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Original Research Article

Prevalence and Antibiotic Resistance Patterns of Micro-organisms in Post-operative Wound Infections from the Surgical Floor of Mayo Hospital

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Abstract: *Surgical site infections (SSIs) remain a major cause of postoperative morbidity in low- and middle-income settings, with rising antimicrobial resistance complicating empirical management. Local data on pathogen profiles and resistance patterns are essential to guide effective therapy and infection control strategies.* ***Objective:*** *To determine the prevalence of surgical site infections and to characterise the microbiological spectrum and antibiotic resistance patterns of pathogens isolated from post-operative wound infections at a tertiary care hospital in Lahore, Pakistan.* ***Methods:*** *A cross-sectional study was conducted at the Surgical Tower of Mayo Hospital, Lahore, from January 2025 to July 2025. Consecutive patients with clinically suspected post-operative wound infections were enrolled. Wound swabs or pus aspirates were collected aseptically from 250 patients and processed using standard microbiological techniques. Isolates were identified by Gram staining and biochemical methods. Antibiotic susceptibility testing was performed using the Kirby–Bauer disc diffusion method in accordance with CLSI guidelines. Demographic and clinical data were recorded, and descriptive statistics were used to summarise prevalence, pathogen distribution, and susceptibility patterns.* ***Results:*** *Of 250 post-operative wound samples, 75 were culture-positive, yielding an SSI prevalence of 30.0%. Culture positivity was higher among males (58.6%) and urban residents (61.3%), with the greatest burden observed in patients aged 35–44 years (34.6%). General and orthopaedic surgeries accounted for the highest proportions of culture-positive infections. A total of 93 bacterial isolates were recovered, predominantly Gram-negative organisms, including Escherichia coli (23.6%), Klebsiella pneumoniae (19.4%), Pseudomonas aeruginosa (19.4%), and Acinetobacter baumannii (17.2%). Methicillin-resistant Staphylococcus aureus constituted 14.0% of isolates. High resistance to penicillins and cephalosporins was observed among Gram-negative pathogens, with reduced fluoroquinolone effectiveness. Carbapenems and amikacin demonstrated the highest activity against Gram-negative isolates, while vancomycin and linezolid remained effective against Gram-positive organisms, including MRSA.* ***Conclusion:*** *Post-operative wound infections at this tertiary care centre were frequent and predominantly caused by multidrug-resistant Gram-negative pathogens. The observed resistance patterns limit the utility of commonly used empirical antibiotics and underscore the need for routine culture-based diagnosis, local antibiogram-guided therapy, and strengthened antimicrobial stewardship and infection control measures in surgical settings.*

Keywords: Surgical Wound Infection, Drug Resistance, Bacterial, Microbial Sensitivity Tests, Gram-Negative Bacteria, Anti-Bacterial Agents

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Introduction

Surgical site infections (SSIs) are a significant complication following surgical procedures, contributing to increased morbidity and healthcare costs. SSIs can arise from various factors, including microbial contamination during surgery, the patient's immune status, and the type of surgical procedure performed. The Centers for Disease Control and Prevention (CDC) classify SSIs into three types: superficial, deep, and organ/space infections, each with varying implications for patient health (1). Globally, SSIs are estimated to occur in approximately 2-5% of all surgical patients, although some studies indicate rates as high as 30% in specific contexts (2).

Antibiotic prophylaxis is a common strategy to prevent SSIs, particularly in high-risk procedures. However, evidence suggests that antibiotic resistance among pathogens implicated in SSIs is escalating rapidly, complicating treatment and management strategies (3-5). For instance, a study in Pakistan revealed that Staphylococcus aureus and Escherichia coli are among the most frequently isolated pathogens in post-operative infections, with resistance patterns indicating a worrying trend towards multidrug resistance (6-7). In recent years, increased attention has been paid to the role of antimicrobial resistance (AMR) in post-operative infections. Research has shown that common pathogens such as methicillin-resistant Staphylococcus aureus (MRSA) and extended-spectrum beta-lactamase (ESBL) producing Enterobacteriaceae are prevalent in surgical wards (8, 3). Moreover, existing literature indicates a 40% prevalence of MRSA among S. aureus isolates from surgical patients in various regions, highlighting the need for stringent antibiotic stewardship programs (9, 10).

A specific focus on antimicrobial resistance patterns in surgical contexts is essential, given the unique microbiological dynamics in post-operative wounds. Khalim et al. reported that chronic wound infections often involve polymicrobial flora that confer higher resistance levels to commonly used antibiotics, necessitating tailored therapeutic approaches (9). The complexity of these infections is exacerbated in resource-limited settings, where inadequate access to antibiotics can worsen treatment outcomes.

