OPEN ACCESS

ORIGINAL ARTICLE

Spectrum of Surgical Site Infections in the Surgical Ward

S H Waqar[1], Ahmed Tehseen Hussain[2], Zakir Jamal[3], Ayesha Shakoor[4], Zoya Khan[5], Abdul Hadi Razaq Wali[6]
Department of General Surgery, Pakistan Institute of Medical Sciences, Islamabad

ABSTRACT

Objective: To analyze the spectrum of bacterial pathogens causing SSIs in surgical patients and to determine the antibiotic resistance and susceptibility patterns of these organisms.

Methodology: A cross-sectional observational study was conducted at the Department of General Surgery, Pakistan Institute of Medical Sciences, Islamabad, from January to December 2024. A total of 300 patients who underwent surgery and developed SSIs were included. Pus samples were collected from infected surgical sites, cultured, and analyzed for microbial identification and antibiotic susceptibility using standard microbiological techniques. Data were analyzed using SPSS version 25.

Results: The study identified Klebsiella (23.3%), Escherichia coli (17%), Pseudomonas (12.7%), and Staphylococcus aureus (9.7%) as the most common pathogens in SSIs. Across the bacterial isolates, a common trend of resistance was observed against amoxicillin, cefixime, ceftriaxone, cotrimoxazole, and penicillin. In contrast, higher sensitivity was seen with amikacin, tobramycin, vancomycin, chloramphenicol, colistin, and minocycline, though the degree of susceptibility varied among species.

Conclusion: There is a predominance of gram-negative bacteria, including Klebsiella and E. coli, among the bacterial pathogens causing SSIs. Among these, significant antibiotic resistance was noted against commonly used antibiotics. Amikacin and tobramycin were found to be effective against a wide range of pathogens. The results underscore the importance of judicious antibiotic use, continuous monitoring of antimicrobial resistance, and the development of alternative treatment options to effectively manage SSIs.

Keywords: Antimicrobial Surveillance; Antibiotic Resistance; MRSA; Surgical Site Infection.

Authors' Contribution:
[1,2]Conception; Literature research; manuscript design and drafting; [3,4]Critical analysis and manuscript review; [5,6]Data analysis; Manuscript Editing.

Correspondence:
S H Waqar
Email: waqardr@yahoo.com

Article info:
Received: October 27, 2025
Accepted: December 09, 2025

Cite this article. Waqar SH, Hussain AT, Jamal Z, Shakoor A, Khan Z, Wali AHR. Spectrum of Surgical Site Infections in the Surgical Ward. J Islamabad Med Dental Coll. 2025; 14(4): *381-389. DOI: https://doi.org/10.35787/jimdc.v14i4.1483*

Funding Source: Nil
Conflict of interest: Nil

Introduction

Surgical site infections (SSIs) are defined as infections occurring up to 30 days after surgery (or up to one year after surgery in patients receiving implants) and affecting either the incision or deep tissue at the operation site.[1] SSIs represent a significant challenge to surgical healthcare. These infections contribute to prolonged hospital stays, higher rates of hospital readmission, elevated treatment expenses, and considerable morbidity and mortality.[2]

Risk factors for SSIs include both patient-related factors and procedure- or treatment-related (external) factors.[3] Among the treatment-related factors, the quality of the surgical technique is the most important determinant, although most surgical site infections are attributable to patient-related risk

factors rather than to flawed surgical care, including malnutrition, older age, coexistent infection, and diabetes.[4]

The common causative organisms found by various studies carried out in other parts of the world include Staphylococcus aureus, β-lactamase-producing Escherichia coli, Enterococcus, and Pseudomonas aeruginosa.[5-7]

One of the key concerns in the management of SSIs is the increasing resistance of pathogenic microorganisms to commonly used antibiotics, making effective treatment more complex and difficult.[8,9] The emergence of antibiotic resistance, driven by factors such as inappropriate antibiotic use, inadequate infection control practices, and the increasing use of medical devices, poses a significant threat to the effectiveness of existing therapeutic strategies. This study aims to explore the resistance and susceptibility patterns of microorganisms involved in SSIs, which is crucial for developing targeted preventive and interventional strategies to enhance patient safety and improve surgical outcomes in the face of evolving antimicrobial resistance.

