge of pus + fever	20	27.4
Pus in the drain	4	5.5
Total	73	100

Table 3: Germ distribution.

Germ	Effective	Percentage (%)
<i>Escherichia coli</i>	27	36.5
<i>Non-coagulase Staphylococcus</i>	11	15
<i>Klebsiella pneumoniae</i>	9	12.2
<i>Staphylococcus aureus</i>	7	9.5
<i>Klebsiella oxytoca</i>	4	5.4
<i>Enterobacter cloacae</i>	4	5.4
<i>Enterobacter agglomerans</i>	2	2.7
<i>Enterococcus spp</i>	2	2.7
<i>Pseudomonas aeruginosa</i>	2	2.7
<i>Citrobacter spp</i>	2	2.7
<i>Citrobacter freundii</i>	1	1.3
<i>Citrobacter diversus</i>	1	1.3
<i>Candida non-albicans</i>	1	1.3
<i>Proteus vulgaris</i>	1	1.3
Total	74	100

Table 4: Antibiogram.

Antibiotics	Germ										
	<i>E. coli</i>	<i>S. non-coagulase</i>	<i>K. pneumoniae</i>	<i>S. aureus</i>	<i>K. oxytoca</i>	<i>Enterobacter cloacae</i>	<i>Enterobacter agglomerans</i>	<i>Enterococcus spp</i>	<i>P. aeruginosa</i>	<i>Citrobacter</i>	<i>Proteus</i>
	N = 27	N = 11	N = 9	N = 7	N = 4	N = 4	N = 2	N = 2	N = 2	N = 4	N = 1
Ampicillin	0 (22)	0 (6)	0 (6)	1 (2)	0 (2)	0 (2)	0 (1)	2 (0)	0 (2)	0 (1)	0 (1)
Amoxicillin	4 (2)	3 (0)	0 (6)	6 (0)	0 (2)				0 (2)	1 (2)	
Amoxicillin-clavulanic acid	4 (18)	2 (7)	0 (3)			0 (4)			0 (2)	2 (1)	0 (1)
Oxacillin	0 (4)	4 (6)	1 (0)	2 (4)							
Piperacillin/Tazobactam	2 (6)	0 (2)	0 (1)		0 (2)	0 (2)			0 (2)	1 (2)	
Imipenem	10 (6)	2 (0)	1 (0)								1 (0)
Meropenem	11 (3)	2 (0)	2 (4)		2 (0)	4 (0)	2 (0)	2 (0)	0 (2)	1 (1)	1 (0)
Cefotaxime	0 (10)	0 (5)	0 (2)		0 (3)	0 (2)				0 (4)	
Ceftazidime	0 (20)	2 (6)	0 (3)		1 (2)	0 (4)			2 (0)	2 (2)	0 (1)
Ceftioxcone			0 (1)				0 (1)				
Ciprofloxacin	2 (25)	4 (6)	4 (4)		2 (1)	0 (2)	2 (0)	2 (0)	0 (2)	1 (3)	0 (1)
Levofloxacin	1 (5)	2 (0)	0 (2)		0 (2)		0 (2)		0 (2)	0 (4)	
Fosfomycin	2 (0)	1 (0)			1 (0)		2 (0)				
Gentamycin	13 (7)	6 (2)	6 (1)	5 (0)	0 (3)	0 (4)			0 (2)	0 (4)	
Amikacin	5 (2)	4 (0)	3 (2)		1 (2)	2 (0)			1 (0)	2 (0)	1 (0)
Erythromycin	0 (5)	2 (6)	0 (1)				2 (0)				
Tobramycin	4 (4)	2 (0)	3 (1)		0 (2)	0 (2)			0 (2)	0 (2)	
Nalidixic acid	0 (15)	3 (6)	2 (4)		1 (2)				0 (2)	0 (4)	
Bactrim/Trimetoprim/ Sulfamethoxazole	0 (20)			0 (4)	0 (3)	0 (4)			0 (2)	0 (4)	0 (1)

Table 5: Predictive factors associated with SSI.

