

# Surgical Site Infection in the Surgery Department of the University Clinics of Kisangani: Epidemiological, Bacteriological, and Antibiotic Resistance Aspects

Asaph Bwini Dianaben<sup>1,2\*</sup>, Felly Kanyinda Ciamala<sup>1,3</sup>, François Pikazio Mawa<sup>2</sup>,  
Ralph Munsense Tshiyombo<sup>1,4</sup>, Moïse Kasongo Madibulaya<sup>5</sup>, Roger Amisi Kitoko<sup>1</sup>,  
Freddy Wami W'Ifongo<sup>1</sup>, Flavien Adipepe Bekale<sup>1</sup>, Jean-Marie Vianney Tshimbila Kabangu<sup>1</sup>

<sup>1</sup>Department of Surgery, Faculty of Medicine and Pharmacy, University of Kisangani, Kisangani, Democratic Republic of the Congo

<sup>2</sup>Department of Surgery, Faculty of Medicine, University of KIKWIT, Kikwit, Democratic Republic of the Congo

<sup>3</sup>Department of Surgery, Faculty of Medicine and Pharmacy, University of MBUJI-MAYI, Mbuji-Mayi, Democratic Republic of the Congo

<sup>4</sup>Military Hospital of the Third Defense Zone (MH3DefZ), Kisangani, Democratic Republic of Congo

<sup>5</sup>Department of Surgery, Faculty of Medicine, University of Kinshasa, Kinshasa, Democratic Republic of the Congo

Email: \*asaphbwini@gmail.com

**How to cite this paper:** Dianaben, A.B., Ciamala, F.K., Mawa, F.P., Tshiyombo, R.M., Madibulaya, M.K., Kitoko, R.A., W'Ifongo, F.W., Bekale, F.A. and Kabangu, J.-M.V.T. (2025) Surgical Site Infection in the Surgery Department of the University Clinics of Kisangani: Epidemiological, Bacteriological, and Antibiotic Resistance Aspects. *Journal of Biosciences and Medicines*, 13, 94-107.

<https://doi.org/10.4236/jbm.2025.1312008>

**Received:** October 31, 2025

**Accepted:** December 2, 2025

**Published:** December 5, 2025

Copyright © 2025 by author(s) and Scientific Research Publishing Inc.  
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

## Abstract

Surgical Site Infection (SSI) is a nosocomial infection occurring at the surgical wound site within 30 days post-operatively or within one year in the case of implanted material. The overall objective of this study was to investigate the epidemiological and bacteriological aspects and the antibiotic resistance of germs in patients who developed surgical site infections during their hospitalization in the surgery department of the Kisangani University Clinics in order to improve patient care. **Materials and Methods:** This was a descriptive cross-sectional study with retrospective data collection over a period of seven years (from 1 January 2018 to 31 December 2024). It covered 74 cases of SSI with bacteriological results documented in their records. The sample was non-probabilistic and convenience-based. **Results:** Out of a total of 713 files collected from patients operated on for various conditions in different departments of the Surgery Department of the Kisangani University Clinics, 86 cases of SSI were recorded, representing a hospital prevalence of 12.06%. The most affected age group was between 21 and 30 years old, with a mean age of 45.25 ± 19.24 years. Males were predominant. A total of 79 bacteria were isolated, with 5 cases of infection caused by 2 bacteria. *Staphylococcus aureus* was predominant with 41.7%, followed by *Escherichia coli* with 17.7% and *Citrobacter*

*diversus* with 11.4%. The sensitivity study showed reduced sensitivity to commonly used antibiotics. **Conclusion:** *Staphylococcus aureus* was the most commonly found bacterium at 41.7%, followed by *E. coli* at 17.7%, and a significant rate of multi-resistant bacteria to commonly used antibiotics was noted.

## Keywords

Infection, Surgical Site, Bacterial Epidemiology, Antibiotic Resistance

---

## 1. Introduction

Surgical Site Infection (SSI) is a nosocomial infection occurring at the surgical wound site within 30 days postoperatively or within one year in the case of implanted devices [1] [2].

Surgical site infection is the third most common nosocomial infection after urinary tract and respiratory tract infections [1] [2]. Despite advances in surgical care, perioperative asepsis, and antibiotic therapy, SSI remains a major public health problem because it can increase antibiotic resistance and healthcare costs, prolong hospital stays, and increase morbidity and mortality [1] [3]. It is a disaster in surgery, as it can ruin the benefits of an operation aimed at improving joint function or repairing trauma [4]. Many factors contribute to its occurrence, some related to the patient, others to the patient's immediate environment (operating theatre, air quality, hygiene of the surgical team and caregivers), and still others to the surgical procedure [4]. Poor management of biomedical waste is thought to be responsible for surgical site infections caused by antibiotic-resistant bacteria [5] [6]. Many studies have identified a number of independent factors that promote the occurrence of SSI, namely diabetes, revision surgery (reoperation), long-term surgery, advanced age, obesity, and incorrect or absent antibiotic prophylaxis [7]. For effective management, it is essential to know the causative organism and its sensitivity to antibiotics [8]. Broad-spectrum probabilistic antibiotic therapy is often necessary, but unfortunately, this approach exposes the patient to the selection of resistant bacteria and has consequences for the bacterial ecology of the ward [8].