Methodology

This cross-sectional observational study was conducted at the Department of General Surgery, Pakistan Institute of Medical Sciences, Islamabad, Pakistan, from January to December 2024. The study included all patients admitted to the surgical ward, both for elective and emergency surgeries, during the one-year study period, provided they met the inclusion criteria. A total of 300 patients were selected using a convenience sampling technique.

The study included patients regardless of gender who underwent elective or emergency surgery and were admitted to the surgical ward.

Patients who were immunocompromised, on immunosuppression therapy, or patients with HIV/AIDS, diabetic patients, or those who had infections elsewhere in the body were excluded from the study.

Patient data, including age, gender, and the organisms responsible for the infections, were collected by reviewing pus culture reports. Surgical site infections (SSIs) were diagnosed by observing local inflammatory signs such as redness, swelling, tenderness, warmth, or purulent discharge during the post-operative period. Pus samples were aseptically collected using sterile swabs or syringes and sent to the laboratory within two hours for culturing and identification of microorganisms using standard microbiological techniques.

Data analysis was performed using SPSS version 25, with all variables presented as frequencies and percentages

Ethical approval was granted by the Ethics Research Review Board of the Pakistan Institute of Medical Sciences, Islamabad (F-5-2-2024(ERRB)/PIMS, dated 11th March 2024).

.Results

The research sample included 300 culture reports from patients who underwent both elective and emergency surgeries, with 74.7% of the participants being males and 25.3% females.

The most common age group to be diagnosed with SSI was 40–49 years. This was followed by individuals aged 30–39 years. (Table I)

Table I: Age group of the study population

Age group	Frequency	Percentage
10-19	18	6.0
20-29	51	17.0
30-39	77	25.7
40-49	83	27.7
50-59	46	15.3
Above 60	25	8.3
Total	300	100.0

Table II: Susceptibility pattern of commonly used antibiotics to the bacterial isolates.

Antibiotic	Klebsiella N=70	E coli N= 51	Pseudomonas N= 38	Staphylococcus Aureus N= 29	Enterobacter N= 24	Acinetobacter N=16	Staphylococcus aureus MRSA N=8
Colistin							
Resistant					4.2%		
Sensitive	5.7%	3.9%	15.8%		8.3%	37.5%	
Intermediate	42.9%	13.7%	23.7%		20.8%	56.3%	
Not Tested	51.4%	82.4%	60.5%	100%	66.7%	6.2%	100%
Cotrimoxazole							
Resistant	57.1%	56.9%	7.9%	58.6%	66.7%	43.8%	62.5%
Sensitive	15.7%	15.7%		24.1%	12.5%	6.2%	12.5%
Not Tested	27.2%	27.4%	92.1%	17.2%	20.8%	50%	25%
Ceftriaxone							
Resistant	61.4%	80.4%	15.8%		75%	50%	12.5%
Sensitive	8.6%	7.8%		6.9%	16.7%		
Not Tested	30%	11.8%	84.2%	93.1%	8.3%	50%	87.5%
Imipenem							
Resistant	31.4%	7.8%	26.3%		16.7%	68.8%	12.5%
Sensitive	25.7%	52.9%	31.6%	6.9%	29.2%	6.2%	
Intermediate	8.6%	2%	2.6%		12.5%		
Not Tested	34.3%	37.3%	39.5%	93.1%	41.7%	25%	87.5%
Amoxicillin							
Resistant	70%	90.2%	5.3%		66.7%	18.8%	12.5%
Sensitive	10%	3.9%	2.6%	3.4%	12.5%	6.2%	
Intermediate	2.9%						
Not Tested	17.1%	5.9%	92.1%	96.6%	20.8%	75%	87.5%
Levofloxacin							
Resistant	40%	41.2%	23.7%	10.3%	20.8%	50%	
Sensitive	4.3%	11.8%	13.2%	6.9%	16.7%		
Intermediate	5.7%						12.5%
Not Tested	50%	47.1%	63.1%	82.8%	62.5%	50%	87.5%
Ciprofloxacin							
Resistant	32.9%	39.2%	39.5%	48.3%	58.3%	56.3%	50%
Sensitive	12.9%	5.9%	28.9%	24.1%	4.2%		
Intermediate	1.4%	2%	2.6%	6.9%			
Not Tested	52.9%	52.9%	28.9%	20.7%	37.5%	43.2%	50%
Amikacin							
Resistant	31.4%	5.9%	39.5%		33.3%	43.8%	
Sensitive	54.3%	82.4%	47.4%	6.9%	50%	25%	
Intermediate	1.4%		5.3%			12.5%	
Not Tested	12.9%	11.8%	7.9%	93.1%	16.7%	18.8%	100%
Gentamicin							
Resistant	42.9%	7.8%	23.7%	17.2%	16.7%	12.5%	100%
Sensitive	12.9%	27.5%	13.2%	65.6%	20.8%	6.3%	
Intermediate	1.4%						
Not Tested	42.9%	64.7%	63.1%	17.2%	62.5%	81.3%	
Chloramphenicol	25.7%	2%			8.3%	87.5%	
Resistant	14.3%	11.8%		96.6%	33.3%		100%
Sensitive		2%					
Intermediate	60%	84.2%	100%	3.4%	58.4%	12.5%	
Not Tested							

