

Original Research Article

Bacteriological profile and antimicrobial susceptibility pattern of microorganisms isolated from surgical site infections at tertiary care center in Western India

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ABSTRACT

Background: Among different types of hospital-acquired infections, Surgical site infections (SSIs) continue to be a major concern, due to prolonged hospitalizations, increased costs, and significant morbidity and mortality. Understanding the etiological agents behind these infections and their antimicrobial susceptibility patterns can greatly aid in the management of SSIs.

Methods: This prospective, single-center, laboratory-based study was carried out over nine months at a tertiary care teaching hospital. Pus-aspirates from 6575 patients suspected of developing SSIs were collected and analyzed according to the standard microbiological techniques. The antimicrobial susceptibility of isolated organisms was tested using Kirby-Bauer's disc diffusion method or by the VITEK-2 compact system.

Results: The study concluded the SSI rate of 5.27%. Gram-negative organisms were the leading cause of SSIs (84%), with *Klebsiella pneumoniae* (22.87%) being the most common pathogen, followed by *E. coli* (21.14%) and *Pseudomonas aeruginosa* (17.94%). Nearly 42.38% of all Gram-negative isolates exhibited Carbapenem-resistance. All Gram-positive isolates were found susceptible to Vancomycin and Linezolid, and all Gram-negative isolates were colistin sensitive.

Conclusions: The present study provides crucial insights into local epidemiology and resistance patterns of SSI-causing microbes. The study also highlighted concerning resistance rates to commonly used antimicrobials, including β -lactams, cephalosporins, and aminoglycosides, with potentially alarming rates of Carbapenem resistance. Implementing strict infection control measures, rational use of antibiotics, and optimal pre-and post-operative care can potentially reduce the growing rates of SSIs.

Keywords: Antimicrobial susceptibility pattern, Bacteriological profile, HAI, SSI

INTRODUCTION

Surgical site infections (SSIs) are defined as infections that occur at the surgical site within 30 days of the procedure or up to 90 days if implants, breast, or cardiac surgeries are involved. SSIs are among the most common nosocomial infections in developing countries and remain a significant

healthcare issue despite advances in infection control and surgical techniques.¹ The global rate of SSIs ranges from 2.5%-41.9%, and nearly 77% of deaths related to nosocomial infections are caused by SSIs. In India, the SSI rate is reported to be between 4.1% and 11.0%.² However, the true burden is likely much higher, as most SSIs develop after the patient is discharged and are not routinely

recorded in surveillance data. SSIs are the leading cause of unplanned readmissions after surgery. They carry serious consequences, including increased treatment costs, longer hospital stays, and significantly higher rates of morbidity and mortality.³ Financially, SSIs are estimated to cost nearly \$3.3 billion globally. On average, each patient with an SSI stays an additional 7 to 11 days in the hospital and has a 2 to 11 times higher risk of mortality than those without an SSI. Patients with SSIs are 60% more likely to be moved to intensive care units and are five times more likely to be readmitted after discharge.⁴

SSIs result from bacterial contamination during or following the procedure; however, only a small number develop into clinical infection, as the innate host defenses radiate most contaminants. The infection leading to SSIs depends on the virulence, the extent of bacterial contamination, and the antimicrobial resistance (AMR) of the bacteria.⁵ Several host factors, such as age, presence of comorbid conditions, immunosuppression, obesity, or history of smoking or alcohol consumption, increase the odds of developing an SSI.⁶ In the majority of cases, the SSIs are uncomplicated and confined to the skin and subcutaneous tissues, but they can lead to necrotizing infections in some individuals. The routine presentation of the SSIs includes pain, warmth, swelling, erythema, tenderness, and pus formation at the infected site.⁷

The SSIs are caused by contamination from exogenous or endogenous microorganisms during or after the surgery. The contaminations that occur during the surgical procedure are known as primary infections, which appear within five to seven days following the surgery. These infections can be prevented or reduced by the rational use of antimicrobial prophylaxis.⁸ However, evidence suggests that nearly 30-50% of antibiotics prescribed for surgical prophylaxis are not appropriate. This incorrect use of antimicrobial agents leads to serious ramifications, including the emergence of drug-resistant bacteria, which in turn increases the risk of post-operative infections.⁹

