

## Original Research Article

# OCCURRENCE OF MULTIDRUG RESISTANT PATHOGEN AMONG PATIENTS HAVING SURGICAL SITE INFECTION

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## ABSTRACT

**Background:** Surgical site infections (SSIs) is the most common infections linked to healthcare, resulting in heightened morbidity, extended hospital stays, and escalating healthcare expenses. Understanding local changes in microbiology and patterns of antibiotic resistance is essential for successful treatment. Objectives: To separate and recognise bacterial and fungal pathogens for having surgical site infections and detect their antimicrobial susceptibility patterns and multidrug-resistant organisms.

**Materials and Methods:** This hospital-based observational cross-sectional study was conducted in the Departments of Microbiology TMMC&RC, Moradabad, from April 2024 to October 2025. There were 161 patients with SSIs that were clinically suspected. Standard microbiological methods were applied to specimens obtained aseptically from infected surgical wounds. The antibiotic sensitivity was done by Kirby Bauer Disc Diffusion Assay according to CLSI Guidelines M100 33rd Edition.

**Results:** Participants were predominantly male (54.0%), with an age distribution centered around 40 years. 59.6% of isolates were Gram-negative bacteria, with Gram-positive bacteria coming in second (37.3%) and fungal isolates (3.1%). The most common pathogen isolated was Methicillin-resistant *Staphylococcus aureus* (MRSA) (29.2%), which was followed by *Escherichia coli* (24.2%) and *Klebsiella pneumoniae* (16.1%). High drug resistance was seen in Ampicillin (89.7%), Ciprofloxacin (88.1%), and Cefotaxime (83.3%), whereas Tigecycline (97.7%), Linezolid (96.7%), Teicoplanin (96.2%), and Vancomycin (93.2%) retained excellent activity against resistant isolates. All fungal isolates were vulnerable to fluconazole and amphotericin-B.

**Conclusion:** Gram-negative bacteria predominated among SSI pathogens, whereas the most prevalent individual isolate was MRSA. The necessity for ongoing monitoring is highlighted by the significant degree of resistance to widely used antibiotics, antimicrobial stewardship, and culture-guided therapy to optimize SSI management.

**Keywords:** Surgical site infection; Antimicrobial resistance; MRSA; Gram-negative bacteria; Antibiotic susceptibility; Multidrug-resistant organisms.

## INTRODUCTION

Surgical site infections (SSIs) continue to be a prominent obstacle to surgical care among the most common illnesses linked to healthcare globally.<sup>[1]</sup> They represent almost one-fifth of the total number of infections associated with healthcare facilities and

are associated with extended length of stay, increased surgical morbidity and mortality, impaired wound healing, and significant financial costs.<sup>[2,3]</sup> Despite the great progress made in surgery, sterilization, perioperative management and prophylaxis against microbes, SSIs continue to affect millions of patients each year, particularly in developing countries where

there are still problems with respect to infection control.<sup>[4,5]</sup>

There are more cases of SSIs in developing countries than those of developed countries. Whereas in developed countries the rate of occurrence is normally between 2 and 5 percent, studies conducted in India have shown that the rate of occurrence is between 5 and 20 percent. The risk factors associated with patients differ depending on the kind of surgery and hospital infrastructure. The growing prevalence of SSI bacteria' tolerance to antibiotics has made matters more difficult. treatment outcomes and increased healthcare expenditure.<sup>[6,7]</sup>

The 'Centre's for Disease Control and Prevention (CDC)' categorise 'SSIs' into three groups: deep incisional SSI, which affects deeper soft tissues including muscle and fascia, superficial incisional surgical site infection (SSI), affects skin and subcutaneous tissues, and organ/space SSI, anatomical structure manipulated during surgery. This classification is important for determining disease severity, therapeutic approach, and prognosis.<sup>[5,8]</sup>

The pathogenesis of SSI involves microbial contamination of the surgical wound during or after surgery. Infection develops when the microbial burden exceeds host defense mechanisms.<sup>[9]</sup> Several factors influence this process, including the virulence of microorganisms, duration of surgery, wound contamination, immunological status of the patient, diabetes mellitus, malnutrition, obesity, prolonged hospitalization, and inappropriate antibiotic use.<sup>[5,10]</sup> Common causative organisms comprise *Acinetobacter* species, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella* spp., *Enterococcus* spp. Many of these organisms have developed multidrug resistance, significantly limiting therapeutic options.<sup>[11,12]</sup>