Cefepime							
Resistant	27.1%	7.8%	15.8%		16.7%	18.8%	
Sensitive			7.9%				
Not Tested	72.9%	92.2%	76.3%	100%	83.3%	81.3%	100%
Meropenem							
Resistant	5.7%	2%	13.2%		16.7%	12.5%	
Sensitive	7.1%	19.6%	18.4%		16.7%		
Intermediate	4.3%						
Not Tested	82.9%	78.4%	68.4%	100%	66.6%	87.5%	100%
Vancomycin							
Resistant	8.6%						
Sensitive				93.1%			87.5%
Not Tested	91.4%	100%	100%	6.9%	100%	100%	12.5%
TZP							
Resistant	40%	21.6%	31.6%	3.4%	37.5%	75%	
Sensitive	12.9%	17.6%	63.2%		16.7%	6.3%	
Not Tested	47.1%	60.8%	5.3%	96.6%	45.8%	18.7%	100%
Cefixime							
Resistant	72.9%	84.3%	2.6%		83.4%	18.8%	
Sensitive	7.1%	3.9%			8.3%		
Not Tested	20%	11.8%	97.4%	100%	8.3%	81.2%	100%
SCF							
Resistant	50%	27.5%	36.8%		62.5%	62.5%	12.5%
Sensitive	18.6%	47.1%	47.4%	6.9%	33.3%	6.3%	
Intermediate	4.3%	3.9%	2.6%		4.2%	6.3%	
Not Tested	27.1%	21.6%	13.2%	93.1%		25%	87.5%
Tobramycin							
Resistant	47.1%	19.6%	44.7%		41.7%	56.3%	
Sensitive	48.6%	58.8%	47.4%		50%	25%	
Intermediate	1.4%	9.8%				6.3%	
Not Tested	2.9%	11.8%	7.9%	100%	8.3%	12.5%	100%
Ceftazidime							
Resistant	20%	9.8%	47.4%	3.4%	8.3%	75%	
Sensitive			47.4%			6.3%	
Intermediate							
Not Tested	80%	90.2%	5.3%	96.6%	91.7%	18.7%	100%
Tetracycline							
Resistant	8.6%	5.9%			4.2%		
Sensitive							
Intermediate					4.2%		
Not Tested	91.4%	94.1%	100%	100%	91.7%	100%	100%
Linezolid							
Resistant							
Sensitive				10.3%			62.5%
Not Tested	100%	100%	100%	89.7%	100%	100%	37.5%
Erythromycin							
Resistant	8.6%			58.6%			37.5%
Sensitive				27.6%	4.2%		50%
Not Tested	91.4%	100%	100%	13.8%	95.8%	100%	12.5%
Ampicillin							
Resistant	8.6%	11.8%					
Not Tested	91.4%	88.2%	100%	100%	100%	100%	100%
Azithromycin							
Resistant	8.6%						
Sensitive							12.5%
Not Tested	91.4%	100%	100%	100%	100%	100%	87.5%

