

## *A Comprehensive Systematic Review of Etiology and Risk Factors of Surgical Site Infections*

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### **Abstract**

**Introduction:** Surgical wound infections (SWIs) remain a significant risk to patients due to their high morbidity and mortality rates. Moreover, they pose substantial economic challenges for both developing and developed countries. The global impact of these infections is staggering, with the World Health Organization (WHO) reporting that millions of patients worldwide are affected by hospital-acquired infections annually, with many succumbing to these infections.

This study aims to analyze the incidence of surgical site infections (SSIs) based on the type of surgical intervention, identify the most frequent causes of these infections, and explore effective management strategies. The findings of this study will provide valuable insights into the prevention and management of SSIs, thereby enlightening the medical community and empowering them to improve patient outcomes.

**Material and Methods:** This study, conducted with meticulous attention to detail, focuses on patients operated on in our clinic from January to October 2024. It will reflect the incidence of SSI according to the type of surgical intervention, the most frequent causes of these infections, and the way of their treatment.

**Results:** From January 2023 to June 2024, 788 patients were hospitalized, and 408 were operated on in the Surgery Department of the Clinical Hospital of Tetovo. Three hundred fifty were male, and 438 were female. The ages of the patients included in the study ranged from 21 to 81.

Most of the patients were operated on because of cholecystolithiasis, inguinal, ventral, and umbilical hernias, breast cancer, acute appendicitis, and neoplasia of the colon and ileus. From the total number of operated patients (408), the infection of operative wounds was recorded in 49, representing an incidence of 11.76 %.

**Conclusion:** The findings of this study underscore the serious global implications of SSIs, including increased morbidity and mortality rates and the strain on healthcare budgets. Therefore, the prevention and reduction of these infections should be a priority for all countries, irrespective of their economic status.

**Keywords:** surgical site infections (SSIs); incidence; risk factors;

### **Introduction**

Nosocomial infections continue to present a significant risk to patients, not only due to their high morbidity and mortality rates but also because of the substantial economic burden they impose on healthcare systems in both developing and developed countries.[1]

The World Health Organization (WHO) reports that millions of patients are affected by hospital-acquired infections annually, with many fatalities resulting from these infections.[2] Concerns regarding bacteria in hospital

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environments causing operative wound infections were first raised in the late 19th century. [3]

Two prominent physicians of the time, the Englishman Joseph Lister and the Hungarian Ignaz Semmelweis hypothesized that bacteria circulating in hospital wards could contaminate patients' wounds.[4]

Both Lister and Semmelweis observed that the risk of puerperal sepsis in pregnant women was significantly higher when medical students who had been in autopsy rooms assisted in deliveries. To address this, they mandated rigorous handwashing with carbolic acid for all medical personnel involved in childbirth and thoroughly cleaning incision sites and wounds. This intervention significantly reduced the incidence of puerperal sepsis. Shortly thereafter, aseptic techniques during surgical interventions were widely adopted and became a mandatory standard in hospitals across Europe. [4, 5]

The introduction of antibiotics in the mid-20th century reduced hospital-acquired infections, particularly surgical wound infections. However, the indiscriminate use of antibiotics soon led to the emergence of multi-drug-resistant bacteria, commonly referred to as "superbugs," which remain a major global health challenge and jeopardize patient safety.[6]

The rise of antibiotic-resistant bacteria led to the establishment of specialized infection prevention teams, initially in the United States and England, and later as a global standard. Nurses have been instrumental in these efforts, playing a key role in infection prevention and control teams since 1959.[7]

For an infection to be classified as nosocomial, it must not be present at the time of hospital admission, and symptoms must appear at least 48 to 72 hours after admission. It is estimated that over 30% of hospital-acquired infections can be effectively prevented through adherence to established algorithms and protocols for infection control.[8]

While all hospitalized patients are at risk of nosocomial infections, the highest incidence is recorded in intensive care units and surgical departments. Pathogenic microorganisms, including bacteria, viruses, and fungi, cause these infections. Among bacterial causes, the most common gram-positive pathogens include *Streptococcus pneumoniae*, *Streptococcus pyogenes*, and *Clostridium difficile*. Among gram-negative bacteria, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Acinetobacter spp.*, and *Escherichia coli* are the most frequently implicated.[9]

**Aim of the study:** This is a descriptive study that aims to show the incidence of nosocomial infections in the surgery department of the Clinical Hospital of Tetova. The most frequent causes of these infections, their sensitivity to antibiotics, and the treatment of patients with these infections will be the focus of this study.

## Material and Methods:

The study included patients hospitalized in the Department of Surgery from January 2023 to 2024 for treatment. Of the total number of patients admitted to the surgery department in this time period (1088), 788 had surgical intervention due to some surgical disease.

Of the operated patients, 98 of them showed signs of infection of the operative wound. Material was taken from each of them with a swab stick for microbiological examination.

The type of surgical intervention, the patient's age and gender, and underactive complications in the sense of wound infection have been studied and analyzed for study.