A major diagnostic and therapeutic challenge is the growing prevalence of fungus and bacteria that are resistant to drugs (MDR). Empirical antibiotic therapy is often initiated before microbiological confirmation, which may contribute to inappropriate antimicrobial use and further selection of resistant strains.<sup>[13]</sup> For efficient clinical therapy, it is consequently crucial to continuously monitor local bacterial profiles and antimicrobial susceptibility trends.<sup>[14]</sup>

Although several studies have suggested that SSI rates and bacterial isolates, the prevalence rate of multidrug-resistant bacteria and fungi causing SSIs remain limited in many healthcare settings.<sup>15</sup> Periodic surveillance is crucial to understand evolving resistance trends and guide evidence-based antimicrobial policies. Therefore, goal of the current investigation was to separate and identify causative organisms of surgical site infections, their antimicrobial susceptibility patterns, and multidrug-resistant organisms, thereby contributing to improved patient management, infection control practices and antimicrobial stewardship.

## MATERIALS AND METHODS

The Department of Microbiology at Teerthanker Mahaveer Medical College and Research Centre (TMMC&RC), Moradabad, a tertiary care teaching hospital that serves both urban and rural populations in Western Uttar Pradesh, was the hospital-based observational cross-sectional study. The research was carried out for a duration of eighteen months, starting from April 2024 up to October 2025, after obtaining permissions from the College Research Committee and the Institutional Ethics Committee.

Patients of all ages that had undergone surgery and had shown clinical signs of SSI that is pain, redness, swelling, purulent drainage, or delayed wound healing were recruited after obtaining their written informed consent. Patients that had sustained trauma wounds, puncture wounds locally or had been transferred from another institution and were already diagnosed with SSI were excluded.

Data on clinical and microbiology were sourced from surgical wards and the laboratory files. The specimen collection was carried out aseptically through the use of sterile cotton swabs or aspiration of pus from infected surgical wounds. From each patient, two specimens were collected, whereby one would be used for direct microscopic examination while the other for culture and the test for antimicrobial susceptibility. The sample processing was done following the normal microbiological practices and taken to the microbiology laboratory immediately. The conventional microbiological procedures were applied in identification of the bacteria and fungi. Disk diffusion by Kirby-Bauer method was applied in testing the antimicrobial susceptibility according to CLSI guidelines.

All experiments adhered to the recognized standards of ethics in biomedical research on humans, and confidentiality of patients was preserved at all times.

### Sample Size Estimation

The number of samples was calculated by means of the formula  $n = Z^2 \times P(100 - P)/E^2$ , where  $Z = 1.96$  for 95% confidence level,  $P = 38\%$  (anticipated prevalence), and  $E = 7\%$  (allowable error). Thus,  $n = (1.96)^2 \times 38 \times (100 - 38) / (7)^2 = 183.9 \approx 184$ . Therefore, the minimum sample size required for the study was 184 patients.

### Statistical Analysis

SPSS software version 26.0 was used for data analysis after data collection in Microsoft Excel. Frequencies and percentages were employed to analyze qualitative data such as sex, the species of isolated microorganism, pattern of antimicrobial susceptibility and multidrug resistance. Mean  $\pm$  standard deviation (SD) was used to analyze quantitative data like age and duration of hospital stay. Differences among continuous variables were determined using the students t-test, while differences between the categorical variables were analyzed using Chi-Square test or Fisher's Exact

Test. The level of significance used was p-value < 0.05.

## RESULTS

The subjects involved in the study were 161 patients with surgical site infection. Clinical and demographic

features in this study population are shown in Table 1 and Figure 1. The participants age were in between 18 to 76 years, with an average age of  $40.9 \pm 14.1$  years, a median age of 40 years. Gender distribution was made up of 54.0% male and 46.0% female. The departments were recruited mostly from General Surgery (52.8%), Orthopedics (28.0%), Gynecology (16.1%), and ENT (3.1%).