Variables	GOLD	IC	p value
ASA score 2	4.03	[1.35-12.97]	0.014
ASA score 3	50.16	[6.06-700]	0.001
Operating mode	3.01	[9.65-10.23]	0.036
NNIS Score 1	9.45	[1.08-108.6]	0.049
NNIS Score 2	43	[4.02-580]	0.002
NNIS Score 3	104	[5.92-2635]	0.002

and probabilistic antibiotic therapy, secondarily adapted to the results of the antibiogram. Six patients underwent further surgery. Evolutionary features The median length of hospital stay was 12 days (Q 1 = 7 days; Q 3 = 21 days) for patients with SSIs, compared to 5 days (Q 1 = 3 days; Q 3 = 7 days) for those without SSIs. We found 7 deaths among the 73 patients with SSIs (9.5%). Multivariate analysis Multivariate analysis after logistic regression determined the following predictive factors for SSI: ASA score, operating mode and NNIS score (Table 5). The first number = number of strains sensitive to the antibiotic in question. The number in parentheses = number of resistant strains (resistant strains + strains of intermediate sensitivity) Most SSI patients had ASA 2 (42.5%) and ASA 3 (39.7%) scores. Emergency surgery patients (82.2%; p = 0.019) developed more SSIs. In addition, we found an increased risk of SSI with increasing NNIS score (NNIS 1: p = 0.049; NNIS 2: p = 0.049; NNIS 3: p = 0.049).

DISCUSSIONS

Our results mainly showed that out of 493 abdominal surgical procedures performed in the surgical departments of 6 hospitals in Brazzaville, 73 patients developed an SSI. The study highlighted the link between SSI and sociodemographic characteristics, clinical, bacteriological, therapeutic and evolutionary aspects.

FREQUENCY

The frequency of SSI in our study was 14.8%. It is close to those found in Mali [25], Togo [21] and Senegal [27] which are respectively 10.9%; 11% and 13.6%. However, this rate is much lower in developed countries. It is around 1.7% in Europe [17], 3.18% in China [19] and varies between 0.5 and 3% in the USA [18]. Since SSI is multifactorial, this difference can be explained by less invasive therapeutic innovations in developed countries with the laparoscopic approach reducing their SSI rate and the mandatory preparation of the patient (bath). On the other hand, in Africa due to the weakness of the technical platform, laparotomy is frequently performed with a longer hospital stay. We also note the promiscuity in the hospitalization rooms, the lack of dressing materials, the insufficiency of hospital linen (sheets, clothes), which means that each patient uses what they have. Most often, a sheet is used for several days without being changed. Nurses sometimes move from a septic wound to a clean wound during dressings. Insufficient preparation of emergency operated patients is found, as well as the lack of rigor in asepsis and antisepsis measures and the precarious state of the technical installations in the operating room.

Distribution of SSIs by hospital

CHU was the center most affected by SSIs (79.4%). This could be explained by the fact that it represents the largest hospital center in the city and performs the greatest number of interventions. Due to budget cuts and the significant decrease in funds allocated to the optimal functioning of operating theaters in recent years, rigorous and periodic surveillance of nosocomial infections must be an absolute priority.

Sociodemographic aspects

The median age is 41 years. Our results are similar to those found by other African authors [25,28,29]. On the other hand, Pivot, et al. [30] in France estimate that SSI occurs frequently at advanced ages with an average age of 54 years. This difference is explained by the aging of the European population, aging leading to a decline in immunity. We

found a male predominance in our series. Bengaly, et al. [31] report the same result as us, with a sex ratio of 1.66.

Clinical aspects

Acute generalized peritonitis represents the first digestive pathology responsible for SSI in our work. These results are similar to those described in the literature [25,26,29]. This can be explained by the fact that it is a dirty surgery with a significant risk of contamination of the wall. In addition, when the lavage is not effective, there is a risk of formation of a residual collection.

Acute generalized peritonitis is followed in our study of tumor and occlusive pathologies. Tumors and occlusions are the pathologies for which a digestive stoma was performed intraoperatively in the majority of cases. Poor management of the stoma (defect and/or non-device due to lack of financial means) by patients and their entourage could explain the occurrence of SSI. The mean time to onset of SSI of 5 days in our study is similar to those reported in the African literature [26,28,31], varying between 5 and 10 days.

This mean time to onset is explained by the incubation time and the inflammatory process but also the high percentage of interventions that are part of dirty and contaminated surgery. The superficial site was the most frequent location of SSIs during our study, 74%. This rate is close to those reported by the ECDC [17] and Note, et al. [26]. In contrast, Mahamadou and al [37] in Niger on a work carried out in three departments (digestive surgery, urology and orthopedics) found a higher rate for the deep seat. This difference can be explained by the multidisciplinary of his study.