The most frequently encountered pathogens in SSIs include *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella species*, *Proteus species*, *Citrobacter species*, *Acinetobacter species*, Coagulase-negative *Staphylococcus aureus*, and *Pseudomonas aeruginosa*.¹⁰ Nevertheless, several studies have shown that these causative microorganisms may differ according to geographical location, type of surgical procedure, surgeons, healthcare settings, and even among different wards in the same hospital. Evidence from recent years reports a surge in SSIs caused by Gram-negative organisms in various hospitals. For SSI prophylaxis and therapy, Beta-lactam antibiotics are the most commonly prescribed group of medications; however, they are incorrectly used in nearly 30-90% of cases.¹¹ This contributes to the emergence of drug-resistant bacteria due to increased selection pressure, resulting in a major public health concern. This issue is exacerbated in developing nations owing to inadequate infection control practices,

inappropriate use of antimicrobial agents, and overcrowded hospitals.¹²

To combat this issue, robust epidemiological data from ongoing surveillance or data from clinical laboratories on antibiotic susceptibility testing (AST) are required. Most data on antimicrobial resistance are generated from high-income countries, whereas the reports documenting antimicrobial resistance patterns in developing nations such as India are limited. Thus, the present study aims to assess the bacteriological profile and antimicrobial resistance patterns in the tertiary care teaching hospital in Western India.

METHODS

The present study was a laboratory-based, prospective single-center study conducted at a Tertiary Care Teaching Centre, Civil hospital, Ahmedabad, India. It was carried out over nine months, from October 2023 to July 2024, on a total of 6575 samples. Ethical approval from the Institutional Ethics Committee was received before the initiation of the study. This study was part of Healthcare-Associated Infection Surveillance in India (HAIS), AIIMS Network Program.

The study included all patients irrespective of their age or gender, undergoing any type of surgical procedures included in the National Healthcare Safety Network (NHSN) operative procedure category(s). These patients were monitored for any signs of SSIs during the postoperative period. Patients with known infections before surgical procedures or any existing wound infections other than the surgical wound were excluded from the study. For each patient, data including demographics, clinical history, relevant investigations, details of surgical procedures, and risk factors were collected.

During post-operative monitoring, the samples from patients showing known signs of infection, including serous or purulent discharge, fever > 38°C, inflammation of the wound site (raised local temperature, oedema, redness, tenderness, induration), or visible wound dehiscence were collected. The aspirates from the wound site were collected with a needle and two sterile swabs one for gram stain and another for culture. The samples of wound aspirates, discharge, and exudes from the depth of the wound were quickly transferred into a sterile container. The collected samples were subjected to routine microbiological procedures to identify the causative pathogen and to assess the antimicrobial susceptibility.

From one of the collected swabs, a gram smear was prepared on a clean, grease-free glass slide and was observed under an oil immersion lens to identify the presence of pus cells and gram-positive or gram-negative organisms. The swab collected for culture was inoculated on blood agar and MacConkey agar. These samples were incubated overnight at 37 degrees Celsius and were

inspected for microbial growth at the intervals of 24 and 48 hours. These isolates were further tested by conventional microbiological techniques, including gram stain, colony morphology, and suitable biochemical reactions. Following the identification using the above techniques, the organisms were differentiated into gram-positive (cocci or bacilli) and gram-negative (cocci or bacilli) bacteria. The antimicrobial susceptibility tests were carried out with Kirby-Bauer's disc diffusion method, utilizing commercially available discs or by the VITEK-2 compact system. The results were interpreted based on Clinical and Laboratory Standards Institute (CLSI) guidelines.

