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Original Research Article

Bacteriological profile of surgical site infections and their antimicrobial susceptibility pattern at a tertiary care hospital, Western Gujarat

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ABSTRACT

Background: Surgical site infection (SSI) is a frequently occurring repercussion of surgery. It results in mortality and morbidity post-surgery. The present study aims to isolate the organisms causing SSI and determine the antimicrobial susceptibility patterns of the isolates.
Materials and Methods: A total of 250 patient samples were included in the study, their demographic details obtained and processed as per Standard Microbiological Protocols. Antibiotic susceptibity of the positive cultures was performed using Modified Kirby-Bauer disc diffusion method.
Results: Out of the 250 samples, 102 (40.8%) samples showed positive culture growth. Positivity rates were higher in male patients (43.88%). The most prevalent Gram-negative isolate was *Klebsiella pneumonia* (23.53 %), followed by *Escherichia coli* (20.59%) and others. The only Gram-positive isolate was *Staphylococcus aureus* (21.57%). Most of the Gram-negative isolates were sensitive to imipenem, meropenem, ertapenem, ceftazidime-avibactam and aztreonam. Most of the gram-positive isolates were sensitive to linezolid and levofloxacin.
Conclusion: The current analysis found that *Klebsiella pneumoniae* was the most often related bacteria to SSI, followed by *Staphylococcus aureus*, *Escherichia coli*, and other infections. Periodic analysis of the causative organisms and their antimicrobial susceptibility pattern is necessary to confine the burden of SSI.

1. Introduction

According to Centre for Disease Control and Prevention (CDC), Surgical Site Infection (SSI) is defined as an infection related to an operative procedure at or near the site of infection within 30 days after the procedure or within 1 year if the procedure includes implanted device or prosthesis.[1]

SSI accounts for 14% to 16% of all nosocomial infections and is the third most commonly reported nosocomial infection.[2,3] The frequency of surgical site infections varies between hospitals as well as among various researches that have been published periodically.[4] Geographical location, surgeon skills, different procedures, hospital-to-hospital, or even different wards within the same hospital can all affect the etiological agents involved in surgical site infections (SSIs).

Surgical site infection (SSI) remains a major cause of hospital-acquired infections and a major source of morbidity and mortality among hospitalized patients in developing countries, despite the latest developments in aseptic techniques, including operating rooms and surgical techniques, sterilization approaches and standard protocols of preoperative preparation and antibiotic prophylaxis.[2,5,6]

Around the globe, the prevalence of surgical site infections varies from 2.5% to 41.9%.[7] Patients having surgery are particularly vulnerable to hospital-acquired infections, which constitute up to 77% of patient deaths.[8]

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A healthy environment is crucial for wound healing to occur, as this will facilitate a normal healing process with minimal scar formation.[9] Infections pose significant obstacles to wound healing, which may have an impact on patients by lengthening their hospital stays and decreasing their quality of life.[10]

Rehospitalization rates, healthcare utilization, drug and diagnostic resource usage, and hospital expenses substantially escalate as a consequence of surgical site infections.[2,11] Compared to patients without SSIs, those who have them have a five-fold greater likelihood of readmission, a sixty percent increased risk of needing to remain in an intensive care unit (ICU), and a twofold increased risk of mortality.[3]

A wide range of factors influence the likelihood of developing surgical site infection, such as the patient's age and clinical status at the time of the procedure, the length of their preoperative hospital stays, the type and the intensity of the operative procedure, the type of anesthesia used, the patient's preoperative skin preparation, the use of an implant and drain, and the postoperative wound care. Determining these variables is crucial to creating SSI preventing strategies.[12,13]

Staphylococcus aureus, *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella* spp., *Enterobacter* spp., Proteus spp., *Acinetobacter* spp. and *Serratia* spp. are among the frequent bacterial infections linked to surgical site infections (SSIs).[14,15]

12.3% of hospital-acquired infections are caused by surgical site infections.[16] According to a study, surgical site infection rates range from 4 to 30% in India.[17] Due to incomplete reporting, a lack of post-discharge data, and a lack of patient follow-up, the entire amount of SSI data in India is probably underestimated.[18] Even hospitals with more contemporary facilities and higher standards of care have reported cases of SSIs.