Penicillin G							
Resistant	8.6%			100%			100%
Not Tested	91.4%	100%	100%		100%	100%	
Minocycline							
Resistant	12.9%	2%	2.6%			25%	
Sensitive	31.4%	15.7%	5.3%	3.4%	33.3%	62.5%	
Intermediate	5.7%		2.6%		4.2%		
Not Tested	50%	82.4%	89.5%	96.6%	62.5%	12.5%	100%
Tigecycline							
Resistant	1.4%		2.6%		4.2%	6.3%	
Sensitive	42.9%	11.8%	21.1%	3.4%	45.8%	31.3%	
Intermediate		3.9%				6.3%	
Not Tested	55.7%	84.3%	76.3%	96.6%	50%	56.3%	100%
Cefoxitin							
Resistant	8.6%			17.3%			75%
Sensitive				79.3%			
Not Tested	91.4%	100%	100%	3.4%	100%	100%	25%
Aztreonam							
Resistant		2%	42.1%	3.4%	8.3%		
Sensitive			28.9%		4.2%		
Intermediate			13.2%				
Not Tested	100%	98%	15.8%	96.6%	87.5%	100%	100%
Clindamycin							
Resistant	8.6%			10.3%			
Sensitive				82.8%			87.5%
Not Tested	91.4%	100%	100%	6.9%	100%	100%	12.5%
Doripenem							
Resistant	14.3%	2%	5.3%		20.8%	37.5%	
Sensitive	5.7%	2%	5.2%				
Not Tested	80%	96%	89.5%	100%	79.2%	62.5%	100%

The most commonly isolated organism was Klebsiella (23.3%), followed by Escherichia coli (17%), Pseudomonas (12.7%), Staphylococcus Aureus (9.7%), Enterobacter, Acinetobacter (5.3%), and Staphylococcus Aureus MRSA (2.66%). Notably, 14.3% of the patients showed no growth on the culture medium. Other organisms were isolated in trace amounts. (Figure 1)

Klebsiella demonstrated the highest sensitivity to amikacin (54.3%) and tobramycin (48.6%), intermediate susceptibility to colistin (42.9%), and resistance to cefixime (72.9%), amoxicillin (70%), ceftriaxone (61.4%), and cotrimoxazole (57.1%). Escherichia coli was mostly sensitive to amikacin (82.4%), tobramycin (58.8%), imipenem (52.9%), and sulfamethoxazole-trimethoprim SCF (47.1%) while exhibiting high resistance to amoxicillin (90.2%), cefixime (84.3%), and ceftriaxone (80.4%). Pseudomonas showed moderate sensitivity to amikacin (47.4%), sulfamethoxazole-trimethoprim SCF (47.4%), tobramycin (47.4%), and ceftazidime (47.4%), and was mostly sensitive to piperacillin-tazobactam TZP (63.2%). Staphylococcus aureus exhibited the greatest sensitivity to chloramphenicol (96.6%), followed by vancomycin (93.1%), clindamycin (82.8%), and cefoxitin (79.3%), while showing 100% resistance to penicillin and notable resistance to erythromycin (58.6%), cotrimoxazole (58.6%), and ciprofloxacin (48.3%). The MRSA strains showed complete sensitivity to chloramphenicol (100%) and retained susceptibility to linezolid (62.5%), vancomycin (87.5%), and clindamycin (87.5%) while exhibiting 100% resistance to gentamicin and penicillin. Enterobacter showed moderate sensitivity to amikacin (50%), tobramycin (50%), and tigecycline (45.8%), while demonstrating resistance to cefixime (83.4%), ceftriaxone (75%), amoxicillin (66.7%), and cotrimoxazole (66.7%). and