The incidence of SSI in developed countries varies from 0.7% to 5%, reaching up to 33% in cases of abdominal surgery [1] [2]. In the United States, SSI accounts for 14% to 16% of all nosocomial infections, making it the second most frequently reported cause after urinary tract infection. It is estimated that 2% to 5% of patients who undergo surgery develop SSI. This depends on patient-related factors (comorbidities), the surgical procedure (type of operation, duration of the operation), and environmental and organizational factors [9] [10].

In Canada, more than 40 hospitals submitted data between 2009 and 2018 on hip and knee surgical site infections, cerebrospinal fluid shunt surgical site infections, and pediatric cardiac surgical site infections. Overall, 4599 pathogens were

detected from surgical site infections. Coagulase-negative *Staphylococci* (29%) and *Staphylococcus aureus* (14%) were the most frequently reported organisms [11].

In France, surveillance of 95,388 procedures revealed 1560 SSIs, representing an incidence of 1.64% occurring within 17 days after surgery [12] [13]. The risk factors for SSI are well identified as the type of surgery according to the Altemeier classification, the duration of the procedure, and the condition of the patient undergoing surgery, often represented by the ASA class. In the absence of risk factors, the incidence of SSI decreases to 0.72% [12] [14]. The European Surveillance Network has identified the three bacteria mainly involved in surgical site infections of all types, regardless of the area of intervention: *Enterococcus sp.* (17.6%), *Escherichia coli* (17.2%), and *Staphylococcus aureus* (15.2%) [12] [13]. In France, data from the Network for the Surveillance and Prevention of Infectious Risk in Surgery show that in 2021, an enterobacterium was found in 31% of SSI cases (including *Escherichia coli* in 14.3% of cases) and a Gram-positive coccus in 53% (*Staphylococcus aureus* 21.9%, *Staphylococcus epidermidis* 10.2%, and *Enterococcus faecalis* 9%) [12] [13]. *Enterobacteria* and *enterococci* are more often responsible for SSI after digestive surgery, while staphylococci are more common in orthopedics and traumatology [12].

In sub-Saharan Africa, SSI is common, with prevalence varying from 6% to over 40% depending on the case [15]. In Mali, the WHO estimates that an average of 240 million patients contract a surgical site infection, with approximately 1 million of them dying each year from this infection [16]. A study conducted by Bengali *et al.* on surgical site infections in B surgery at the Point G University Hospital found an overall prevalence of SSI of 4.74%. It identified the following germs in order of frequency: *Escherichia coli*, *Staphylococcus aureus*, *Acinetobacter baumannii*, and *Enterococcus spp.* The frequency of germs responsible for surgical site infections depends on the working environment, the rigor of asepsis, and the type of surgery [16].

At the National Surgery Department in Niamey, Ousmane A. *et al.* conducted a study on the bacteriological aspects of surgical site infections. Bacteriological analyses isolated 126 bacterial strains, predominantly *S. aureus* (n = 39, 31%), followed by *Escherichia coli* (n = 29, 23%) and *Pseudomonas aeruginosa* (n = 12, 9.5%). The *Escherichia coli* strains were 100% sensitive to imipenem. They showed marked resistance to ampicillin, amoxicillin, clavulanic acid, and ticarcillin. They showed variable resistance to aminoglycosides (62% to gentamicin and 78% to amikacin) and fluoroquinolones (nalidixic acid 74%, pefloxacin 33%, ofloxacin 69%, ciprofloxacin 61%). All Enterobacteriaceae isolates were sensitive to imipenem. *S. aureus* strains showed resistance to penicillin G (88.6%) and oxacillin (83%) [17]. In the DRC, the prevalence of surgical site infection reported at Panzi Hospital in Bukavu in 2024 by Lungere *et al.* was 8.8% [18]. The isolated germs were, in order of frequency: *E. coli*, in all departments, *Klebsiella pneumoniae*, and *Staphylococcus spp.*, with a high prevalence in digestive surgery [18].

Despite the efforts made, controlling resistant bacterial infections remains a national and international challenge. In 2017, the World Health Organization (WHO) updated its list of priority resistant bacteria for research and development of new antibiotics, based on their prevalence, impact on health, evolution over the past decade, transmissibility, and treatability, among other factors [19].

Several factors contribute to the increase in the frequency of ISO and antibiotic resistance in the DRC. In addition to those common to the rest of the world, these include a lack of regulation in this area, poor diagnostic tools, the precariousness of the health system, and a shortage of qualified human resources for laboratory diagnosis [20]. The precarious nature of hospital waste management, especially biomedical waste, and the lack of laminar flow are major public health problems [5] [6]. Socio-economic conditions, poor hospital hygiene, the surgical environment, the behavior of operating theatre staff and dressing personnel, self-medication, probabilistic antibiotic therapy, the use of poor-quality antibiotics, and the indiscriminate use of antibiotics promote the emergence of bacterial resistance. The excessive, often incorrect and irrational prescription of antibiotics, underdosing, and the growing number of unqualified prescribers have led to multiple resistances and increased surgical site infections caused by germs resistant to commonly used antibiotics [21]-[23]. The shortage of consumables for bacteriological tests, particularly cultures and antibiograms, makes it difficult, if not impossible, to administer appropriate and adequate antibiotic therapy. The lack of electricity seriously hinders the functioning of our laboratories and sterilization equipment, which are needed to better manage infections [21] [23]. The overall objective of this study is to examine the epidemiological and bacteriological aspects of surgical site infection and determine the resistance of germs to antibiotics commonly used in the Department of Surgery at the Kisangani University Clinics in order to improve patient care.