Exogenous or endogenous microorganisms that enter the site during or even after surgical procedures (primary infection) or even later (secondary infection) typically infiltrate the surgical wound. The majority of surgical site infections affect the skin's superficial layers and subcutaneous tissues, but some can develop into necrotizing infections, particularly in certain high-risk groups, as shown by prior research.[19]

Up to 50% fewer SSIs are reported when surgeons receive feedback on surgical site infections rate and related parameters, as well as periodic surveillance, according to research conducted by the World Health Organization (WHO) and others.[11] In line with the literature, 60% SSIs are avoidable.[3]

Because of the widespread bacterial resistance to antibiotics, limiting post-operative infection has become a harder task. Recognizing the agents responsible for post-operative infection has therefore proven useful in determining appropriate antibiotic therapy and infection control measures in healthcare facilities.

2. Aims and Objectives

1. To identify the isolates causing Surgical Site Infection.
2. To study the antimicrobial susceptibility pattern of the isolated organisms.

3. Materials and Methods

3.1. Study design and setting

For six months, from July to December 2023, a cross sectional descriptive study was carried out in the Microbiology department of a tertiary care hospital in Jamnagar, Western Gujarat.

Following approval by the Institutional Ethics Committee of Shri M.P. Shah Government Medical College, Jamnagar, the study was initiated. There was respect for confidentiality. A total of 250 samples from patients operated from various departments of the government hospital were collected and data was obtained for the defined time duration.

3.2. Inclusion criteria selected

1. Specimens of post-operative patients of various clinical departments developing infection within 30 days after surgery or within year in case of implant surgery i.e. patients with clinically diagnosed Surgical Site Infection were included.
2. Patients of all age groups and gender were included.

3.3. Procedure

All clinically diagnosed surgical site infection cases had their pus or wound swabs collected aseptically and promptly sent to the Microbiology department for analysis. In accordance with standard protocols, the laboratory samples were prepared for direct microscopy, aerobic culture and sensitivity. The morphological form of bacteria was determined by using Gram's staining on the swabs used to prepare the smear.

The necessary agar plates, such as Blood Agar (BA), MacConkey Agar (MAC) and Nutrient Agar (NA), were inoculated from the samples. For 18 to 24 hours, the plates were incubated aerobically at 37°C. Using standard microbiological techniques, distinct microbes were identified from positive cultures contingent on their morphological and biochemical features after incubation.[20]

All isolates underwent an antibiotic susceptibility test on Mueller Hinton Agar (MHA) medium using the relevant antibiotic discs that were available, in compliance with CLSI (Clinical Standard Laboratory Institute) guidelines. As controls, reference strains of *Klebsiella pneumoniae* (ATCC 700603), *Pseudomonas aeruginosa* (ATCC 27853), *Staphylococcus aureus* (ATCC 25923), and *Escherichia coli* (ATCC 25922) were investigated.

3.4. Statistical analysis

The observations were entered into a Microsoft Excel spreadsheet and subjected to appropriate statistical analysis. The data were calculated and presented as percentages and numbers.

4. Result

The study comprised 250 surgical site infection patients in total, of whom 139 (55.6%) were male and 111 (44.4%) were female. Of the 250 samples, 102 (40.8%) showed aerobic bacterial growth, while 148 (59.2%) were sterile, as depicted in Figure 1.

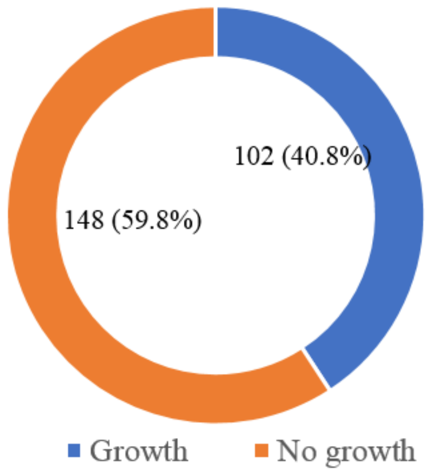

Figure 1: Graph showing positive bacterial culture in study participants.