**Table 1: Baseline Demographic and Clinical Characteristics of Patients with Surgical Site Infections (N = 161)**

| Characteristic                          | Value           |
|-----------------------------------------|-----------------|
| <b>Age (years)</b>                      |                 |
| Mean $\pm$ SD                           | 40.9 $\pm$ 14.1 |
| Median (Range)                          | 40 (14–76)      |
| <b>Sex, n (%)</b>                       |                 |
| Male                                    | 87 (54.0)       |
| Female                                  | 74 (46.0)       |
| <b>Hospital Department, n (%)</b>       |                 |
| General Surgery                         | 85 (52.8)       |
| Orthopedics                             | 45 (28.0)       |
| Gynecology                              | 26 (16.1)       |
| ENT                                     | 5 (3.1)         |
| <b>Type of Microbial Isolate, n (%)</b> |                 |
| Gram-negative bacteria                  | 96 (59.6)       |
| Gram-positive bacteria                  | 60 (37.3)       |
| Fungal isolates                         | 5 (3.1)         |
| <b>Clinical Specimen, n (%)</b>         |                 |
| Pus                                     | 161 (100.0)     |

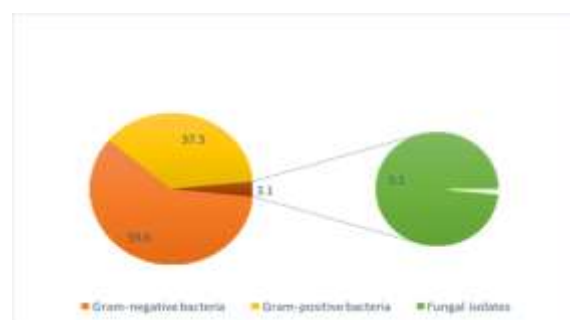


**Figure 1: Microbial Categories Among SSI Isolates**

Table 2 depicts the number of microbial isolates obtained from various hospital departments. General Surgery was found to have the highest number of isolates accounting for 64.0%, while Orthopedics had 28.0%, Gynecology 16.1% and ENT 3.1%. General Surgery and Orthopedics wards mostly gram negative bacilli were isolated, while Gram-positive bacteria were isolated from all wards. Fungal isolates were rare and isolated from General Surgery.

**Table 2: Distribution of Microbial Isolates According to Hospital Department**

| Department      | Gram-negative n (%) | Gram-positive n (%) | Fungal n (%)   | Total n (%)      |
|-----------------|---------------------|---------------------|----------------|------------------|
| General Surgery | 74 (46.0)           | 25 (15.5)           | 4 (2.5)        | 103 (64.0)       |
| Orthopedics     | 24 (14.9)           | 20 (12.4)           | 1 (0.6)        | 45 (28.0)        |
| Gynecology      | 13 (8.1)            | 13 (8.1)            | 0              | 26 (16.1)        |
| ENT             | 3 (1.9)             | 2 (1.2)             | 0              | 5 (3.1)          |
| <b>Total</b>    | <b>96 (59.6)</b>    | <b>60 (37.3)</b>    | <b>5 (3.1)</b> | <b>161 (100)</b> |

Surgical site infection microorganism profile is outlined in Table 3 and Figure 2. The most frequent causative organism was methicillin-resistant *Staphylococcus aureus* (MRSA), which comprised 29.2% of all isolated organisms, *Escherichia coli* comprising 24.2% and *Klebsiella pneumoniae*, comprising 16.1%. Other important pathogens that

have been identified include *Pseudomonas aeruginosa* (8.1%), *Acinetobacter baumannii* (5.6%) and *Enterococcus* spp. (5.0%). Fungi have been rarely found to be associated with the causation of surgical site infections, where only *Candida tropicalis* and *Candida albicans* were identified comprising 3.1% of all organisms.