Acinetobacter was mostly sensitive to colistin (56.3%) and minocycline (62.5%), and mostly resistant to chloramphenicol (87.5%), ceftazidime (75%), and TZP (75%). (Table II)

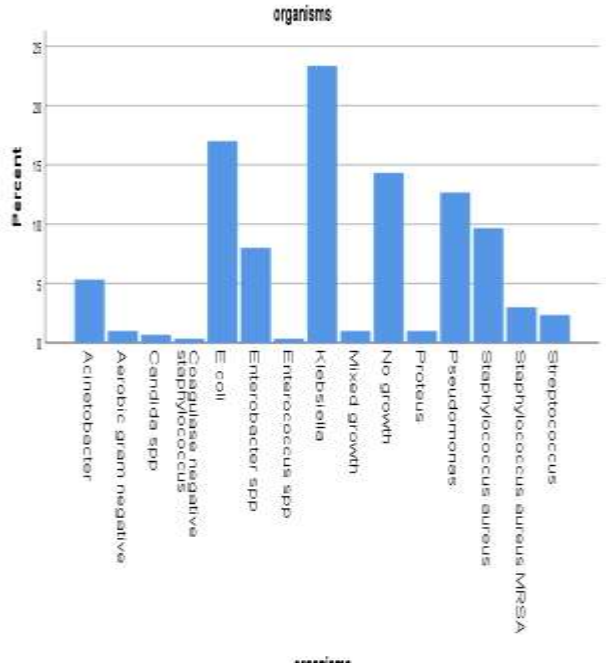

Figure 1. Distribution of pathogenic bacteria isolated from the study participants.

Discussion

The disparity in gender distribution in the study, with more male patients (74.7%) than female patients (25.3%), is a finding consistent with other reports, could be due to factors like cultural or social norms, differences in healthcare access, the types of surgeries being performed (e.g., trauma-related or hernia surgeries are more common in males), and the specific patient population during the study period.[10,11] Additionally, certain surgical conditions may be more prevalent in males, further contributing to the gender imbalance.

The antimicrobial susceptibility profile of the Klebsiella isolate reveals a significant sensitivity to aminoglycosides, particularly amikacin and tobramycin, suggesting their potential efficacy in treating infections caused by this strain. This aligns with the existing literature supporting the role of aminoglycosides in managing multidrug-resistant Gram-negative infections due to their potent bactericidal activity.[12] The intermediate susceptibility to colistin is noteworthy, as it may indicate emerging resistance or borderline susceptibility, warranting cautious use and further confirmatory testing. Conversely, resistance to cephalosporins and amoxicillin underscores the reduced efficacy of these beta-lactam antibiotics, likely due to the production of beta-lactamases, particularly extended-spectrum beta-lactamases (ESBLs), with similar resistance patterns reported in previous studies.[13,14]

The observed antimicrobial susceptibility pattern of *E. coli* highlights a concerning trend of high resistance to commonly used beta-lactam antibiotics, including third-generation cephalosporins and amoxicillin, consistent with findings reported in a previous study whereas the predominant sensitivity of *E. coli* to amikacin aligns with findings from earlier studies and moderate sensitivity to tobramycin, sulfamethoxazole-trimethoprim (SCF), and imipenem suggests that aminoglycosides and carbapenems remain effective therapeutic options against such resistant strains.[13,15] The efficacy of imipenem also underscores the importance of reserving carbapenems for severe infections to prevent the emergence of carbapenem-resistant Enterobacteriaceae (CRE).[16] The analysis of Pseudomonas strains revealed moderate sensitivity to several antibiotics, including amikacin, sulfamethoxazole-trimethoprim (SCF), and tobramycin, while sensitivity to ceftazidime has also been documented in numerous other studies.[10,13,17] While these antibiotics showed some efficacy, the moderate sensitivity suggests that their use should be carefully considered based on individual patient factors and local resistance patterns. Notably, Pseudomonas was found to be mostly sensitive to piperacillin-tazobactam (TZP), indicating that it may be the most reliable option for treating