## **2. Materials and Methods**

### **2.1. Study Setting**

Our study was conducted at the Department of Surgery of the Kisangani University Clinics (CUKIS).

#### **2.1.1. Geographical Location of the Kisangani University Clinics**

The Kisangani University Clinics (CUKIS), the setting for our study, are a tertiary-level medical facility in the province of Tshopo and the city of Kisangani, the capital of the province of Tshopo in the Democratic Republic of Congo. They are located on Munyororo Avenue, in the Plateau Medical district of the commune of Makiso.

#### **2.1.2. Study Population**

The population for this study consisted of all patients who underwent surgery in various departments of the surgery department at the Kisangani University Clinics (Cukis). During our study period, 713 patients underwent surgery in various

departments of the Cukis Surgery Department.

### **2.1.3. Sample**

Our sample consisted of patients who underwent surgery in various departments of the surgery department at Kisangani University Clinics and who developed a Surgical Site Infection (SSI) during their hospital stay. Of the 713 patients who underwent surgery during our study period, 86 developed an SSI during their hospital stay.

### **2.1.4. Study Period**

Data collection took place over a period of seven years, from 1 January 2018 to 31 December 2024.

## **2.2. Methods**

### **2.2.1. Type of Study**

This was a descriptive, cross-sectional study with retrospective data collection.

### **2.2.2. Sampling Technique**

This was a non-probabilistic convenience sample consisting of a review of patient records, hospitalization registers, and bacteriology laboratory registers that were made available to us.

### **2.2.3. Selection Criteria**

#### **a) Inclusion criteria**

The following were included in this study:

Any patient operated on in the Surgery Department of the Kisangani University Clinics during the study period who had a Surgical Site Infection (SSI) with well-documented positive bacteriological results, including Gram stain, culture, and antibiogram results. Thus, out of 86 patients who developed SSI during their hospital stay, 74 patients met the inclusion criteria.

#### **b) Exclusion criteria**

The following were not included in this study:

Any patients operated on in the Surgery Department of the University Clinics of Kisangani during the period of our study who presented clinical signs of surgical site infection during their hospitalization and who did not have documented bacteriological results.

### **2.2.4. Data Collection Technique**

This involved a documentary analysis technique. It consisted of reviewing patient files, patient hospitalization records, doctors' duty logs, operating theatre registers, anesthetists' registers, surgical protocol registers, and bacteriology laboratory registers that were made available to us and contained the study parameters sought according to the study's inclusion criteria.

### **2.2.5. Study Variables**

Sociodemographic data: age, gender, residence, occupation, marital status.

Admission method: emergency, outpatient consultation, or transfer.

Clinical data: complaint, medical history, locoregional physical signs, and admission diagnosis.

Paraclinical data: biology (Hb, Hct, GS and Rhesus factor, GB, FL, VS); bacteriology (Gram stain, culture and antibiogram); radiography; therapeutic data: Treatment: probabilistic antibiotic therapy initiated, its duration, and surgical treatment received.

Progression: onset of infection, time between surgery and the onset of infection.

Final outcome after antibiotic treatment based on the results of the antibiogram.

#### **2.2.6. Sampling and Antibiogram**

Samples were taken either by syringe puncture if there was abundant suppuration, or by swabbing for minimal suppuration of the wound. They were taken under strictly aseptic conditions in hospital wards. The identification and sensitivity of the germs were assessed based on the culture and antibiogram results provided by the laboratories of the Kisangani University Clinics and EMA ESU. Microscopic examination: for each sample, direct observation without staining was performed to look for cellular elements (leukocytes, red blood cells, and bacteria). Examination after staining: with the suppuration fluid, an initial smear was made and then stained with May Grunwald Giemsa (MGG). Subsequently, quantitative and qualitative cytology of the leukocyte elements was performed through microscopic observation. Another smear was prepared and stained with Gram stain to determine the bacterial morphology and its dye affinity with gentian violet and fuchsin. If the bacteria stain purple, they are Gram-positive. However, if the bacteria stain pink, they are Gram-negative. The results of Gram staining guide the subsequent bacteriological treatment of the sample, particularly in the choice of culture media. Culture: each sample was seeded on ordinary agar, fresh blood agar, Mannitol Salt Agar (MSA), and MacConkey agar, and incubated at 37°C for 18 to 24 hours. An antibiogram was performed in the event of a positive culture on Mueller-Hinton Agar using the diffusion method with a bacterial suspension of 0.5 turbidity according to the MacFarland scale. Antibiotic discs measuring 5 mm to 10 mm were used.