The antimicrobials tested for gram-Positive cocci were: Penicillin-G (10 units), Cefoxitin (30 mcg), Cefuroxime (30 mcg), Ampicillin/Sulbactam (10/10 mcg), Erythromycin (15 mcg), Clindamycin (2 mcg), Linezolid (30 mcg), Vancomycin (30 mcg), Gentamicin (10 mcg), Amikacin (30 mcg), Ciprofloxacin (5 mcg), Levofloxacin (5 mcg), Tetracycline (30 mcg), Doxycycline Hydrochloride (30 mcg), Co-Trimoxazole (Sulpha/Trimethoprim) (25 mcg), Chloramphenicol (30 mcg), Tigecycline (15 mcg), High Level Gentamicin (120 mcg). The antimicrobials tested for gram-negative bacteria were: Ampicillin (10 mcg), Cefazolin (30 mcg), Cefixime (30 mcg), Cefotaxime (30 mcg), Cefepime (30 mcg), Ampicillin/Sulbactam (10/10 mcg), Cefoperazone/Sulbactam (75/10 mcg), Piperacillin/Tazobactam (100/10 mcg), Gentamicin (10 mcg), Amikacin (30 mcg), Ciprofloxacin (5 mcg), Levofloxacin (5 mcg), Tetracycline (30 mcg), Doxycycline Hydrochloride (30 mcg), Co-Trimoxazole

(Sulpha/Trimethoprim) (25 mcg), Chloramphenicol (30 mcg), Imipenem (10 mcg), Meropenem (10 mcg), Ertapenem (10 mcg), Tigecycline (15 mcg). For Pseudomonas, following antimicrobials were used: Piperacillin (100 mcg), Piperacillin/Tazobactam (100/10mcg), Ceftazidime (30 mcg), Cefepime (30 mcg), Gentamicin (10 mcg), Amikacin (30 mcg), Levofloxacin (5 mcg), Netilmicin Sulphate (30 mcg), Imipenem (10 mcg), Meropenem (10 mcg), Aztreonam (30 mcg).

The detection of vancomycin resistance was carried out using brain heart infusion (BHI) agar containing 6 µg/ml vancomycin. The presence of Colistin resistance was detected using the agar dilution method or the broth microdilution method. Moreover, carbapenem resistance was identified by disk diffusion of imipenem, meropenem, and ertapenem for enterobacterial. In case of non-lactose fermenting gram-negative bacilli, carbapenemase testing was done by disk diffusion of imipenem and meropenem. Following the incubation, each plate was examined under reflected light. The zone of inhibition was measured with the naked eye using the antibiotic zone scale, and the zone diameters, including the diameter of the disks, were noted using the current CLSI guidelines as reference.

RESULTS

From October 2023 to July 2024, a total of 21,860 patients underwent various surgical procedures in the different departments at the study site. Out of these, 6575 samples from post-operative patients were investigated for SSIs. A total of 1154 samples cultured positive for microbial growth, concluding the SSI rate of 5.27%.

Table 1: Distribution of isolates.

	Name of organism	No. of patients	%
Gram Positive	Streptococcus spp.	1	0.09
	Staphylococcus aureus	188	16.29
Gram negative	Acinetobacter baumannii	118	10.23
	Burkholderia cepacia	2	0.17
	Escherichia coli	244	21.14
	Klebsiella pneumonia	264	22.87
	Morganella morgagnii	13	1.13
	Proteus mirabilis	86	7.45
	Proteus vulgaris	7	0.61
	Providencia spp.	23	1.99
	Pseudomonas aeruginosa	207	17.93
	Stenotrophomonas maltophilia	1	0.09

Among the 1154 positive cultures, *Klebsiella pneumoniae* (22.87%), and *Escherichia coli* (21.14%) were the most commonly isolated organisms (Table 1). The other isolated organisms included *Pseudomonas aeruginosa* (17.94%), *Staphylococcus aureus* (16.29%), *Acinetobacter baumannii* (10.23%), *Proteus spp.* (8.06%), *Providencia spp.* (2.17%), *Morganella morgagnii* (1.13%), *Burkholderia Cepacia* (0.17%), *Stenotrophomonas Maltophilia* (0.09%), and *Streptococcus spp.* (0.09%).

Regarding the proportion of isolated microorganisms according to the type of surgery, the most frequently isolated bacteria in the general surgery department (n=126) and the obstetrics and gynecology department (n=32) were *E. coli*. In the orthopedic (n=102), burns and plastic surgery (n=38), and neurology (n=9) departments, the most commonly isolated organism was *Klebsiella pneumoniae*. For the ENT (n=15) and pediatrics (n=18) departments, the most frequently isolated microorganism

was *Staphylococcus aureus*. The distribution pattern of various microorganisms based on departments is summarized in Table 2. All isolated Gram-positive bacteria in the study were found to be susceptible to Linezolid and Vancomycin. The majority of patients (95%) with gram-positive isolates of *Staphylococcus aureus* were found to be resistant to β -lactam antibiotics.