Pseudomonas-related infections.[18] The complete resistance of *Staphylococcus aureus* to penicillin is consistent with global reports,[13,14,19] attributed to the widespread production of penicillinase among *S. aureus* strains. Additionally, resistance to erythromycin, cotrimoxazole, and ciprofloxacin suggests a growing challenge in the empirical treatment of *S. aureus* infections, potentially due to overuse or misuse of these agents in clinical settings. However, it demonstrated the greatest sensitivity to chloramphenicol, clindamycin, cefoxitin, and vancomycin, while the MRSA (Methicillin-resistant Staphylococcus aureus) isolates demonstrated predominant sensitivity to chloramphenicol, linezolid, clindamycin, and vancomycin. The sensitivity of all *Staphylococcus aureus* strains to vancomycin observed in this study is consistent with findings reported in various other studies.[20-23] This sustained susceptibility may be attributed to the restricted use of vancomycin, typically reserved for severe or resistant infections, thereby reducing the selective pressure for resistance development.

The resistance pattern observed in *Enterobacter* spp. aligns with findings from other studies,[24,25] highlighting widespread resistance to β-lactams, including cefixime, ceftriaxone, and amoxicillin. This resistance may be attributed to the production of extended-spectrum β-lactamases (ESBLs). Although moderate sensitivity to amikacin, tobramycin, and tigecycline provides some therapeutic options, these results emphasize the importance of susceptibility-guided therapy. On the other hand, *Acinetobacter* species showed a high level of sensitivity to colistin, aligning with the results of previous studies,[24] as well as to minocycline, making these antibiotics preferred treatment options for *Acinetobacter*-related infections. In contrast, the resistance of *Acinetobacter* isolates to ceftazidime and ciprofloxacin observed in this study is consistent with findings reported by other researchers.[13] The decreased efficacy of ceftazidime and ciprofloxacin significantly limits treatment options, especially in nosocomial settings where *Acinetobacter* is a common cause of severe infections.

The absence of growth on culture media in surgical site infection (SSI) samples could be attributed to several factors: prior antibiotic treatment, improper sample collection, failure of sterile techniques, low bacterial load, or the presence of fastidious organisms that require specific conditions for growth. These factors can hinder the detection of microorganisms in culture, leading to negative results.

In this study, common antibiotics such as the beta-lactam group, macrolides, tetracyclines, cephalosporins, and quinolones were found to be resistant to most bacterial strains. This widespread resistance poses a significant challenge to clinical treatment, as these antibiotics are frequently used to manage various bacterial infections. The resistance observed may be attributed to factors such as overuse and misuse of these antibiotics, which contribute to the development of resistance mechanisms like the production of beta-lactamases, efflux pumps, and altered target sites. The findings underscore the urgent need for continuous surveillance, the development of new antibiotics, and alternative treatment strategies to effectively combat resistant bacterial infections.

Limitations of the study: This study has some limitations, including a small sample size. The focus on a limited set of antibiotics may overlook other potentially effective agents, and the use of culture-based methods might not detect all microbial species. Future research with larger sample sizes, broader antibiotic testing, and molecular analysis would help overcome these limitations and provide more comprehensive insights.

Conclusion

This study found Klebsiella, E. coli, Pseudomonas, and Staphylococcus aureus to be among the most common bacterial pathogens responsible for surgical site infections (SSIs). It also revealed high levels of antibiotic resistance in these bacterial

strains. Common antibiotics like beta-lactams and macrolides were mostly ineffective, highlighting the need for alternative treatments. However, antibiotics such as amikacin and tobramycin showed promising sensitivity. The study stresses the importance of continuous monitoring of antimicrobial resistance to guide effective treatment strategies.