Moreover, several studies emphasize the nuances in infection prevalence across different geographical regions, underpinning the need for localized research (11, 12). For example, research in Nepal indicates distinct bacterial profiles in surgical wound infections, predominantly influenced by local antibiotic prescribing practices and resistance patterns (13). This underscores the necessity for similar investigations within Pakistani healthcare settings, where knowledge of local microbial flora and corresponding resistance patterns is critical for effective clinical management.

This study aims to investigate the prevalence of microbial pathogens responsible for post-operative wound infections on the surgical floor at Mayo Hospital, Lahore, Pakistan, and to determine their antibiotic susceptibility patterns. The findings are significant not only in tailoring local antimicrobial therapy but also in shaping broader hospital infection control policies.

In the context of the Pakistani population, the burden of SSIs presents unique challenges. The rising rates of antibiotic resistance in this region, exacerbated by the overprescription and misuse of antibiotics, necessitate urgent attention (14, 5). The lack of consistent guidelines for prophylactic antibiotic use further complicates efforts to mitigate this public health issue. Understanding the local resistance patterns in surgical settings is paramount to improving patient outcomes and addressing the growing concern of AMR. Therefore, this study is strategically positioned to provide critical insights that will inform clinical practice and guide healthcare policy in Pakistan.

Methodology

This cross-sectional study was conducted at the Surgical Tower of Mayo Hospital, Lahore, Pakistan, from January 2025 to July 2025, with microbiological analyses performed in collaboration with the well-equipped microbiology laboratory of King Edward Medical University. Patients presenting with clinically suspected post-operative wound infections during in-hospital stay or follow-up visits were consecutively recruited after obtaining written informed consent. Both adult and pediatric patients were eligible for inclusion, with consent obtained from parents or legal guardians for minors. Eligible participants included patients with incisional surgical wounds showing clinical features suggestive of infection, such as purulent discharge, pain, redness, or swelling. Patients who had received systemic antibiotic therapy within 72 hours prior to sample collection, those without clinical or laboratory evidence of wound infection, individuals with severe immunosuppressive conditions, including HIV infection, or those receiving chemotherapy or long-term corticosteroids, patients with multiple concurrent infection sites that could confound microbiological findings, and those with incomplete clinical or surgical histories were excluded to minimize bias and confounding.

A total of 250 wound samples were collected using aseptic techniques, either by sterile swab or aspiration of pus from the infected surgical site, depending on the wound characteristics. Samples were promptly transported to the microbiology laboratory for processing. Primary isolation of micro-organisms was performed using standard culture techniques on appropriate bacteriological media, followed by incubation under aerobic conditions. Identification of isolates was carried out using colony morphology, Gram staining, and a battery of conventional biochemical tests, including catalase, coagulase, oxidase, urease, citrate utilization, triple sugar iron (TSI) agar reaction, and indole testing, as appropriate for organism differentiation. In cases of mixed growth, each morphologically distinct colony type was sub-cultured and identified separately to ensure accurate characterization of polymicrobial infections. Antibiotic susceptibility testing was performed for all confirmed isolates using the Kirby-Bauer disc diffusion method in accordance with Clinical and Laboratory Standards Institute guidelines. A standardized inoculum equivalent to 0.5 McFarland turbidity standard was prepared for each isolate and uniformly inoculated onto Mueller-Hinton agar plates. Antibiotic discs representing commonly prescribed classes, including penicillins, beta-lactam/beta-lactamase inhibitor combinations, cephalosporins, fluoroquinolones, aminoglycosides, carbapenems, macrolides, glycopeptides, and oxazolidinones, were applied, and plates were incubated at 35 to 37°C for 18 to 24 hours. Zones of inhibition were measured and interpreted as sensitive, intermediate, or resistant according to CLSI interpretive criteria. Quality control procedures were maintained using standard reference strains to ensure the reliability of susceptibility results.

Demographic and clinical data, including age, gender, area of residence, occupation, type of surgery performed, and time elapsed since surgery, were recorded using a structured questionnaire. Data were entered and analyzed using standard statistical software. Descriptive statistics were applied to calculate frequencies and percentages of culture positivity, distribution of bacterial isolates, and antibiotic susceptibility patterns. Demographic and surgical variables were used to stratify the prevalence of surgical site infections and the distribution of causative pathogens, to explore potential associations. All procedures adhered to ethical principles, and confidentiality of patient data was strictly maintained throughout the study.