#### **2.2.7. Data Analysis Technique**

Our data were collected and recorded in Microsoft Excel 2020 and analysed using R software version; we calculated percentages to analyse our qualitative variable, the mean and standard deviation for our symmetrically distributed quantitative variables, and the median for our non-symmetrically distributed quantitative variables. The results are presented in tables.

### **3. Results**

#### **3.1. Epidemiological Aspect**

During this period, 713 patients underwent surgery, and 86 suspected cases of SSI

were diagnosed, representing a prevalence of 12.06%. However, 74 cases of SSI had positive and documented bacteriological results. The sample consisted of 55 men and 19 women, representing a sex ratio of 2.89 in favor of men. The average age was  $45.25 \pm 19.24$ , with extremes of 0 and 83 years. Emergency surgery was performed in 85.1% of cases. Surgical procedures were classified into four groups according to Altemeier and are shown in **Table 1**.

**Table 1.** Distribution of cases according to Altemeier's classification.

| ALTEMEIER class               | NUMBER    | Percentage   |
|-------------------------------|-----------|--------------|
| Clean Surgery I               | 22        | 29.7         |
| Clean-Contaminated Surgery II | 9         | 12.2         |
| Contaminated Surgery III      | 10        | 13.5         |
| Surgery Room IV               | 33        | 44.6         |
| <b>TOTAL</b>                  | <b>74</b> | <b>100.0</b> |

Chi-square = 20.7; ddl = 3; p-value = 0.000.

Analysis of this table shows that class IV was the most represented, with 33 cases (44.6%). The difference in frequency between classes is statistically significant.

Patients were classified according to ASA class in **Table 2**.

**Table 2.** Distribution of cases according to ASA class.

| ASA class    | NUMBER    | Percentage   |
|--------------|-----------|--------------|
| I            | 14        | 18.9         |
| II           | 60        | 81.1         |
| <b>TOTAL</b> | <b>74</b> | <b>100.0</b> |

Chi-square = 24.4; ddl = 1; p-value = 0.000.

This table shows that class II is predominant, with 60 cases (81.1%). The difference in frequency between classes is statistically significant.

Suppuration was more prevalent in patients between the 5th and 10th days after surgery in 54 cases (73%). Probabilistic antibiotic therapy in the department consisted of metronidazole in combination with ceftriaxone or ciprofloxacin in 93.2% of cases, and ceftriaxone in 86.5% of cases.

### 3.2. Bacteriological Findings

Of the 74 samples, 79 germs were isolated, including 69 single-microbe cultures and 5 polymicrobial cultures with 2 germs. The germs identified according to surgical departments are shown in **Table 3** and **Table 4**, the multi-resistant germs are shown in **Table 5**, and the overall antibiogram for the department is shown in **Table 6** and **Table 7**.

**Table 3.** Distribution of cases according to identified germs 79.

| Germ                          | Number | Percentage |
|-------------------------------|--------|------------|
| <b>Gram positive</b>          |        |            |
| <i>Staphylococcus aureus</i>  | 33     | 41.7       |
| <b>Gram negative</b>          |        |            |
| <i>Escherichia coli</i>       | 14     | 17.7       |
| <i>Citrobacter diversus</i>   | 9      | 11.4       |
| <i>Pseudomonas aeruginosa</i> | 7      | 8.9        |
| <i>Proteus mirabilis</i>      | 6      | 7.6        |
| <i>Enterobacter spp.</i>      | 5      | 6.3        |
| <i>Enterobacter</i>           | 4      | 5.1        |
| <i>Proteus vulgaris</i>       | 1      | 1.3        |

This table shows that *Staphylococcus aureus* was the predominant germ with 33 cases (41.7%), followed by *Escherichia coli* with 14 cases (17.7%), *Citrobacter diversus* with 9 cases (11.4%), and *Pseudomonas aeruginosa* with 7 cases (8.9%).

**Table 4.** Distribution of bacteria according to surgical specialty.

| Surgical specialty        | <i>S. aureus</i> | <i>P. aeruginosa</i> | <i>P. mirabilis</i> | <i>E. coli</i> | <i>C. diversus</i> | <i>E. spp.</i> | <i>P. vulgaris</i> | <i>Enterobacter</i> |
|---------------------------|------------------|----------------------|---------------------|----------------|--------------------|----------------|--------------------|---------------------|
| Traumatology-orthopaedics | 10               | 2                    | 2                   | 2              | 2                  | 1              | 0                  | 0                   |
| Abdominal surgery         | 13               | 3                    | 3                   | 9              | 6                  | 3              | 1                  | 2                   |
| Urology                   | 3                | 1                    | 1                   | 1              | 1                  | 1              | 0                  | 1                   |
| Neurosurgery              | 3                | 0                    | 0                   | 1              | 0                  | 0              | 0                  | 0                   |
| Oncology                  | 1                | 0                    | 0                   | 0              | 0                  | 0              | 0                  | 0                   |
| General surgery           | 3                | 1                    | 0                   | 1              | 0                  | 0              | 0                  | 1                   |
| Total                     | 33               | 7                    | 6                   | 14             | 9                  | 5              | 1                  | 4                   |

This table shows that *S. aureus* was the most common bacterium found in abdominal surgery, with 13 cases out of 33, followed by *E. coli* with 9 cases out of 14, and *Citrobacter diversus* with 6 cases out of 9. In trauma and orthopedic surgery, *S. aureus* was the most common bacterium found (in 10 cases out of 33).