References

1. Zabaglo M, Leslie SW, Sharman T. Postoperative Wound Infections. [Updated 2024 Mar 5]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK560533/
2. Oliveira M, Antunes W, Mota S, Madureira-Carvalho Á, Dinis-Oliveira RJ, Dias da Silva D. An Overview of the Recent Advances in Antimicrobial Resistance. Microorganisms. 2024; 12(9): 1920. https://doi.org/10.3390/microorganisms12091920
3. Kundarapu V, Shelke A, Priya P, Mishra S, Chauhan R, Dhingra S. Assessment of surgical site infections with antimicrobial resistance among cancer patients at a tertiary care hospital: A prospective study. Clinical Epidemiology and Global Health 2025; 34: 102103.https://doi.org/10.1016/j.cegh.2025.102103
4. Bucataru A, Balasoiu M, Ghenea AE, Zlatian OM, Vulcanescu DD, Horhat FG et al. Factors Contributing to Surgical Site Infections: A Comprehensive Systematic Review of Etiology and Risk Factors. Clin Pract. 2023; 14(1): 52-68. https://doi.org/10.3390/clinpract14010006.
5. Bush K, Bradford PA. Epidemiology of β-Lactamase-Producing Pathogens. Clin Microbiol Rev. 2020; 33(2): e00047-19. https://doi.org/10.1128/CMR.00047-19.
6. Lakoh S, Yi L, Russell JBW, Zhang J, Sevalie S, Zhao Y, et al. The burden of surgical site infections and related antibiotic resistance in two geographic regions of Sierra Leone: A prospective study. Therapeutic Advances in Infectious Disease. 2022; 9. https://doi.org/10.1177/20499361221135128
7. Prajescu B, Gavriliu L, Iesanu MI, Ioan A, Boboc AA, Boboc C, Galos F. Bacterial Species and Antibiotic Resistance - A Retrospective Analysis of Bacterial Cultures in a Pediatric Hospital. Antibiotics (Basel). 2023; 12(6): 966. https://doi.org/10.3390/antibiotics12060966.
8. Rezaei AR, Zienkiewicz D, Rezaei AR. Surgical site infections: a comprehensive review. J Trauma Inj. 2025 Jun;38(2):71-81. https://doi.org/10.20408/jti.2025.0019.
9. Pinchera B, Buonomo AR, Schiano Moriello N, Scotto R, Villari R, Gentile I. Update on the Management of Surgical Site Infections. Antibiotics (Basel). 2022; 11(11): 1608. https://doi.org/10.3390/antibiotics11111608.
10. Bashir J, Sahito RA, Abbasi MA, Jabeen A. Surgical site infection: evaluation of causative organisms involved. Professional Med J 2015; 22(2): 181- 85. https://doi.org/10.29309/TPMJ/2015.22.02.1367
11. Mukagendaneza MJ, Munyaneza E, Muhawenayo E, Nyirasebura D, Abahuje E, Nyirigira J et al. Incidence, root causes, and outcomes of surgical site infections in a tertiary care hospital in Rwanda: a prospective observational cohort study. Patient Saf Surg. 2019; 13: 10. https://doi.org/10.1186/s13037-019-0190-8.
12. Thy M, Timsit JF, de Montmollin E. Aminoglycosides for the Treatment of Severe Infection due to Resistant Gram-Negative Pathogens. Antibiotics (Basel). 2023; 12(5): 860. https://doi.org/10.3390/antibiotics12050860.
13. Alanazi B, Muhiuddin G, Albalawi Y, Alhazmi K, Alzahrani O, Alamri M et al. Antibiotic Resistance & Extended-Spectrum ß-Lactamase Production in Clinical and Non-Clinical Isolates in Tabuk. Medical Sciences. 2024; 12(3): 42.
14. Dessie W, Mulugeta G, Fentaw S, Mihret A, Hassen M, Abebe E. Pattern of bacterial pathogens and their susceptibility isolated from surgical site infections at selected referral hospitals, Addis Ababa, Ethiopia. International Journal of Microbiology. 2016; 2016: 1–8. https://doi.org/10.1155/2016/2418902
15. Ali KM, Al-Jaff BMA. Source and antibiotic susceptibility of gram-negative bacteria causing superficial incisional surgical site infections. International Journal of Surgery Open. 2021; 30: 100318. https://doi.org/10.1016/j.ijso.2021.01.007
16. Alshehri AA, Irekeola AA. Prevalence of carbapenem-resistant Enterobacterales (CRE) in Saudi Arabia: A systematic review and meta-analysis. Saudi Pharmaceutical Journal 2024; 32(11): 102186.https://doi.org/10.1016/j.jsps.2024.102186.
17. Thabit AK, Alghamdi AM, Miaji MY, Alharbi FS, Jawah AF, Alturki F et al. Antibiotic susceptibility of Pseudomonas aeruginosa in Saudi Arabia: a national antimicrobial resistance surveillance study. Front. Public Health 2024; 12: 1436648. https://doi.org/10.3389/fpubh.2024.1436648
18. Karruli A, Catalini C, D'Amore C, Folgia F, Mari F, Harxhi A et al. Evidence-Based Treatment of Pseudomonas aeruginosa Infections: A Critical Reappraisal. Antibiotics (Basel). 2023; 12(2): 399. https://doi.org/10.3390/antibiotics12020399