At the same time, other disorders related to the patient's health condition and that may impact the risk of infection of operative wounds, such as the level of glucose in the blood, the level of hemoglobin, and the hematocrit before surgery, were taken into consideration to increase the value of this study.

The study excluded patients with existing infectious processes such as abscesses, fistulas, circumscribed or generalized peritonitis, or those who underwent dirty surgical interventions such as anorectal procedures.

All the necessary data for this study were taken from the patient's records and were carefully processed.

## Results

Out of the 788 patients operated on in the period from January 2023 to June 2024, 350 were male, while 438 were female. The patients included in the study were from 21 to 81 years old. The surgical interventions performed have been different, but most of the patients were operated on for cholecystolithiasis, inguinal, ventral, and umbilical hernias, breast cancer, acute appendicitis, and neoplasia of the colon and ileus. (tab. 1)

Of the 408 patients operated on during this period, 49 had operative wound infections, representing an incidence of 11.76 %. The highest incidence of surgical wound infection is recorded in patients whose gastrointestinal tract integrity is broken, such as those with colorectal neoplasia, acute appendicitis, perforated ulcers, and mechanical ileus.

The data show that of the 14 patients operated on for acute appendicitis, three of them developed an infection of the operative wound, which represents an incidence of 21%. None of these patients had any co-morbidities and were not treated with therapy that would increase the risk of surgical wound infection.

Of the 11 patients operated on for colorectal cancer, infection of the surgical wound was recorded in four patients, which also represents the highest incidence of 36% in this study. All four of these patients have accompanying problems, such as one with diabetes and cardiorespiratory

Diagnosis	Age (years)												Total
	20-30		31-40		41-50		51-60		61-70		>70		
Inguinal hernias	9		23		31		38		14		8		123
	M	F	M	F	M	F	M	F	M	F	M	F	
	9	0	20	3	26	5	36	2	14	0	8	0	
Cholecystolithiasis	9		25		40		37		16		8		136
	M	F	M	F	M	F	M	F	M	F	M	F	
	2	7	3	22	5	35	3	34	2	14	1	7	
Incisional hernias	-		7		9		13		5		3		37
	M	F	M	F	M	F	M	F	M	F	M	F	
	-	-	1	6	2	4	4	9	2	12	3	5	
Appendicitis acuta	8		3		2		1		-		-		14
	M	F	M	F	M	F	M	F	M	F	M	F	
	3	5	1	2	1	2	1	-	-	-	-	-	
Ileus	-		1		1		2		2		2		8
	M	F	M	F	M	F	M	F	M	F	M	F	
Ca colorectal	-		-		-		2		5		4		11
	M	F	M	F	M	F	M	F	M	F	M	F	
	-	-	-	-	-	-	2	-	3	2	3	1	
Perforated gastroduodenal ulcer	-		1		2		1		1		-		5
	M	F	M	F	M	F	M	F	M	F	M	F	
	-	-	1	-	2	0	1	0	1	-	-	-	
Sigmoid diverticulosis	-		-		1		1		-		-		2
	M	F	M	F	M	F	M	F	M	F	M	F	
	-	-	-	-	1	-	1	-					
Ca of the breast	-		11		23		19		6		-		69
	M	F	M	F	M	F	M	F	M	F	M	F	
	-	-	-	11	-	23	-	19	-	6	-	-	

Table 1 Age and gender of the patients included in this study according to the performed surgical intervention

disease, the other with obesity and cardiovascular disease, and the third patient was previously treated with radiotherapy. One of the patients who operated on for colorectal cancer received fresh blood and plasma transfusions one day before the operation.

Of the patients with perforated gastroduodenal ulcers (5 patients), wound infection was seen only in one, thus marking an incidence of 20%.

Of the three patients operated on for sigmoid diverticulosis, sigmoid resection and terminal-terminal anastomosis were performed in two, while in another, a provisional colostomy was opened after sigmoid resection. Only one of these patients registered an infection of the operative wound, which marks an incidence of 33%.

Among the eight patients operated on due to mechanical ileus, the surgical wound infection was registered only in one (incidence of 12.5%). It should be mentioned that in no patient was the continuity of the TGI broken during the surgical intervention, and no one had any accompanying disease or received any therapy that could affect the increase in the risk of infection of the operative wound.

Patients operated on with so-called "clean operations"

such as cholecystectomies and inguinal and incisional hernias have shown a much lower incidence of surgical wound infection. Thus, of the 137 patients operated on for Cholecystolithiasis, 16 had an operative wound infection, representing an incidence of 11.7%. Two of these patients had diabetes, four were overweight, and three patients had a reduced blood count but without the need for transfusions.

Of the 122 patients operated on for inguinal hernia, the infection of the surgical wound occurred only in 11 of them, representing an incidence of 8.2%. Two of these patients had diabetes, one overweight and another with cardiorespiratory problems and previously operated on for BPH.

In this period, a total of 38 patients with incisional hernia were operated on, and only 4 of them (10%) had surgical wound infection. Three patients were overweight, while one also suffered from poorly controlled diabetes.