### 3.3. Multiresistant Bacteria

**Table 5.** Distribution of cases according to multi-resistant bacteria.

| Multiresistant bacteria      | NUMBER | Percentage |
|------------------------------|--------|------------|
| <i>Escherichia coli</i>      | 6      | 42.9       |
| <i>Staphylococcus aureus</i> | 5      | 35.7       |
| <i>Citrobacter diversus</i>  | 2      | 14.3       |



## Continued

|                               |           |              |
|-------------------------------|-----------|--------------|
| <i>Pseudomonas aeruginosa</i> | 1         | 7.1          |
| <i>Proteus mirabilis</i>      | 1         | 7.1          |
| <i>Enterobacter</i>           | 1         | 7.1          |
| <i>Enterobacter spp.</i>      | 1         | 7.1          |
| <b>TOTAL</b>                  | <b>14</b> | <b>100.0</b> |

Chi-square = 94.6; ddl = 6; p-value = 0.000.

The most common bacteria are *Escherichia coli* (42.9%), followed by *Staphylococcus aureus* (35.7%), *Citrobacter diversus* (14.3%), and *Pseudomonas aeruginosa* (7.1%).

### 3.4. Antibiotic Resistance

**Table 6.** Distribution of cases according to antibiogram results.

| Antibiotic            | <i>Staphylococcus aureus</i> |      | <i>Escherichia coli</i> |      | <i>Enterobacter spp.</i> |      | <i>Enterobacter</i> |      |
|-----------------------|------------------------------|------|-------------------------|------|--------------------------|------|---------------------|------|
|                       | NR/NT                        | %    | NR/NT                   | %    | NR/NT                    | %    | NR/NT               | %    |
| Amikacin              | 0/3                          | 0    | 0/4                     | 0    | -                        |      | -                   |      |
| Amoxicillin           | 16/29                        | 55.1 | 5/8                     | 63   | 2/4                      | 50   | 2/3                 | 66.6 |
| Amoxicillin AC        | 0/5                          | 0    | 2/2                     | 100  | -                        |      | -                   |      |
| Ampicillin            | 17/28                        | 60.7 | 6/11                    | 54.5 | 2/5                      | 40   | 1/3                 | 33.3 |
| Cefatax               | 1/3                          | 33   | -                       |      | -                        |      | -                   |      |
| Ceftriaxone           | 16/27                        | 59.3 | 6/11                    | 54.4 | 2/5                      | 40   | 1/3                 | 33.3 |
| Cefuroxime            | -                            |      | -                       |      | -                        |      | -                   |      |
| Chloramphenicol       | 14/20                        | 70   | 4/8                     | 50   | 3/7                      | 57.1 | -                   |      |
| Ciprofloxacin         | 18/30                        | 60   | 5/11                    | 45.4 | 2/5                      | 40   | 3/5                 | 60   |
| Cloxacillin/oxacillin | NA                           |      | NA                      |      | NA                       |      | NA                  |      |
| Doxycycline           | 14/26                        | 53.8 | ¾                       | 75   | 4/6                      | 66.6 | 2/3                 | 66.6 |
| Erythromycin          | 20/32                        | 62.5 | 2/5                     | 40   | 2/6                      | 33.3 | -                   |      |
| Fosfomycin            | 1/3                          | 33   | 0/1                     | 0    | 0/2                      | 0    | 0/1                 |      |
| Gentamicin            | 13/28                        | 48.4 | 8/13                    | 61.5 | 3/6                      | 50   | 2/3                 | 60   |
| Imipenem              | -                            | -    | 0/1                     | 0    | --                       |      |                     |      |
| Levofloxacin          | 0/3                          | 0    | -1/2                    | 50   | -                        |      | -                   |      |
| Meropenem             | 0/5                          | 0    | 0/3                     | 0    |                          |      | 0/2                 |      |
| Metronidazole         | NA                           |      | NA                      |      | NA                       |      | NA                  |      |
| Norfloxacin           | 4/8                          | 50   | -                       |      | 2/5                      | 40   | 2/4                 | 50   |
| Penicillin            | 21/28                        | 75   | 9/12                    | 75   | 6/12                     | 50   | -                   |      |

- NR: Number of times the antibiotic was resistant.
- NT: Number of times the antibiotic has been tested.
- Dash (-): Antibiotics not tested on the bacterium.
- NA: Not applicable, antibiotics not tested by the laboratory.