**Table 3: Microbiological Profile of Organisms Isolated from Surgical Site Infections**

| Organism                                                  | n  | %    |
|-----------------------------------------------------------|----|------|
| <i>Methicillin-resistant Staphylococcus aureus (MRSA)</i> | 47 | 29.2 |
| <i>Escherichia coli</i>                                   | 39 | 24.2 |
| <i>Klebsiella pneumoniae</i>                              | 26 | 16.1 |
| <i>Pseudomonas aeruginosa</i>                             | 13 | 8.1  |
| <i>Acinetobacter baumannii</i>                            | 9  | 5.6  |
| <i>Enterococcus</i> spp.                                  | 8  | 5    |
| <i>Proteus mirabilis</i>                                  | 6  | 3.7  |

|                                                                     |     |     |
|---------------------------------------------------------------------|-----|-----|
| <i>Staphylococcus aureus</i> (MSSA)                                 | 3   | 1.9 |
| <i>Candida tropicalis</i>                                           | 3   | 1.9 |
| <i>Candida albicans</i>                                             | 2   | 1.2 |
| Other isolates ( <i>S. marcescens</i> <i>Streptococcus</i> species) | 3   | 3.1 |
| <i>Enterobacter</i> species                                         |     |     |
| Group A <i>Streptococcus</i>                                        |     |     |
| <i>Enterobacter cloacae</i>                                         |     |     |
| Total                                                               | 161 | 100 |

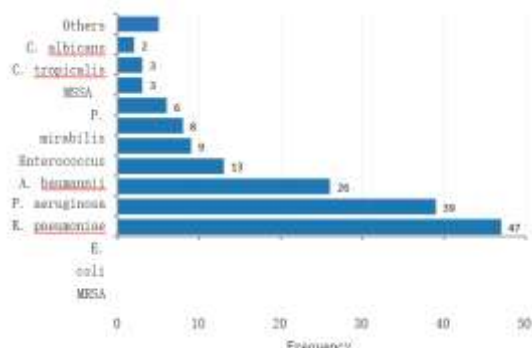


**Figure 2: Distribution of Microorganisms in SSI**

Table 4 and Figure 3 below illustrate the antimicrobial susceptibility profiles of regularly used antibiotics. There is considerable resistance to Ampicillin (89.7%), Ciprofloxacin (88.1%) and Cefotaxime (83.3%). Moreover, there is significant resistance to Ceftazidime, Gentamicin and Amoxicillin-Clavulanate, whereby these drugs are ineffective against more than two-thirds of the isolates. On the other hand, carbapenems demonstrate relatively higher susceptibility rates compared to other antibiotics. Susceptibility rates of Imipenem and Meropenem are 49.5% and 51.6%.

**Table 4: Antimicrobial Susceptibility Pattern of Commonly Used Antibiotics**

| Antibiotic              | Resistant n (%) | Intermediate n (%) | Sensitive n (%) |
|-------------------------|-----------------|--------------------|-----------------|
| Ampicillin              | 70 (89.7)       | 1 (1.3)            | 7 (9.0)         |
| Ciprofloxacin           | 133 (88.1)      | 3 (2.0)            | 15 (9.9)        |
| Cefotaxime              | 70 (83.3)       | 3 (3.6)            | 11 (13.1)       |
| Ceftazidime             | 57 (69.5)       | 4 (4.9)            | 21 (25.6)       |
| Gentamicin              | 90 (65.2)       | 10 (7.2)           | 38 (27.5)       |
| Amoxicillin-Clavulanate | 43 (65.2)       | 3 (4.5)            | 20 (30.3)       |
| Imipenem                | 36 (39.6)       | 10 (11.0)          | 45 (49.5)       |
| Meropenem               | 34 (36.6)       | 11 (11.8)          | 48 (51.6)       |

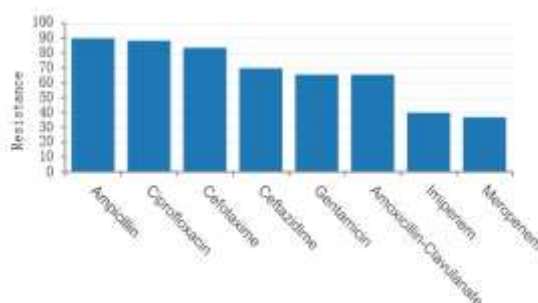


**Figure 3: Resistance Pattern of Commonly Used Antimicrobial Agents**

The susceptibility profile of reserve antimicrobial and antifungal agents is shown in Table 5. Tigecycline exhibited the highest antibacterial activity, with 97.7% of isolates remaining susceptible. Similarly, Linezolid (96.7%), Teicoplanin (96.2%), and Vancomycin (93.2%) demonstrated excellent effectiveness against Gram-positive pathogens. All fungal isolates were susceptible to Amphotericin-B and Fluconazole. These findings suggest that reserve antimicrobial agents continue to retain substantial activity against resistant microorganisms causing surgical site infections.