Results

Out of 250 post-operative wound samples, 75 were culture-positive, yielding an SSI prevalence of 30.0% (Table 1). Among culture-positive cases, a higher proportion of patients were urban residents (61.3%) than rural or semi-urban residents (38.7%). Skilled workers constituted the largest occupational group affected (38.7%), followed by housewives (32.0%). Male patients accounted for a greater share of infections than females (58.6% vs 41.3%) (Table 1). General surgical procedures represented the largest proportion of enrolled cases (31.2%), followed by orthopedic (25.6%) and gynecological surgeries (18.4%). The highest SSI culture positivity was observed following general surgery (37.2%) and orthopedic procedures (32.8%), whereas lower positivity rates were seen in gynecological and urological surgeries (Table 2). Age-stratified analysis showed that SSI positivity was most frequent in patients aged 35–44 years (34.6%), followed by 45–54 years (26.6%). The burden of bacterial isolates was also highest in these age groups, accounting for the majority of recovered pathogens (Table 3). A total of 93 bacterial isolates were recovered from 75 culture-positive cases. Gram-negative organisms predominated, with Escherichia coli (23.6%), Klebsiella pneumoniae (19.4%), Pseudomonas aeruginosa (19.4%), and Acinetobacter baumannii (17.2%) being the most frequent isolates. MRSA accounted for 14.0% of isolates. The distribution of pathogens was broadly similar between males and females, with a consistent predominance of Gram-negative organisms in both genders (Table 4). When stratified by age group, these Gram-negative pathogens remained dominant across all age categories, with the highest isolate counts observed in patients aged 35–54 years (Table 5). The antibiotic susceptibility profile revealed high resistance among Gram-negative isolates to commonly used agents, including penicillins and cephalosporins, with reduced fluoroquinolone effectiveness. Carbapenems and amikacin showed the highest activity against Gram-negative organisms. Gram-positive isolates, particularly MRSA, demonstrated substantial resistance to penicillin, erythromycin, and gentamicin, while vancomycin and linezolid remained highly effective. These findings highlight a high burden of multidrug-resistant pathogens and support the need for culture-guided therapy (Table 6)

Table 1: Baseline characteristics and SSI prevalence among post-operative patients (n = 250)

Variable	Category	n	%
SSI culture result	Positive	75	30.0
	Negative	175	70.0
Residence (positives)	Urban	46	61.3
	Rural/Semi-urban	29	38.7
Occupation (positives)	Skilled workers	29	38.7
	Housewives	24	32.0
	Office workers	11	14.7
	Others	11	14.6
Gender (positives)	Male	44	58.6
	Female	31	41.3

Table 2: Type of surgery and SSI culture positivity (n = 250)

Type of surgery	Total n (%)	SSI positive n (%)	SSI negative n (%)
General surgery	78 (31.2)	29 (37.2)	49 (62.8)
Orthopedic	64 (25.6)	21 (32.8)	43 (67.2)
Gynecological	46 (18.4)	13 (28.3)	33 (71.7)
Urological	32 (12.8)	7 (21.9)	25 (78.1)
Other surgeries	30 (12.0)	5 (16.7)	25 (83.3)

Table 3: Age-wise distribution of SSI positivity and bacterial isolates (n = 75 patients; 93 isolates)

Age group (years)	SSI positive n (%)	Total isolates (n)
15–24	8 (10.7)	8
25–34	12 (16.0)	12
35–44	26 (34.6)	32
45–54	20 (26.6)	30
55–64	9 (12.1)	11
Total	75 (100)	93

Table 4: Distribution of bacterial isolates by gender and overall frequency (n = 93 isolates)

Organism	Male n (%)	Female n (%)	Total n (%)
Escherichia coli	13 (24.1)	9 (23.1)	22 (23.6)
Klebsiella pneumoniae	10 (18.5)	8 (20.5)	18 (19.4)
Pseudomonas aeruginosa	11 (20.4)	7 (17.9)	18 (19.4)
Acinetobacter baumannii	9 (16.7)	7 (17.9)	16 (17.2)
MRSA	8 (14.8)	5 (12.8)	13 (14.0)
Proteus mirabilis	2 (3.7)	2 (5.1)	4 (4.3)
MSSA	1 (1.8)	0	1 (1.1)
Citrobacter freundii	0	1 (2.6)	1 (1.1)

Table 5. Distribution of bacterial isolates across age groups (n = 93 isolates)

Organism	15–24	25–34	35–44	45–54	55–64	Total
Escherichia coli	2	3	8	6	3	22
Klebsiella pneumoniae	2	2	7	5	2	18
Pseudomonas aeruginosa	1	3	6	6	2	18
Acinetobacter baumannii	1	2	5	6	2	16
MRSA	1	1	4	5	2	13
Proteus mirabilis	1	1	1	1	0	4
MSSA	0	0	1	0	0	1
Citrobacter freundii	0	0	0	1	0	1
Total isolates	8	12	32	30	11	93