However, a single case of isolated *Streptococcus spp.* in the study was reported to be susceptible to Penicillin-G. A total of 9% of the *Staphylococcus aureus* strains were methicillin-resistant (MRSA). Antimicrobial susceptibility pattern of gram-positive isolates is summarized in Table 3.

Table 2: Department wise distribution of bacterial infection.

Name of department	Gram positive			Gram negative										Total
	SS	MRSA	SA	AB	BC	EC	KP	MM	PM	PV	PS	PA	SM	
General surgery	0	6	57	38	2	12 6	81	6	25	3	9	77	0	430
Orthopedic	0	4	63	41	0	53	102	4	37	4	11	66	0	385
OBGYN	0	0	11	16	0	32	13	0	1	0	0	6	0	79
Paediatric surgery	0	2	18	5	0	16	8	1	4	0	0	3	0	57
Uro surgery	0	0	2	0	0	6	5	1	0	0	0	4	1	19
Neuro surgery	0	2	2	6	0	2	9	0	1	0	0	3	0	25
Burns and plastic surgery	0	0	4	9	0	6	38	1	16	0	3	36	0	113
ENT	1	2	15	3	0	3	8	0	2	0	0	12	0	46
Total	1	16	172	118	2	24 4	264	13	86	7	23	207	1	1154

SS:Streptococcus spp., MRSA:Methicillin Resistant Staphylococcus Aureus, SA: Staphylococcus Aureus, AB: Acinetobacter baumannii, BC: Burkholderia Cepacia, EC:Escherichia coli, KP: Klebsiella pneumoniae, MM:Morganella morgagnii, PM:Proteus Mirabilis, PV: Proteus Vulgaris, PS:Providencia spp., PA:Pseudomonas Aeruginosa, SM:Stenotrophomonas Maltophilia, OBGYN:Obstetrics and Gynaecology, ENT:Ear, Nose and Throat.

Table 3: Antibiotic susceptibility profile of gram-positive isolates.

Name of antibiotic	SS	MRSA	SA	Total
Amikacin	-	13	122	135
Cefoxitin	-	0	172	172
Cefuroxime	-	0	172	172
Chloramphenicol	0	5	71	76
Clindamycin	1	5	110	116
Co-trimoxazole	-	5	57	62
Doxycycline	-	8	115	123
Erythromycin	1	5	88	94
Gentamicin	-	4	83	87
Levofloxacin	1	1	26	28
Linezolid	1	16	172	189
Penicillin-G	1	0	10	11
Tetracycline	0	8	108	116
Vancomycin	1	16	172	189
Ampicillin	1	-	-	1

Ss=streptococcus spp; MRSA:methicillin resistant staphylococcus aureus, SA: staphylococcus aureu.

In the present study, all isolated gram-negative microorganisms (100%) were reported to be susceptible to colistin. *Klebsiella pneumoniae* and *E. coli* isolates were least susceptible to Ampicillin/Sulbactam (2%) and Ampicillin (3%) respectively; whereas highest level of susceptibility was

found towards Amikacin (25 % and 61%), followed by piperacillin/tazobactam (23% and 40%) and cefepime (22% and 36%) respectively. The majority of gram-negative isolates from the study exhibited the lowest susceptibility to cephalosporins, except cefepime. The *Proteus spp.*, *Morganella morgagnii*, and *Providencia spp.*

showed the least resistance to piperacillin/tazobactam (49%, 69% and 35%), cefoperazone/sulbactam (44%, 69% and 30%), and cefepime (43%, 69% and 35%), respectively. For the *Pseudomonas aeruginosa* species, the highest susceptibility was reported for colistin (100%), followed by meropenem (70%), aztreonam (64%), and imipenem (61%). The lowest susceptibility was observed for Piperacillin (39%), which was improved (53%) when

combined with tazobactam. The lowest susceptibility to the majority of tested antimicrobials, except for colistin, was observed in the *Acinetobacter baumannii* species. The highest susceptibility rates were observed for tigecycline (66%) and meropenem (24%). The antibiotic susceptibility profile of the isolated gram-negative microorganisms is summarized in Table 4.