Bacteriological aspects

Escherichia coli was the dominant germ as revealed in several works [8,29,30]. It is a commensal germ of the digestive tract that can infect the abdominal wall through the stoma and by direct contamination of the peritoneal cavity following perforation of the digestive tract. Regarding the antibiogram, it was found to be sensitive to Meropenem and Imipenem, which is in accordance with the study of Tririsha, et al. [33] in India. We have observed resistance of germs to the majority of antibiotics. This can be explained by the misuse of antibiotics as well as self-medication. Indeed, so-called blanket antibiotic therapy does not reduce SSIs but, on the contrary, promotes bacterial resistance to antibiotics by selecting resistant mutants.

Evolutionary aspects

The median length of hospitalization was 12 days for

infected patients. This duration is relatively short compared to those of Diarra and al. [25] in Mali, Note, et al. [26] in Congo who obtained 21 and 19 days respectively. This difference could be explained by prolonged parenteral antibiotic therapy and close local care (twice daily) in case of SSI. The overall case fatality rate in our series was 9.5%. Note, et al. [26] in Congo reported a case fatality rate of 12.5%. These results are close to ours

Associated factors

Multivariate analysis allowed us to establish a predictive model for SSI. The predictive factors retained after logistic regression were: ASA score, operating mode and drain placement. We found an increase in the SSI rate with the ASA score ($p = 0.0000$). Bengaly, et al. [31] in Mali, Karima, et al. [32] in Morocco, Rattatsoa, et al. [38] in Madagascar, Astagneau, et al. [35] in France, also consider the ASA score as a factor influencing the occurrence of SSI. The severity of pre-existing pathologies would explain this. Furthermore, patients operated on in emergency developed SSI the most

Mahamadou, et al. [37] in Niger as well as Note, et al. [26] in Congo made the same observation. Similarly, emergency interventions influence the occurrence of SSI in our study as in those of Diarra, et al. [25] in Mali and Flouchi [35] in Morocco. The lack of preparation (bathing) of patients in the emergency room could explain this.

The NNIS score assesses the risk of acquiring a postoperative infection. The SSI rate stratified on the NNIS index was 4.1% (NNIS = 0); 31.5% (NNIS = 1); 50.7% (NNIS = 2) and 13.7% (NNIS = 3). During our study we recorded twelve (12) patients with a NNIS score of 3, ten of whom presented an SSI. We found an increased risk of SSI with NNIS score. This result corroborates with the data of Escutnair, et al. [36].

The NNIS score is multifactorial. It is obtained by combining the following three risk factors: duration of the procedure, the patient's ASA score and the ALTMEIER contamination class. The parameters constituting this score could explain the increased risk of SSI occurrence. Indeed, the extension of the duration of the procedure exposes patients to the risk of contamination of the surgical site. In addition, the existence and severity of underlying pathologies would increase the risk of SSI occurrence. Finally, the dirtier the surgery, the higher the risk of SSI occurrence [9,34] due to contamination of the wall and cavities during the procedure.

Limitations and strengths of study

Our study of SSIs in digestive surgery in Brazzaville was

conducted in the general surgery departments of four referral hospitals and the digestive surgery department Hospital. These five departments are in fact the departments responsible for digestive surgical pathologies. Note, et al. [26] conducted a single-center study on SSIs. We believe that the multicenter nature of this study provides a comprehensive view of SSIs in digestive surgery. The prospective data collection of this study ensures good quality of our results. The collection of information is contemporary with the events described. The exhaustive sampling allowed us to include 493 patients. Mahamadou, et al. [37], Kanassoua, et al. [21,38] report samples of 485 and 271 patients respectively. Electronic forms reduced bias in data entry and facilitated data collection. However, the period of our study constitutes a bias in the diagnosis of SSIs in patients wearing prostheses. Indeed, SSIs can occur up to one year after the placement of prosthesis.

CONCLUSION

SSIs are common in digestive surgery in BBMCH BALANGIR. The median age is 41 years, with a male predominance. These are mostly early and superficial SSIs. *Escherichia coli*, noncoagulase *Staphylococcus*, and *Klebsiella pneumoniae* are the most SSIs-related bacteria. SSIs were influenced by the ASA score, the surgical procedure (emergency), and the NNIS score. Despite appropriate antibiotic therapy, local care, and surgical reintervention in severe cases, SSIs still carry significant morbidity and mortality. Prevention relies on rigorous epidemiological surveillance and adherence to good perioperative hygiene practices.

CONFLICTS OF INTEREST

None.

AUTHORS' CONTRIBUTION

MMD designed and developed the study. Data collection was performed by BB MCH, EOP, NMC, TWNG, and TR. MMD and NMMEDJ analyzed and interpreted the results. MMD, NMMEDJ, and MA prepared the draft manuscript. All authors reviewed the results and approved the final version of the manuscript.

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