**Table 7.** Distribution of cases according to the antibiogram results (continued).

| Antibiotic            | <i>Citrobacter diversus</i> |      | <i>Proteus mirabilis</i> |      | <i>Proteus vulgaris</i> |     | <i>Pseudomonas aeruginosa</i> |      |
|-----------------------|-----------------------------|------|--------------------------|------|-------------------------|-----|-------------------------------|------|
|                       | NR/NT                       | %    | NR/NT                    | %    | NR/NT                   | %   | NR/NT                         | %    |
| Amikacin              | -                           |      | -                        |      | -                       |     | 0/4                           | 0    |
| Amoxicillin           | 5/8                         | 62.5 | 2/5                      | 40   | 1/1                     | 100 | 4/6                           | 66.6 |
| Amoxicillin AC        | -                           |      | -                        |      | -                       |     | 3/3                           | 100  |
| Ampicillin            | 5/7                         | 71.4 | 2/6                      | 33.3 | 1/1                     | 100 | 4/5                           | 80   |
| Ceftriaxone           | 4/8                         | 50   | 2/5                      | 40   | 1/1                     | 100 | 5/8                           | 62.5 |
| Chloramphenicol       | 6/9                         | 66.6 | -                        |      | 4/4                     | 100 | 4/5                           | 80   |
| Ciprofloxacin         | 4/8                         | 50   | 2/4                      | 50   | -                       |     | 3/6                           | 50   |
| Cloxacillin/oxacillin | NA                          |      | NA                       |      | NA                      |     | NA                            |      |
| Doxycycline           | 3/6                         | 50   | ¼                        | 25   | -                       |     | 5/6                           | 83.3 |
| Erythromycin          | 4/7                         | 57.1 | 4/7                      | 57.1 | -                       |     | ½                             | 50   |
| Fosfomycin            | -                           |      | -                        |      | 0/1                     | 0   | 0/2                           | 0    |
| Gentamicin            | 2/6                         | 33.3 | ¼                        | 25   | 1/1                     | 100 | 2/6                           | 33.3 |
| Imipenem              | -                           |      | -                        |      | -                       |     | -                             |      |
| Levofloxacin          | -                           |      | -                        |      | -                       |     | 0/1                           | 0    |
| Meropenem             | -                           |      | -                        |      | -                       |     | 0/2                           | 0    |
| Metronidazole         | NA                          |      | NA                       |      | NA                      |     | NA                            |      |
| Norfloxacin           | 1/1                         | 100  | 1/1                      | 100  | -                       |     | -                             |      |
| Penicillin            | 4/6                         | 66.6 | 2/4                      | 50   | 1/1                     | 100 | 3/6                           | 50   |

- NR: Number of times the antibiotic was resistant.
- NT: Number of times the antibiotic has been tested.
- Dash (-): Antibiotics not tested on the bacterium.
- NA: Not applicable, antibiotics not tested by the laboratory.

#### 4. Discussion

The results of this study can be discussed in terms of three aspects: epidemiological, bacteriological, and antibiotic resistance.

The prevalence of surgical site infection in our study was 12.06%. Our prevalence was higher than that reported by N'Sinabau *et al.* [24] in Kinshasa (8.3%) and Lungere *et al.* [18] in Bukavu (8.8%), Douchi *et al.* [2] (7.83%) at the National Hospital in Zinder, Niger; Bengaly *et al.* [18] in Mali (4.72%); and the ISO Sur-

veillance Network in France (1.64%) [12]-[14].

However, it was lower than that reported by Bafeno *et al.* [25] at Makiso General Hospital, 30.65%.

We believe that this high frequency in our series could be explained in our setting by the precarious nature of certain aseptic measures, hospital practices, and a lack of information on antibiotic prophylaxis.

The sample consisted of 55 men and 19 women, giving a sex ratio of 2.89. The average age was  $45.25 \pm 19.24$ , with extremes of 0 and 83 years. Relatively similar results were reported by Lungere *et al.* [18] in Bukavu, where the 20 - 40 age group was predominant, with an average age of  $33 \pm 2$  years. Our results differ from those found by Kimuni *et al.* [21] in Lubumbashi, where the 18 - 24 age group was predominant, with an average age of  $33 \pm 17$  years; and Bafeno *et al.* [25] in Kisangani, who found a predominance of patients aged between 61 and 75 years.

We believe that the predominance of this age group in our series is due to the nature of our sample, which consists of many cases of peritonitis, which often occur in this age group.

The results of the pyoculture isolated 79 germs, including 5 cases of microbial association with two germs. The predominant germs were *Staphylococcus aureus*, *Escherichia coli*, *Citrobacter diversus*, and *Pseudomonas aeruginosa* with 41.7%, 17.7%, 11.4%, and 8.9%, respectively. Relatively similar results have been reported by several African and non-African authors who found a predominance of *Staphylococcus aureus*, notably Ousmane A. *et al.* [17], Ide Garba *et al.* [26], and the SSI Surveillance Network in France [12]-[14]. However, our results do not corroborate those of Kimuni *et al.* [21], who reported a predominance of *Pseudomonas aeruginosa* 50%, *Escherichia coli* 22%, and *Staphylococcus aureus* 20.5%; Lungere *et al.* [18] reported a predominance of *E. coli* followed by *Staphylococcus aureus*, and Bengaly *et al.* in Mali [16] reported a predominance of *E. coli* followed by *S. aureus*. We believe that the predominance of *Staphylococcus aureus* in our series is due to the fact that these germs constitute flora in the hospital environment and are commensals of the skin and mucous membranes. Contamination of the surgical site occurs more often during the surgical period, either from the patient's flora before the incision, from the flora of the staff during the procedure or during dressing, or from antiseptic solutions or contaminated instruments. The poor hygiene of our hospital environment is thought to be the cause of SSI.