Table 6: Antibiotic susceptibility patterns of bacterial isolates recovered from post-operative wound infections (n = 93)

Antibiotic Class	Antibiotic	Gram-negative isolates	Gram-positive isolates
Penicillins	Penicillin	High resistance	High resistance
	Ampicillin	High resistance	High resistance
	Amoxicillin-clavulanate	High resistance	High resistance
Cephalosporins	Ceftriaxone	High resistance	Moderate resistance
	Cefotaxime	High resistance	Moderate resistance
	Cefepime	High resistance	Variable response
Fluoroquinolones	Ciprofloxacin	Low effectiveness	Variable effectiveness
	Levofloxacin	Low effectiveness	Variable effectiveness
Aminoglycosides	Amikacin	High sensitivity	Moderate sensitivity
	Gentamicin	High resistance	High resistance (especially MRSA)
Carbapenems	Imipenem	Highest sensitivity	Not routinely tested
	Meropenem	Highest sensitivity	Not routinely tested
Glycopeptides	Vancomycin	Not applicable	High sensitivity
Oxazolidinones	Linezolid	Not applicable	High sensitivity
Macrolides	Erythromycin	High resistance	High resistance
Sulfonamides	Co-trimoxazole	High resistance	Moderate resistance

High resistance indicates >70% of isolates are resistant. High sensitivity indicates >70% of isolates are susceptible. Susceptibility testing was performed using the Kirby-Bauer disc diffusion method, according to CLSI guidelines.

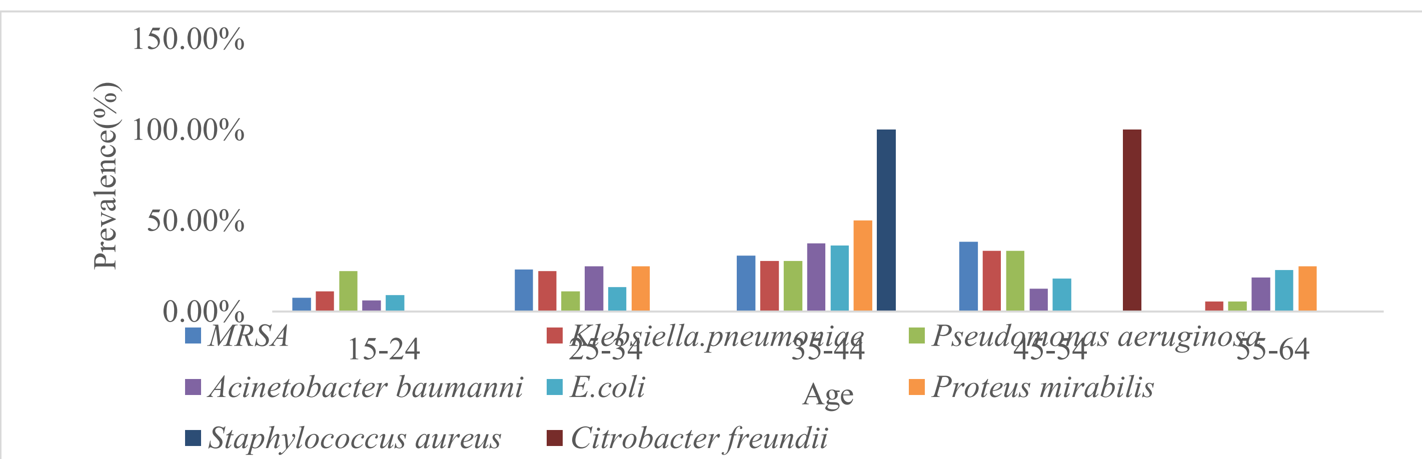

Figure 1: Prevalence of different micro-organisms in different age groups

Discussion

Our study aimed to investigate the prevalence and antibiotic resistance patterns of microbial infections in post-operative wound samples. Among 250 post-operative wound samples analyzed, the observed 30% culture positivity for surgical site infections (SSIs) aligns with recent literature, which consistently reports SSI prevalence rates ranging from 13% to 35% across various healthcare settings worldwide (15-17). For instance, the work of Namburi et al. indicated a similar prevalence of culture-positive infections, highlighting the pervasive issue of post-operative infections in surgical wards (15).