Out of the 102 positive samples, 41 (40.20%) were female patients, while 61 (59.80%) positive samples came from patients who were males. (Figure 2)

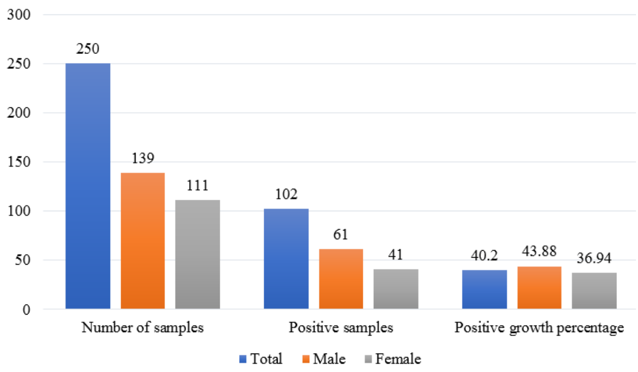

Figure 2: Chartillustrating distribution of samples on the basis of gender.

The maximum number of isolates were found in the age group of more than 70 years, i.e. 28 (27.45%), followed by 23 (22.59%) cases in the age group of 51-60 years, as illustrated in Figure 3.

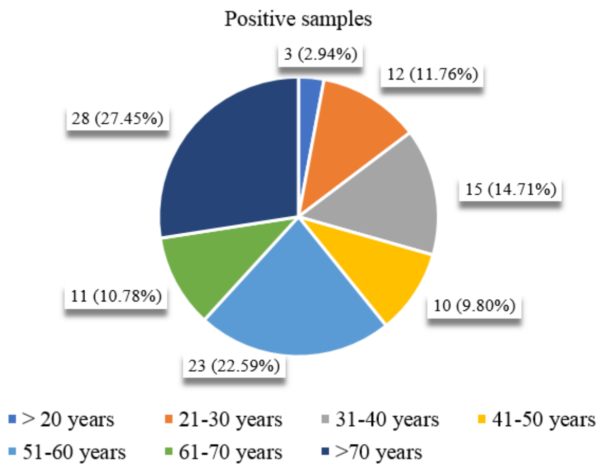

Figure 3: Chart showing age-wise distribution of positive culture.

Out of the 250 samples collected, the maximum number, i.e., 110 (44.0%), were from the surgical wards, 74 (29.6%) from the orthopaedics wards, and 57 (22.8%) from the gynaecology and obstetrics departments. Nine samples (3.6%), the fewest number, were taken from the ENT ward. The department-wise data for the samples are displayed in Figure 3.

Table 1: Department-wise distribution of cases and their positivity rates.

Department	Total number of cases	Total number of positive cases	Culture positivity rate
Surgery	110	53	48.18%
Orthopaedics	74	28	37.84%
Gynaecology and Obstetrics	57	18	31.58%
ENT	09	03	33.33%
Total	250	102	100%

191(76.4%) of the 250 samples were obtained from patients receiving care indoors, and the remaining 59(23.6%) were received from outpatient clinics. Compared to outpatient clinics, where the culture positive rate was 20.34%, the indoor patient population had a significantly higher positivity rate of 47.12%. The above-mentioned data is illustrated in Figure 4.

Eighty (78.43%) of the 102 culture-positive samples produced Gram-negative bacteria, while the remaining twenty-two (21.57%) contained Gram-positive bacteria.

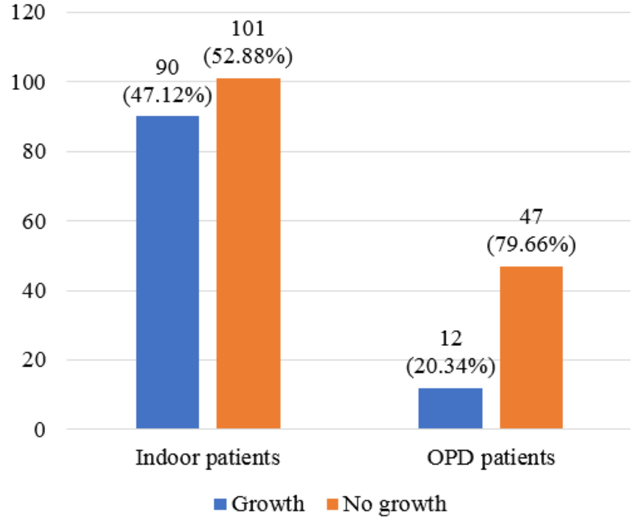

Figure 4: Chart showing the distribution of samples into outpatient and indoor patient categories.