The results of the antibiogram by germ showed the following resistance: ***Staphylococcus aureus***: ceftriaxone 59%, ciprofloxacin 60%, gentamicin 48.4%, amoxicillin 55.1%, penicillin 75%; ***Escherichia coli***: ceftriaxone 54.5%, ciprofloxacin 45.4%, gentamicin 45%, amoxicillin 63%; ***Citrobacter diversus***: ceftriaxone 50%, ciprofloxacin 60%, gentamicin 48.4%, penicillin 75%, amoxicillin 55.1%. Relatively similar results were reported by Nsiata *et al.* [27] and Ousman A. [17]. However, our results differ from those reported by Lungere *et al.* [20]. There is reason to believe that frequent use of antibiotic molecules ultimately leads to resistance [2] [28]. The high resistance to the molecules used in our Surgery Department could

also be related to their quality. This high resistance of bacteria isolated from SSIs to certain families of antibiotics confirms that these are indeed hospital germs. It must completely change the protocol for probabilistic antibiotic therapy. The antibiotics that have shown efficacy against most germs isolated from surgical site infections in the surgery department are amikacin, fosfomycin, meropenem, and imipenem. These antibiotics can be used as a first-line treatment in the case of empirical antibiotic therapy.

This study has some limitations due to its single-center design, and its retrospective and non-probabilistic nature, meaning that data recording was not exhaustive. Other patients could not be included in this database as having surgical site infections due to the loss of many medical records in the archives department. Some patients who were clinically diagnosed with surgical site infection were excluded because pus samples were not sent to the laboratory for bacteriological study. The results cannot be generalized to the entire population.

However, the results obtained are encouraging. They will allow hospital services to gain an understanding of the bacterial ecology of the department, establish their infection prevention policy for surgical sites, and improve antibiotic prescription practices.

## 5. Conclusion

Surgical site infection is a real public health problem. Its impact is considerable because it can lead to antibiotic resistance, long hospital stays, increased healthcare costs, and significant morbidity and mortality. Incorrect antibiotic prescriptions, self-medication, and the use of poor-quality antibiotics are responsible for the selection of multi-resistant strains in healthcare facilities. Reduced sensitivity to commonly used antibiotics has been observed in the Cukis surgery department.

## Ethical Considerations

Before starting the collection, we received a research permit from the faculty, granting us access to the hospitalizations register and Register of doctors' on-call reports. The information concerning our patients has been kept confidential.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References

- [1] Fournel, L. (2017) Surgical Site Infections. *Revue Francophone de Cicatrisation*, **1**, 27-30. [https://doi.org/10.1016/S2468-9114\(17\)30345-6](https://doi.org/10.1016/S2468-9114(17)30345-6)
- [2] Douchi, M., Amadou, H., Lawali, M., Ousmane, L., Amadou, I., Halidou, M., *et al.* (2020) Surgical Site Infections at the National Hospital of Zinder, Niger: Epidemiological and Bacteriological Aspects. *European Scientific Journal*, **16**, 576-589.
- [3] Allegranzi, B., Bischoff, P., de Jonge, S., Kubilay, N.Z., Zayed, B., Gomes, S.M., *et al.* (2016) New WHO Recommendations on Preoperative Measures for Surgical Site Infection Prevention: An Evidence-Based Global Perspective. *The Lancet Infectious Dis-*