Even in the group of patients operated on for breast cancer, in 8 cases out of a total of 69 operated patients, infection of the operative wound was observed, which marks an incidence of 11.6%.

The incidence of SSI according to surgical intervention is shown in Table 2

Diagnosis	Patients		SSI	
	M	F	M	F
Inguinal hernias	122		11	
	98	24	8	2
	M	F	M	F
Cholecystolithiasis	138		16	
	35	102	4	9
	M	F	M	F
Incisional hernias	38		4	
	11	26	1	3
	M	F	M	F
Appendicitis acuta	14		3	
	6	8	2	2
	M	F	M	F
Ileus	8		1	
	5	3	2	0
	M	F	M	F
Ca colorectalis	11		4	
	8	3	3	1
	M	F	M	F
Perforated gastro-duodenal ulcer	5		1	
	4	1	1	0
	M	F	M	F
Sigmoid diverticulosis	3		1	
	2	0	1	0
	M	F	M	F
Ca of the breast	69		8	
	0	69	0	8
	M	F	M	F

Table 2. The incidence of SSI according to surgical intervention

Out of a total of 49 patients with operative wound infections, in 40 of them, the interventions were clean, while in 10 (20.8%), others were contaminated or dirty; this is because during the surgical intervention, there was a TGI opening, or damage, to this tract was the reason for the surgical intervention.

The infection of the operative wound was recorded in 49 patients during their hospital stay. In comparison, it was identified in 11 patients after discharge during routine follow-up appointments prescribed by the surgeon.

The most frequent causes of surgical wound infection were the bacteria *S. aureus*, isolated in 41.2% of patients, and *E. coli* in 32.5%. Other isolated bacteria were *Pseudomonas aeruginosa* (12%), *Klebsiella* (9%) (15%), *Enterococcus spp* (9%), and *Streptococcus* (8 %).

## Discussion

This study focuses on the incidence of surgical wound infections (SWIs) in the General Surgery Clinic of Tetovo Clinical Hospital from January 2023 to 2024. Cases involving generalized peritonitis due to gastrointestinal (GI) tract lesions, proctological pathologies, and abscesses—whether superficial or in the abdominal cavity—were excluded from this analysis.

Numerous studies' data on surgical wound infections reveal significant variations in their incidence across countries. These differences are primarily influenced by factors such as adherence to infection prevention protocols, the knowledge, and training of medical personnel regarding prevention and treatment, the care and precision exercised by surgeons, the surgical techniques employed, the ventilation systems in operating theaters, and the sterilization and storage methods for surgical instruments and materials.

The incidence of SWIs observed in this study was 12%. Comparatively, other studies report varying rates of postoperative wound infections, with some demonstrating higher incidences, particularly in countries with lower socio-economic standards [10, 11, 12, 13, 14, 15]

Conversely, studies from higher-income countries often report lower infection rates, highlighting the disparity. This study observed aty.

There was a notable difference in SWI incidence between conventional and laparoscopic surgical studies, a finding corroborated by various other studies [16,17, 18, 19]

Factors contributing to an increased risk of surgical wound infections, such as diabetes, obesity, chronic anemia, longer operation duration, extended hospital stays, and postoperative complications, were also evident in this research and are similarly reported in the literature. [20, 21, 22].

Age is another factor influencing the risk of postoperative infections. This study found an increased incidence of SWIs in older patients, aligning with findings from other authors. Gender also plays a role; excluding breast surgeries (where all patients were women), a higher incidence of SWIs was observed in male patients. This gender-based difference is consistent with findings from several other study. [22, 23, 24, 25]

Microbiological cultures of swabs from infected wounds indicated a predominance of gram-positive bacteria, including *Staphylococcus aureus*, *Staphylococcus spp.*, and *Enterococcus spp.* *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella spp.* were most frequently identified among gram-negative bacteria. Similar studies, particularly in developed countries, also report gram-positive bacteria as the primary causative agents of SWIs [26, 27]17,18, except in surgeries involving the large intestine, where gram-negative bacteria, especially *E. coli*, are more prevalent. [28, 29, 30, 31, 32]

The treatment of SWIs in this study involved thoroughly cleaning the surgical wounds daily and administering antibiotics based on microbiological culture results and antibiograms. However, the data highlight an alarming rise in antibiotic-resistant bacteria, particularly gram-negative bacteria resistant to third-generation cephalosporins such as ceftriaxone. This phenomenon is also widely reported in the literature and underscores the need for effective antibiotic stewardship. [33].

## Conclusion

This study underscores the growing challenge of surgical site infections and their multifactorial nature. Prevention requires strict adherence to aseptic principles, proper sterilization, and awareness among medical personnel. Gram-positive bacteria, such as *S. aureus*, dominate most SSIs, while gram-negative bacteria are prevalent in GI tract surgeries.

Effective treatment includes aggressive wound management and antibiotic therapy guided by microbiological results. Future efforts should focus on establishing detailed etiological profiles to define preventive and therapeutic strategies, particularly in surgical departments.

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