The single organism identified from the 22 Gram-positive cocci isolates was *Staphylococcus aureus*. Klebsiella pnuemoniae 24 (23.53%) was the most prevalent Gram-negative bacterium, followed by *Escherichia coli* 21 (20.59%), *Pseudomonas aeruginosa* 18 (17.65%), *Acinetobacter baumannii* 12 (11.76%), and Proteus species 5 (4.90%), being the least isolated.

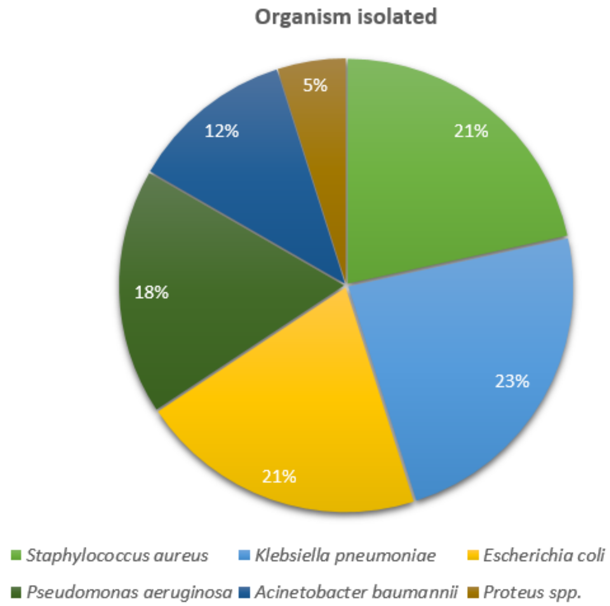

Figure 5: Chart illustrating Bacteriological profile of the isolated organisms.

The most effective antibiotic for *Staphylococcus aureus*, the only Gram-positive bacteria that had been isolated, was linezolid (86.36%), followed by levofloxacin and gentamicin (81.82%), while the least effective antibiotic was doxycycline (59.09%). Table 2 demonstrates the number of isolates and percentage of antimicrobial sensitivity of the Gram-positive isolates.

Table 2: Antibiotic susceptibility pattern of gram-positive isolates (N=22) to various antibiotics. N refers to the total number of isolates.

Antibiotic	***Staphylococcus aureus* (N=22)**
Azithromycin (15μg)	15 (68.18%)
Clindamycin (2 μg)	15 (68.18%)
Cefoxitin (30 μg)	14 (63.64%)
Doxycycline (30 μg)	13 (59.09%)
Minocycline (30 μg)	14 (63.64%)
Tetracycline (30 μg)	16 (72.73%)
Cotrimoxazole (23.75/1.25 μg)	16 (72.73%)
Linezolid (30 μg)	19 (86.36%)
Ceftaroline (30 μg)	17 (77.27%)
Ciprofloxacin (5 μg)	14 (63.64%)
Levofloxacin (5 μg)	18 (81.82%)
Gentamicin (10 μg)	18 (81.82%)

The most effective antibiotics with 100% sensitivity for all the *Enterobacterales* that were isolated, including *Escherichia coli*, *Klebsiella pneumoniae*, and Proteus spp., were ceftazidime, aztreonam, ceftazidime-avibactam, imipenem, meropenem, and ertapenem. The least effective were ampicillin (42%), followed by gentamicin (48%). The antimicrobial sensitivity pattern of the *Enterobacterales* is illustrated in Table 3.