- eases, **16**, e276-e287. [https://doi.org/10.1016/s1473-3099\(16\)30398-x](https://doi.org/10.1016/s1473-3099(16)30398-x)
- [4] KPB Bouhelo-Pam, Shimi, M., EL Ayoubi, A., Khaissidi, A., Bachiri, M., EL Ibrahim, A., *et al.* (2014) Nosocomial Infections in Orthopaedic and Trauma Surgery. *Revue Marocaine de Chirurgie Orthopédique et Traumatologique*, **55**, 24-29.
- [5] WHO (2016) Biomedical Waste Management.
- [6] WHO (2016) Strategic Plan for Biomedical Waste Management 2016-2020.
- [7] Maître, S., Pirrello, T., Hoffmeyer, P., Uçkay, I., Lew, D. and Pittet, D. (2012) Prevention of Post-Operative Infections in Orthopaedics. *Revue Médicale Suisse*, **8**, 890-893. <https://doi.org/10.53738/revmed.2012.8.338.0890>
- [8] Aya, K., Natacha, A., Blaise, Y.L., Léopold, K.K., Innocent, M.K., Niaoré, S.B.J.L. and Michel, K. (2019) Bacteriological Profile of Infections in Orthopaedics and Traumatology in Bouaké. *Revue Internationale des Sciences Médicales d'Abidjan, RISM*, **21**, 326-329.
- [9] Institute National de Santé Publique du Québec (2024) Surveillance of Surgical Site Infections: Tools and Methodologies for Healthcare Settings.
- [10] Wong, E. (1999) Surgical Site Infections. In: Mayhall, C., Ed., *Hospital Epidemiology and Infection Control*, 2nd Edition, Lippincott, 189-210.
- [11] Canadian Public Health Agency (2020) Surgical Site Infections, Report from 40 Hospitals from 2009-2018.
- [12] Formalised Recommendations from Experts from the French Society of Anaesthesia and Intensive Care and the French Society of Infectious Diseases (2024) Antibiotic Prophylaxis in Surgery and Interventional Medicine.
- [13] SPICIMI Mission, ISO Rasin Network and Santé Publique France (2020) Surveillance of Surgical Site Infections in French Healthcare Facilities.
- [14] European Centre for Disease Prevention and Control (2023) Healthcare-Associated Infections: Surgical Site Infections—Annual Epidemiological Report for 2018-2020.
- [15] Ouédraogo, A.-S. Somé, D.A., Dakouré, P.W.H., Sanon, B.G., Birba, E., Poda, G.E.A. and Kambou, T. (2011) Bacteriological Profile of Surgical Site Infections at the Souro Sanou University Hospital Centre in Bobo Dioulasso. *Médecine Tropicale*, **71**, 49-52.
- [16] Bengaly, B., Traoré, D., Togola, B., Sanogo, S., Coulibaly, M., Dembele, S., Ouattara, D. and Coulibali. (2020) Surgical Site Infection in “B” Surgery at the Point B University Hospital. *Mali Médical*, **35**, 29-34.
- [17] Abdoulaye, O., Harouna Amadou, M.L., Amadou, O., Adakal, O., Lawanou, H.M., Boubou, L., *et al.* (2018) Epidemiological and Bacteriological Aspects of Surgical Site Infections in the National Surgery Department of Niamey. *Pan African Medical Journal*, **31**, Article No. 33. <https://doi.org/10.11604/pamj.2018.31.33.15921>
- [18] Lungere Bazibuhe, P., Alfred Chasumba Murhula, A., Mongwa Mbikilile, J., Bandeke, D., Fataki Rutega, J. and Alumi Munyali, D. (2024) Surgical Site Infections: Frequency, Bacteriology and Antibigram in Eastern DRC. *Kivu Medical Journal*, **2**, 1-10. <https://doi.org/10.64263/kmj.v2i2.38>
- [19] World Health Organisation (2017) Global Priority List of Antibiotic-Resistant Bacteria to Guide Research, Discovery, and Development of New Antibiotics.
- [20] WHO (2022) Antimicrobial Resistance DRC.
- [21] Kamona, K., Mbang, M., Mwema, N., Mbaz, K.A., *et al.* (2021) Carbapenem Resistance in Germs Isolated from Surgical Wounds in Lubumbashi Hospitals: The Case of Jason Sendwe, Gécamines Sud, SNCC (Société Nationale de Chemin de Fer du Congo) and Polyclinique Shalina Hospitals. *IOSR Journal of Pharmacy and Biological Sciences*,

16, 50-55.

- [22] Kakupa, D.K., Muenze, P.K., Byl, B. and Dramaix, M. (2016) Study of the Prevalence of Nosocomial Infections and Associated Factors in Two University Hospitals in Lubumbashi, Democratic Republic of Congo. Case Studies of the Lubumbashi University Clinics and Janson Sendwe Hospital. *Pan African Medical Journal*, **24**, Article No. 275. <https://doi.org/10.11604/pamj.2016.24.275.7626>
- [23] Drancourt, M. (1998) Antibiotic Prescription and Bacterial Resistance. In: Raoult, D., Ed., *Controlling Antibiotic Prescription in Hospitals*, Scientific and Medical Publishing, 45-50.
- [24] Eyay, N., Madibulaya, K., Kiana, M., Kabali, A., Panya, M., Musema, M., *et al.* (2019) Antibiotic Prophylaxis and Surgical Site Infection at the N'djili General Reference Hospital/ISTM-Kinshasa. *Congo Sciences*, **7**, 167-171.
- [25] Bafeno Lyande, L., Basanja, E., Tagoto, A., Luka, G., Lobwa, S., Pami, L., *et al.* (2024) Analysis of Factors Associated with Surgical Site Infections in Kisangani (Experience at Makiso-Kisangani General Reference Hospital). *JACCR Infectiology*, **6**, 44-52.
- [26] Garba, I., Mohamed, A.W., Younssa, H., Habibou, D. and Aristote, H.-M. (2018) Surgical Site Infection in Orthopaedic and Trauma Surgery at CNHU-HKM in Cotonou. *Health Sciences and Diseases*, **19**, 108-111.
- [27] Nsiata, N., Mumba, D., Kabedi, M.J., Manienga, J. and Muyembe, J.J. (2014) Prevalence of Surgical Wound Infections in Kinshasa. *Congo Science*, No. 1, 30-36.
- [28] Carl, J. and Le Coz, P. (2015) Let's All Work Together to Save Antibiotics. Proposals from the for the Preservation of Antibiotics. French Republic, Ministry of Social Affairs, Health and Women's Rights. 150.