Table 4: Antibiotics profile of gram-negative bacilli.

Name of antibiotic	AB	BC	EC	KP	MM	PM	PV	PS	PA	SM	Total
Amikacin	12	-	148	65	8	18	1	5	-	-	257
Amoxicillin/clavulanic acid	-	-	25	5	-	-	-	-	-	-	30
Ampicillin	-	-	8	0	-	-	-	-	-	-	8
Ampicillin/sulbactam	9	-	19	5	2	15	2	4	-	-	56
Aztreonam	-	-	-	-	-	-	-	-	133	-	133
Cefazolin	-	-	11	15	2	11	1	3	-	-	43
Cefepime	17	-	87	59	9	36	4	8	108	-	328
Cefexime	-	-	16	22	4	18	1	4	-	-	65
Cefoperazone/sulbactam	17	-	97	59	9	37	4	7	-	-	230
Cefotaxime	9	-	38	37	7	29	3	7	-	-	130
Ceftazidim	11	2	-	-	-	-	-	-	104	-	117
Ceftriaxone	-	-	38	37	-	-	-	-	-	-	75
Cefuroxime	-	-	17	21	-	-	-	-	-	-	38
Chloramphenicol	-	-	64	41	5	6	1	3	-	0	120
Ciprofloxacin	6	-	33	39	4	14	1	6	105	-	208
Co-trimoxazole	11	0	57	44	3	9	1	5	-	-	130
Colistin	0	0	0	0	0	0	0	0	0	0	0
Doxycycline	16	-	16	10	-	-	-	-	-	-	42
Ertapenem	-	-	174	129	10	55	3	16	-	-	387
Gentamicin	13	-	121	52	8	17	1	5	-	-	217
Imipenem	21	-	145	96	7	45	2	11	126	-	453
Levofloxacin	6	1	41	41	6	14	1	6	109	1	226
Meropenem	28	2	174	129	10	55	3	16	144	-	561
Minocycline	16	0	-	-	-	-	-	-	-	-	16
Piperacillin	-	-	-	-	-	-	-	-	81	-	81
Piperacillin/tazobactam	17	-	97	62	9	42	3	8	110	-	348
Tigecycline	78	-	233	225	-	-	-	-	-	-	536
Tetracycline	14	-	10	7	-	-	-	-	-	0	31
Tigercycline	3	-	63	11	-	-	-	-	-	-	77

AB: acinetobacter baumannii, BC: burkholderia cepacia, EC: escherichia coli, KP: klebsiella pneumoniae, MM: morganelia morgagnii, PM: proteus mirabilis, PV: proteus vulgaris, PS: providencia spp., PA: pseudomonas aeruginosa, SM: stentrophomonas maltophilia, OBGY: obstetrics and gynaecology, ENT: ear, nose and throat.

Extended-spectrum beta-lactamases (ESBL) are a group of enzymes responsible for inactivation of the majority of beta-lactam drug molecules. However, the microorganisms producing these enzymes generally respond to Carbapenems. In the present study, ESBL production was reported in 24.18% isolates of *E. coli* and 8.71% isolates of *Klebsiella spp.* Similarly, Amp C beta-lactamases are cephalosporinase enzymes responsible for the hydrolysis of all beta-lactam antibiotics except carbapenems and cefepime. Amp C beta-lactamase synthesis was observed in a total of 27.36% isolates of *E. coli* and *Klebsiella spp.* Among the total of 965 gram-

negative isolates identified in the study, Carbapenem resistance was observed in nearly 42.38% of the cases. The highest frequency of carbapenem resistance was reported in the *Klebsiella pneumoniae* (14%), followed by *Acinetobacter baumannii* (9%), *E. coli* and *Pseudomonas* (7%), *Proteus spp.* (4%) and *Providencia spp.* (1%).