With 100% sensitivity, the ceftazidime-avibactam, aztreonam, and carbapenem antibiotic group proved to be the most successful against *Pseudomonas aeruginosa*, whereas ciprofloxacin and levofloxacin exhibited the lowest effectiveness, with 55.56% sensitivity. Imipenem and meropenem (100% sensitivity) were most sensitive to *Acinetobacter baumannii* isolates, followed by minocycline and doxycycline (91.67% sensitivity). Table 4 depicts the antimicrobial susceptibility pattern of the non-fermenter isolates (which include *Pseudomonas aeruginosa* and *Acinetobacter baumannii*).

5. Discussion

There are significant consequences for public health linked to the establishment and spread of bacteria resistant to antibiotics.Compared to their contemporaries, patients who have surgical site infections spurred on by antibiotic-resistant bacteria are more likely to experience poorer clinical outcomes and utilize more medical resources.

A total of 250 patients with surgical site infections were included in the current study. Of the 250 cases, 148 (59.20%) were determined to be sterile, while 102 (40.80%)

Table 3: Antibiotic susceptibility pattern of *Enterobacterales* isolates (N=50) to various antibiotics. N refers to the total number of isolates.

Antibiotic	*Escherichia coli* (N=21)	*Klebsiella pneumoniae* (N=24)	Proteus species (N=05)	Overall sensitivity (Total N=50)
Ampicillin (10 μg)	06 (28.57%)	12 (50.00%)	3 (60.00%)	21 (42%)
Ceftriaxone (30 μg)	12 (57.14%)	15 (62.50%)	3 (60.00%)	30 (60%)
Cefotaxime (30 μg)	12 (57.14%)	15 (62.50%)	3 (60.00%)	30 (60%)
Amoxicillin-Clavulanic acid (20/10 μg)	14 (66.67%)	16 (66.67%)	4 (80.00%)	34 (68%)
Ampicillin-sulbactam (10/10 μg)	13 (61.90%)	16 (66.67%)	4 (80.00%)	33 (66%)
Gentamicin (10 μg)	09 (42.86%)	12 (50.00%)	3 (60.00%)	24 (48%)
Ciprofloxacin (5 μg)	10 (47.62%)	13 (54.17%)	2 (40.00%)	25 (50%)
Levofloxacin (5 μg)	10 (47.62%)	13 (54.17%)	2 (40.00%)	25 (50%)
Cotrimoxazole (23.75/1.25 μg)	12 (57.14%)	15 (62.50%)	3 (60.00%)	30 (60%)
Piperacillin-Tazobactam (110 μg)	18 (85.71%)	21 (87.50%)	4 (80.00%)	43 (86%)
Amikacin (30 μg)	13 (61.90%)	17 (70.83%)	4 (80.00%)	34 (68%)
Cefuroxime (30 μg)	16 (76.19%)	18 (75.00%)	4 (80.00%)	38 (76%)
Cefepime (30 μg)	16 (76.19%)	18 (75.00%)	4 (80.00%)	38 (76%)
Cefoxitin (30 μg)	16 (76.19%)	18 (75.00%)	4 (80.00%)	38 (76%)
Tetracycline (30 μg)	17 (80.95%)	19 (79.17%)	3 (60.00%)	39 (78%)
Ertapenem (10 μg)	21 (100%)	24 (100%)	5 (100%)	50 (100%)
Imipenem (10 μg)	21 (100%)	24 (100%)	5 (100%)	50 (100%)
Meropenem (10 μg)	21 (100%)	24 (100%)	5 (100%)	50 (100%)
Ceftazidime-Avibactam (30/20 μg)	21 (100%)	24 (100%)	5 (100%)	50 (100%)
Aztreonam (30 μg)	21 (100%)	24 (100%)	5 (100%)	50 (100%)
Ceftazidime (30 μg)	21 (100%)	24 (100%)	5 (100%)	50 (100%)

Table 4: Antibiotic susceptibility pattern of non-fermenter isolates (N=30) to various antibiotics. N refers to the total number of isolates.