In our cohort, urban residents accounted for a higher share of the culture-positive group (61.3%) than their rural or semi-urban counterparts (38.7%). This finding resonates with that of Wang et al., who observed that demographic factors, particularly urban residency, are consistently associated with increased SSIs, likely due to the availability of healthcare resources and factors affecting health-seeking behavior (16).

Our analysis also showed a predominance of SSIs among skilled workers (38.7%). Male patients accounted for 58.6% of cultures, which reflects trends found in the contemporary studies indicating that males and working populations are at higher risk for surgical infections due to higher exposure rates from workplace injuries and other factors (18, 19). This gender disparity aligns with studies such as those by Shakthi et al., who highlighted similar demographic trends, noting that the occupational distribution of patients plays a crucial role in infection prevalence (20).

Further, our results indicated that general surgical procedures had the highest SSI culture positivity rate (37.2%), followed by orthopedic (32.8%) and gynecological procedures (28.3%). This aligns with findings from Liu et al., who reported that surgical type significantly affects infection risk, particularly emphasizing that general and orthopedic surgeries have inherently higher complication rates due to factors such as the nature and duration of the procedures (21).

The age-group analysis in our study demonstrated that patients aged 35–44 years showed the highest SSI positivity (34.6%), followed by those aged 45–54 years (26.6%). This trend corresponds with findings by Majumder et al., which suggested that susceptibility to postoperative infections increases with age due to declining health status and the prevalence of comorbidities in these age groups (22).

The study reported a total of 93 bacterial isolates, predominantly Gram-negative bacteria including Escherichia coli (23.6%), Klebsiella pneumoniae (19.4%), and Acinetobacter baumannii (17.2%). The dominance of Gram-negative organisms is a well-documented trend in recent literature, indicating their prevalence in surgical site infections. For instance, a study by Quddus et al. identified similar organisms in higher proportions, reiterating the significance of these pathogens in post-operative settings (23).

Moreover, the significant prevalence of methicillin-resistant Staphylococcus aureus (MRSA), accounting for 14.0% of isolates, highlights a concerning trend noted by Antony et al. in their investigations into wound management strategies, emphasizing the global rise in resistance patterns among common pathogens (24, 25).

Our findings revealed a high resistance rate among Gram-negative isolates to commonly prescribed antibiotics, including penicillins and cephalosporins, corroborating recent literature that underscores alarming resistance trends (16, 26). This is consistent with the findings from Hafudh et al., who also noted that Acinetobacter baumannii exhibited a high degree of multidrug resistance, complicating treatment options (27). Other studies have similarly pointed out the diminished effectiveness of fluoroquinolones in treating these infections (28).

On the positive side, carbapenems and amikacin showed stronger activity against Gram-negative isolates, reaffirming their role as last-resort antibiotics for treating severe infections (23, 29). The susceptibility of Gram-positive MRSA to vancomycin and linezolid remains a crucial finding, aligning with WHO guidelines that advocate these antibiotics for resistant Staphylococcus infections (30).

Given the high rates of multidrug-resistant organisms identified in this study, there is a pressing need to implement robust infection control measures and improve antibiotic stewardship protocols across surgical departments. Routine susceptibility testing can guide more effective empirical therapy, minimize the impact of antibiotic resistance, and ultimately improve patient outcomes (31).

In conclusion, the complexities surrounding surgical site infections, especially in our Pakistani context, necessitate tailored approaches that integrate local data on incidence and resistance patterns. Continuous monitoring and systematic data collection regarding SSIs are crucial in combating the rising tide of antibiotic resistance. This can guide not only clinical practice but also public health interventions aimed at reducing the incidence of these infections.

Conclusion

This study demonstrates a high burden of surgical site infections, predominantly caused by multidrug-resistant Gram-negative bacteria, in a tertiary care hospital in Pakistan. The limited effectiveness of commonly used antibiotics highlights the need for routine microbiological surveillance, culture-guided antimicrobial therapy, and robust antimicrobial stewardship programs to improve postoperative outcomes and curb the progression of antimicrobial resistance.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-MMNCS-0331d-24)

Consent for publication

Approved

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Conflict of interest

The authors declared no conflicts of interest.

Author Contribution

MF (Student), SA (Student)

Contributed to study design, data collection, and initial manuscript drafting

Assisted in data acquisition, literature review, and manuscript editing

Performed statistical analysis and contributed to the interpretation of results

Helped in methodology development, data organization, and manuscript formatting

Contributed to patient recruitment, data entry, and results compilation

UFG (Assistant Professor), US (Assistant Professor), KA (PGR)

Assisted in referencing, proofreading, and final revisions of the manuscript

Guided study execution and critically reviewed the manuscript

Supervised the research, coordinated among authors, finalized the manuscript, and approved the final version

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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