DISCUSSION

In patients treated with any type of surgical procedure, post-operative infections remain a substantial challenge for surgeons and physicians across the globe. SSI

continue to be a major healthcare concern despite major advancements in surgical and infection control techniques and improved understanding of wound infections. The findings from the present study offer a better understanding of the microbiology and antibiotic susceptibility patterns within the study site.

The rate of SSIs varies greatly among different hospitals, depending upon surgical and infection control techniques, geographical location, patient population, availability of resources, and antimicrobial prophylaxis protocols. In the present study, the reported rate of SSI was 5.27%, similar to that reported by Golia S et al (4.3%) and Shahane V et al (6%).^{13,14} In contrast, the study conducted by Satyanarayana et al reported a higher SSI rate of 13.7%.¹⁵ Generally, the SSI rate reported by studies conducted in an Indian setting ranges between 6.1%-38.7%.¹⁶ This is significantly higher than the rate reported by other countries, such as European countries (2-5%) and the USA (2.8%).¹⁵ The higher SSI rate in India can be attributed to overcrowded hospitals, inadequate hand hygiene measures, and disregard for infection control measures. A wide range of microorganisms are involved in the development of the SSIs, which can significantly influence the risk, severity, and outcomes. The distribution of isolated organisms is dependent on the study population and the antimicrobial usage pattern at the study site. In the present study, the burden of gram-negative isolates (83.62%) was greater compared to gram-positive isolates (16.38%). The predominantly isolated organisms amongst Gram-negative microorganisms were *Klebsiella pneumoniae* (22.87%) and *Escherichia coli* (21.14%). This was supported by the findings reported by the studies done by Nikarika et al, Panchalamarri et al, and Sikdar et al, where these two organisms constituted 66%, 74.2% and 58.72% of the total gram-negative isolates.¹⁷⁻¹⁹ This study reported only two gram-positive organisms - *Staphylococcus aureus* (16.39%) and *Streptococcus spp.* (0.09%). These numbers were in contrast to those reported by Poornima J et al, where gram-positive isolates constituted more than half (66.7%) of the total isolates from the study.²⁰

All gram-positive bacteria isolated from the study exhibited full susceptibility to vancomycin and linezolid, consistent with findings reported by Negi et al and Pradeep et al.^{18,21} The majority of Gram-positive isolates (95%) from the study were found to be resistant to β -lactam antibiotics, underscoring the limited effectiveness of Penicillin for the management of these infections. These findings align with the study by Worku et al, where a high level of resistance to penicillin (88.6%) and ampicillin (77.3%) was reported in *S. aureus* isolates.²² From the isolated *S. aureus* strains in the study, 9% reported resistance to methicillin. This was in contrast to the findings by Kownhar et al, Eagye et al, and Kaye et al, who reported 21.7%, 45% and 58.2% incidence of MRSA, respectively.²³⁻²⁵ The single isolate of *Streptococcus spp.* was found to be susceptible to penicillin-G, erythromycin, and levofloxacin. All gram-negative microorganisms

isolated in the study demonstrated 100% susceptibility to Colistin, aligning with the findings reported by Poornima J et al, Negi et al, and Niharika et al. For *Klebsiella pneumoniae* and *E. coli* isolates, the highest resistance rates were observed against ampicillin/sulbactam (98%) and ampicillin (97%), respectively.^{17,18,20} Similarly, Poornima J et al reported 100% resistance to ampicillin and most classes of tested cephalosporins.²⁰ In this study, nearly all gram-negative isolates showed resistance to cephalosporins, consistent with numerous reports worldwide. This trend is driven by the widespread use of cephalosporins for both prophylaxis and treatment of various infections, as well as the higher prevalence of ESBLs among these organisms. In this study, *Klebsiella pneumoniae* and *E. coli* isolates exhibited the highest susceptibility to amikacin (25% and 61%), followed by piperacillin/tazobactam (23% and 40%), and cefepime (22% and 36%). Similarly, Shahane et al reported the highest susceptibility to amikacin (78%), and Negi et al found the highest sensitivity to amikacin, piperacillin-tazobactam, and meropenem.¹⁴ For the *Proteus spp.*, *Morganella morganii*, and *Providencia spp.*, the highest susceptibility was reported for piperacillin/tazobactam (49%, 69% and 35%), cefoperazone/sulbactam (44%, 69% and 30%), and cefepime (43%, 69% and 35%) in contrast to higher resistance frequency reported towards cephalosporins for other organisms. These observations were in contrast to those reported by Choudhary et al, where *Proteus spp.* isolates were found completely resistant to cefepime, cefuroxime, and ceftriaxone.²⁶ The isolates of *Pseudomonas aeruginosa* from the study demonstrated high susceptibility to levofloxacin (53%) and lowest susceptibility to netilmicin (80%). Nearly 39% of the isolates were susceptible to piperacillin, which was increased to 53% when piperacillin was combined with tazobactam. This indicates that β -lactamase production is the key mechanism of resistance in these isolates, which can be overcome by the addition of β -lactamase inhibitor tazobactam.