Antibiotic	*Pseudomonas aeruginosa* (N=18)	*Acinetobacter baumannii* (N=12)	Overall sensitivity (N=30)
Ceftazidime (30 μg)	12 (66.67%)	09 (75.00%)	21 (70.00%)
Cefepime (30 μg)	12 (66.67%)	09 (75.00%)	21 (70.00%)
Ciprofloxacin (5 μg)	10 (55.56%)	08 (66.67%)	18 (60.00%)
Levofloxacin (5 μg)	10 (55.56%)	08 (66.67%)	18 (60.00%)
Ampicillin-sulbactam (10/10 μg)	13 (72.20%)	09 (75.00%)	22 (73.33%)
Gentamicin (10 μg)	13 (72.2%)	07 (58.33%)	20 (66.67%)
Piperacillin-Tazobactam (110 μg)	14 (77.78%)	10 (83.33%)	24 (80.00%)
Imipenem (10 μg)	18 (100%)	12 (100%)	30 (100%)
Meropenem (10 μg)	18 (100%)	12 (100%)	30 (100%)
Amikacin (30 μg)	-	10 (83.33%)	10 (83.33%)
Cotrimoxazole (23.75/1.25 μg)	-	10 (83.33%)	10 (83.33%)
Minocycline (30 μg)	-	11 (91.67%)	11 (91.67%)
Ceftazidime-avibactam (30/20 μg)	18 (100%)	-	18 (100%)
Aztreonam (30 μg)	18 (100%)	-	18 (100%)
Doxycycline (30 μg)	-	11 (91.67%)	11 (91.67%)
Cefotaxime (30 μg)	-	10 (83.33%)	10 (83.33%)
Ceftriaxone (30 μg)	-	10 (83.33%)	10 (83.33%)

Table 5: Table illustrating the age group with maximum isolates and their percentage of several similar studies.

Author of study	Age group with maximum isolates	Percentage of positive isolates
Vikrant Negi et al.[21]	>50 years	51.8%
Pooja Patel et al.[22]	48-58 years	31.57%
R. Chaudhary et al.[23]	>45 years	31.8%
Naz et al.[24]	>45 years	31.8%
S. A. Deshpande et al.[25]	70-79 years	33.33%
Present study	>60 years	38.23%

Table 6: Table representing the gram-positive and gram-negative isolates, along with the most frequent isolate of different studies.

Author of study	Gram-positive isolates	Gram-negative isolates	Most frequent isolate
Kochhal N et al.[26]	16.67%	83.33%	*Klebsiella pneumoniae* (33.33%)
Pooja Patel et al.[22]	17.39%	82.51%	*Pseudomonas aeruginosa* (39.13%)
M.S.S. Pradeep et al.[27]	33.7%	66.3%	*Escherichia coli* (27.91%)
Kanwalpreet Kaur et al.[28]	29.90%	70.10%	*Staphylococcus aureus* (29.90%)
R. Chaudhary et al.[23]	58.4%	41.6%	*Staphylococcus aureus* (47.4%)
Vikrant Negi et al.[21]	50.4%	49.6%	*Staphylococcus aureus* (50.4%)
G.S. Sharnathe et al.[29]	55.8%	44.2%	*Staphylococcus aureus* (53.92%)
Present study	21.57%	78.43%	*Klebsiella pneumoniae* (23.53%)

cases produced positive bacterial cultures. This conclusion is consistent with the findings of several previous studies conducted by various authors, including Pooja Patel et al.[22] (38% culture positivity rate), Anirudh S. et al.[4] (32%), and N Patel et al.[30] (31.19%). Contrary to our findings, a few studies of other research have discovered a very high frequency of culture-positive patients in their investigations like Khan et al.[31] (52.2% culture positivity rate), Usha Verma et al.[32] (61.58%) and Kanwalpreet Kaur et al.[28] (58%)

Compared to other countries, such as the USA, where the rate is 2.8%, and European countries, where it is 2-5%, the infection rate in Indian hospitals is substantially higher.[33,34] It's plausible that the extremely different working circumstances found in industrialized nations account for the low infection rate in these nations.

In this study, the incidence of culture positive surgical site infection (SSI) was 40.2% in females (41/102) and 59.8% (61/102) in males. A comparable pattern was observed in other research by Ruby Naz et al.,[24] with 60% of males and 40% of females. This could be because of the outdoor activities that make men more vulnerable to trauma. Other studies by Pooja Patel et al.[22] (78.94% males and 21.05% females), Vikrant Negi et el.[21] (74.6%males and 25.5% females) and Nitin Goel Insan et al.[35] have shown a similar pattern.