19. Brdová D, Ruml T, Viktorová J. Mechanism of staphylococcal resistance to clinically relevant antibiotics, Drug Resistance Updates 2024; 77: 101147. Doi. https://doi.org/10.1016/j.drup.2024.101147.
20. Rasheed Y, Imdad K, Yasmin R, Gul A, Jamil A, Aslam U. Antimicrobial susceptibility pattern of Staphylococcus aureus strains in Islamabad, Pakistan. Pak Armed Forces Med J 2021; 71(3): 1056-60. Doi. https://www.pafmj.org/PAFMJ/article/view/5451
21. Jha B, Gautam S, Sharma J, Sharma M. Bacteriological profile and antimicrobial resistance pattern in surgical site infection in a tertiary care hospital, central Nepal. Medical Journal of Shree Birendra Hospital. 2021; 20(2): 110–15. https://doi.org/10.3126/mjsbh. v20i2.33399
22. Akhi MT, Ghotaslou R, Beheshtirouy S, Asgharzadeh M, Pirzadeh T, Asghari B et al. Antibiotic Susceptibility Pattern of Aerobic and Anaerobic Bacteria Isolated from Surgical Site Infections of Hospitalized Patients. Jundishapur J Microbiol. 2015; 8(7): e20309. https://doi.org/10.5812/jjm.20309v2.
23. Gebissa T, Bude B, Yasir M, Mekit S, Noorulla KM. Bacterial isolates and their antibiotic sensitivity pattern of surgical site infections among the surgical ward patients of Asella Referral and teaching hospital. Future Journal of Pharmaceutical Sciences. 2021; 7(1). https://doi.org/10.1186/s43094-021-00255-x
24. Ullah Z, Asghar J, Aziz N, Ullah A, Ashour AA, Felemban MF et al. Bacterial profiling and antibiotic resistance patterns in urinary tract infections: a microbiological analysis from Dera Ismail Khan, Pakistan. BMC Infect Dis 2025; 25(1): 1151. https://doi.org/10.1186/s12879-025-11588-w
25. Ramanisankar A, Shanmugasundaram N, Paramasivam M, Priyamalar EMN, Sundararajan AP, Sivakumar DR et al. Antimicrobial Resistance Patterns and the Role of Antibiotic Stewardship in a Secondary Care Hospital. Recent Advances in Anti-Infective Drug Discovery 2025; 20(3): 203-222. Doi. http://dx.doi.org/10.2174/0127724344369266250310084603.