Acinetobacter baumannii exhibited comparatively lower susceptibility compared to other gram-negative isolates. Highest susceptibility was observed for tigecycline (66%) and meropenem (24%). Highest resistance was reported for cefotaxime (92%), ampicillin/sulbactam (92%), ceftazidime (91%), ciprofloxacin (95%), and levofloxacin (95%). These findings were similar to those reported by Worku et al, where *Acinetobacter baumannii* isolates exhibited high resistance to commonly used antibiotics such as ceftazidime (89.5%), cefotaxime (95.3%), and cefepime (84.2%).²²

In addition to the above observations, a concerning level of carbapenemase resistance was reported in the present study. Carbapenems are first-line agents for infections with penicillin and cephalosporin-resistant infections. This scenario is rapidly shifting due to the emergence of carbapenem-resistant organisms. This is truly alarming as these agents are considered a last resort for multidrug-resistant infections. In the present study, out of 965 gram-

negative isolates, 42.38% were carbapenem-resistant. Among these, *Klebsiella pneumoniae* exhibited the highest resistance (14%), followed by *Acinetobacter baumannii* (9%), *E. coli* and *Pseudomonas* (7%), *Proteus spp.* (4%) and *Providencia* (1%). These higher rates of carbapenem resistance can be attributed to irrational use or misuse of these broad-spectrum antibiotics, which can pose a major threat to global public health.

The current guidelines for surgical antimicrobial prophylaxis recommend the administration of an antimicrobial agent approximately 60 minutes before a surgical procedure and to be discontinued afterwards.⁹ The most commonly used antimicrobials for this are cephalosporins and aminoglycosides. However, as per the observations from the current study, a very high proportion of SSI-causing microbes are resistant to these agents. This renders the prophylaxis ineffective and potentially increases the odds of acquiring an SSI, thereby necessitating the use of broad-spectrum agents, which accelerates the development of antimicrobial resistance. This issue raises a serious concern and demands prompt revision of antimicrobial policies and prescribing guidelines.

CONCLUSION

SSIs are a major global health concern, associated with high healthcare costs and a profound impact on mortality and morbidity rates. This single-center study concluded the SSI rate of 5.27%, with gram-negative organisms being the leading cause (84%) of SSIs. *Klebsiella pneumoniae*, *E. coli*, and *Pseudomonas aeruginosa* were the most commonly isolated organisms. All of the isolated gram-negative microbes were found susceptible to colistin, and all gram-positive isolates exhibited susceptibility to vancomycin and linezolid. A total of 9% of *Staphylococcus aureus* isolates were reported to be methicillin-resistant (MRSA).

The detection of a very high number of carbapenem-resistant gram-negative isolates highlights the growing concern of multidrug resistance in routine clinical settings. Hence, in order to prevent and reduce the spread of multidrug resistance, targeted infection control measures and judicious use of antibiotics in clinical settings are imperative. The information obtained from the present study regarding the most commonly encountered pathogens and their resistance patterns provides valuable insights into local microbial etiology, which can aid in designing improved strategies for the prevention and management of SSIs. Additionally, healthcare workers should be educated to avoid irrational and prolonged use of antimicrobials, as it can result in the emergence of resistant microorganisms, potentially exacerbating the resistance crisis. Although SSIs can't be eliminated, reducing the rates of infection can provide tremendous benefits by reducing the healthcare expenditure and morbidity and mortality rates.

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