**Table 5: Susceptibility Pattern of Reserve Antimicrobial and Antifungal Agents**

| Agent          | Tested (n) | Sensitive n (%) | Resistant n (%) |
|----------------|------------|-----------------|-----------------|
| Tigecycline    | 43         | 42 (97.7)       | 1 (2.3)         |
| Vancomycin     | 59         | 55 (93.2)       | 4 (6.8)         |
| Linezolid      | 60         | 58 (96.7)       | 2 (3.3)         |
| Teicoplanin    | 26         | 25 (96.2)       | 1 (3.8)         |
| Amphotericin-B | 5          | 5 (100)         | 0               |
| Fluconazole    | 5          | 5 (100)         | 0               |

In Table 6, The relationship between organism type and antimicrobial susceptibility is shown. Difference in the susceptibility pattern was significantly observed in the case of Ampicillin ( $\chi^2 = 23.7$ ,  $p < 0.001$ ), Cefotaxime ( $\chi^2 = 27.9$ ,  $p < 0.001$ ), Ciprofloxacin ( $\chi^2 = 7.46$ ,  $p = 0.024$ ), and

Chloramphenicol ( $\chi^2 = 120.0$ ,  $p < 0.001$ ) between Gram-negative and Gram-positive bacteria. However, no significant difference in susceptibility pattern was found in the case of Ceftazidime and Gentamicin between the two organism types.

**Table 6: Association between Organism Type and Antimicrobial Susceptibility Pattern**

| Antibiotic      | $\chi^2$ Value | p-value |
|-----------------|----------------|---------|
| Ampicillin      | 23.7           | <0.001  |
| Ceftazidime     | 2.94           | 0.23    |
| Cefotaxime      | 27.9           | <0.001  |
| Ciprofloxacin   | 7.46           | 0.024   |
| Gentamicin      | 0.535          | 0.765   |
| Chloramphenicol | 120            | <0.001  |

## DISCUSSION

This current study was conducted to investigate the microbial spectrum and antibiotic susceptibility of microorganisms associated with SSIs. In this study, 161 SSIs were subjected to laboratory investigation. The majority of the isolates (59.6%) were Gram-negative bacteria, followed by Gram-positive bacteria (37.3%) and fungi (3.1%). There have been reports of a similar prevalence of Gram-negative microorganisms by Alhumaid S et al,<sup>[16]</sup> who observed that 56.3% of isolates were Gram-negative, while Dahal K et al,<sup>[17]</sup> and Dessie et al. reported Gram-negative prevalence rates of 78% and 73.1%, respectively. These findings suggest a growing dominance of Gram-negative organisms in SSI epidemiology, likely driven by selective antibiotic pressure and prolonged hospital exposure.

In terms of the group of isolated pathogens, the methicillin-resistant *Staphylococcus aureus* (MRSA) was noted to be the most frequently detected organism (29.2%), while *Escherichia coli* and *Klebsiella pneumoniae* accounted for 24.2% and 16.1%, respectively. Similar findings have been recorded by Negi et al,<sup>[18]</sup> where *Staphylococcus aureus* has been found to be the major cause of SSIs and accounted for 50.4% of isolates. In the same way, Saadatian-Elahi et al,<sup>[19]</sup> showed *Staphylococcus aureus* to be the leading organism causing SSIs, while Alelign et al,<sup>[20]</sup> indicated that 76% of orthopedic SSIs were due to *S. aureus*, which were significantly resistant to methicillin. However, Misha et al,<sup>[21]</sup> recorded *E. coli* as the major isolated pathogen.