In the present study, the age group above 70 years had the highest number of isolates, 28 (27.45%), followed by 23 (22.59%) cases in the 51–60 year age group. This finding lines up with a number of other studies that show a greater proportion of culture-positive infections in older age groups.[22–25] This trend of rising incidence of surgical site infection culture positivity with age could be explained by the fact that growing older is linked to a number of risk factors, including anemia, malnutrition, decreased immunity, and many more. One such study is that of Vikrant Negi et al.,[21] which indicated that the age group over 50 years old had the highest percentage of positive isolates (51.8%).The following Table 5 displays the comparison of the age group with the highest culture-positive frequencies from several studies published by distinct authors.

Gram-negative isolates (78.43%) were far more common in our study than gram-positive isolates (21.57%). This outcome aligns with a number of earlier, comparable investigations.[22,26–28] A few studies, however, have produced results that are in opposition to this, indicating that gram-positive isolates are more prevalent than gram-negative isolates.[21,23,29] *Klebsiella pneumoniae* (23.53%) is the most frequently isolated bacterium in the current investigation, followed by *Staphylococcus aureus* (21.57%). This result is consistent with other similar investigations where *Klebsiella pneumoniae* or other related gram-negative bacteria are frequently isolated.[22,26] Conversely, a number of other investigations have demonstrated that the isolate most frequently detected in surgical site infections is *Staphylococcus aureus*.[21,23,27,28] Table 6 presents the findings of multiple investigations, indicating the proportions of gram-positive and gram-negative isolates, as well as the most often isolated organism in each study.

The results of this investigation indicate that gram-negative isolates are most susceptible to imipenem, meropenem, ceftazidime-avibactam, and aztreonam (100%), with piperacillin-tazobactam (86%), and amikacin (84%), following in order of preference. Similar findings have been reported by numerous other researchers, including Nidhi S. Patel et al.[21,22,30] Linezolid (86.36%) was found to be the most effective antibiotic against gram-positive isolates, followed by gentamicin (81.82%) and levofloxacin (81.82%). According to Pooja Patel et al.[22] and many more similar studies, vancomycin and linezolid were found to be the most sensitive against gram-positive isolates.[22,24]

6. Conclusion

Our study provides details regarding the antibiotic susceptibility patterns of bacterial pathogens isolated from individuals with surgical site infections in a tertiary care hospital. The most frequent bacteria linked to SSI, according to the current investigation, was *Klebsiella pneumoniae*, which was followed by *Staphylococcus aureus*, *Escherichia coli,* and other pathogens. It was discovered that gram-positive and gram-negative isolates are becoming more resistant to widely used, reasonably priced antibiotics, including ampicillin, azithromycin, and even cephalosporins. There are just a few remaining reserve medications, such as carbapenems, which are extremely efficient against infections and ought to be used with great caution.

Nowadays, one of the biggest concerns about surgery is surgical site infection. It is among the major factors contributing to death and morbidity following surgery. In any hospital, the standard of care and patient care are reflected in the rate of infection. Therefore, improved SSI management is necessary, and appropriate antibiotic policies can aid in lowering the rate of SSI in developing nations as well as the significant issue of antibiotic resistance in hospital-acquired illnesses.

It is advised to periodically analyse the aetiology and antibiotic susceptibility in both hospital and community settings.

7. Authors' Contribution

The study has received approval for publishing from all the mentioned authors, and each has made considerable and direct contributions.

8. Data Availability

The manuscript incorporates all the databases that have been generated and evaluated for the purpose of this research.

9. Ethics Statement

The Institutional Ethics Committee of M.P. Shah Govt. Medical College and Guru Gobindsingh Hospital, Jamnagar, gave their approval to this study with Ref No. 205/03/2023 on 22/02/2024.

10. Source of Funding

None.

11. Conflict of Interest

The authors want to render it clears that they have no conflicts of interest.

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