The antimicrobial sensitivity profile of the present study showed significantly higher resistance levels against commonly used antibiotics. The antibiotic resistance levels were 89.7% for Ampicillin, 88.1% for Ciprofloxacin, and 83.3% for Cefotaxime. Similar findings have been found by Nobel et al,<sup>[22]</sup> High resistance to amoxicillin, cephalosporins, and other commonly prescribed antibiotics was found in wound-related bacteria. Hope et al. also found resistance to ampicillin and gentamicin. whereas Dessie et al,<sup>[23]</sup> observed marked resistance to ampicillin, amoxicillin, and tetracycline. Pop-Vicas et al,<sup>[24]</sup> Moreover, there is evidence to show that multidrug resistance is prevalent among the Gram-negative bacilli associated with SSIs. Based on these results, there are indications of an increasing inefficiency of the frontline antimicrobials.

In the present study, carbapenems were found to have better performance, with Imipenem having a susceptibility of 49.5%, and Meropenem having a

susceptibility of 51.6% by Zhanel et al,<sup>[25]</sup> who reported good activity of Imipenem and Meropenem against Gram-negative isolates. Negi et al,<sup>[26]</sup> Similarly, Meropenem is considered to be one of the most efficient drugs against resistant Gram-negative bacteria. The results confirm the continued importance of carbapenems in treating serious surgical site infections (SSIs), despite the problem of developing drug resistance.

A positive outcome from this study includes the great effectiveness demonstrated by the reserve antimicrobials. Tigecycline, Linezolid, Teicoplanin, and Vancomycin were found to be susceptible at greater than 93%. Same results were seen by Zhanel et al,<sup>[25]</sup> and Negi et al,<sup>[26]</sup> Vancomycin and Linezolid have shown nearly universal sensitivity for Gram-positive strains. The continued efficacy of both these drugs highlights their importance as valuable treatment options for SSI pathogens that have become resistant.

Fungal pathogens represented 3.1% of total isolated pathogens in the present study, where isolation of *Candida tropicalis* and *Candida albicans* was seen. All fungi were found susceptible to Amphotericin B and Fluconazole. The same results have been obtained by Shirani K et al,<sup>[27]</sup> who classified *Candida* spp. as important opportunistic pathogens causing infection at the surgical site and highlighted the importance of monitoring fungi in high-risk patients.

The significant amount of resistance to antibiotics highlighted in this study is in keeping with the worldwide phenomenon of increasing resistance to SSI organisms. Similar worries have been expressed by Salam m et al,<sup>[28]</sup> who reported multidrug resistance in 64.6% of SSI isolates, and by Manyahi et al,<sup>[29]</sup> who found that nearly two-thirds of SSI pathogens were multidrug resistant. Likewise, Nobel et al,<sup>[22]</sup> Multidrug resistance (MDR) levels greater than 80% have been reported for several wound infections. The problem of development of resistant bacteria not only makes the selection of treatment options difficult but is also responsible for delayed discharge, worse clinical results, and higher cost of healthcare delivery. In view of increasing cases of antimicrobial resistance in post-surgical patients, these observations highlight the need for regular surveillance of microbiology, prepare antibiogram, infection control, and antibiotic stewardship programme.

## CONCLUSION

The current study showed that Gram-negative organisms were the prominent cause of surgical site infections, but methicillin-resistant *Staphylococcus aureus* (MRSA) was the leading cause among the single microorganisms. Resistance to many antibiotics commonly used in the treatment of surgical infections was observed. There was resistance to such commonly prescribed antibiotics as ampicillin, ciprofloxacin, and cefotaxime, highlighting the increased risk of antibiotic resistance. However, last-resort antibiotics tigecycline, linezolid, vancomycin, and teicoplanin had high activity against the vast majority of bacterial strains. These findings emphasize for routine microbiological monitoring, drug susceptibility testing and microbiologically directed therapy in the treatment of infections of surgical sites.

## Limitations

There is limited generalizability of the results of this study since it took place in one tertiary care center only. The period for which the study took place may be insufficient to understand any trend regarding pathogen transfer and there is a small number of patients as well as a lack of information on the antimicrobial resistance. In addition, there is no analysis of the resistance mechanisms and the multidrug-resistance of the isolates. Therefore, further studies need to be conducted using molecular diagnosis to understand surgical site infections' antibiotic resistance pattern.

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