International Surgery Journal
Mani K et al. Int Surg J. 2026 Aug;13(8):1395-1402
https://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: https://dx.doi.org/10.18203/2349-2902.isj20262461

Original Research Article

Epidemiology, risk factors and microbiological profile of surgical site infections in emergency surgeries

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Received: 01 June 2026
Revised: 10 July 2026
Accepted: 21 July 2026

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ABSTRACT

Background: Surgical site infections (SSIs) remain a major cause of postoperative morbidity, prolonged hospitalization, and increased healthcare expenditure. Identification of risk factors and local microbial patterns is essential for effective prevention and management. The objectives of this study are to evaluate the incidence of surgical site infections (SSI) in emergency surgical patients, identify associated risk factors, and analyze the bacteriological profile and antimicrobial susceptibility patterns of the isolated organisms.
Methods: A prospective observational study was conducted in the Department of General Surgery, Postgraduate Institute of Medical Sciences (PGIMS), Rohtak, Haryana. A total of 150 adult patients who underwent emergency surgery and subsequently developed wound-related complications were included. Patients were followed for 30 days postoperatively. Clinical, demographic, and perioperative variables were recorded. Wound swabs were subjected to microbiological culture and antibiotic susceptibility testing. Statistical analysis was performed using SPSS version 21.0.
Results: The mean age of patients was 41.46±17.93 years, with males constituting 72.7% of cases. Culture positivity was observed in 67 patients, of whom 76% yielded Gram-negative organisms and 24% Gram-positive organisms. *Escherichia coli* (14.7%) was the most common isolate, followed by *Klebsiella* spp. (12.7%). Gram-negative isolates demonstrated high resistance to fluoroquinolones and third-generation cephalosporins, while piperacillin-tazobactam and meropenem showed the best susceptibility profiles. Significant associations with SSI were observed for prolonged duration of surgery (p=0.003), blood transfusion requirement (p=0.024), and higher Southampton wound scores (p<0.001). Age, sex, comorbidities, body mass index, anemia, previous surgery, and type of surgery were not significantly associated with SSI.
Conclusions: Prolonged operative duration, blood transfusion, and higher Southampton scores were significant predictors of SSI. The predominance of multidrug-resistant Gram-negative organisms highlights the importance of institution-specific antibiograms and antimicrobial stewardship programs to optimize patient outcomes.

Keywords: Surgical site infection, Wound infection, Emergency laparotomy, Antibiogram

INTRODUCTION

Wound infection is defined as the invasion and multiplication of microorganisms within tissues following disruption of local or systemic host defence mechanisms, resulting in conditions such as cellulitis, lymphangitis, abscess formation, and bacteraemia. Koch established the first formal criteria defining infectious diseases, now known as Koch's postulates. These postulates describe the causal role of an infective organism as follows: the organism must be present in significant numbers at the site of infection; it should be capable of being isolated and cultured in pure form from the infected focus; the cultured organism should reproduce similar disease when introduced into a susceptible host.[1]

Surgical site infection (SSI) is defined as an infection occurring at the incision site within 30 days following surgery, or within one year when a prosthetic implant is used.[2] SSIs contribute substantially to healthcare costs by increasing postoperative hospital stay, morbidity and overall treatment expenditure.[3]

The Centers for Disease Control and Prevention (CDC) classify surgical wounds into four categories based on the degree of contamination: clean, clean-contaminated, contaminated, and dirty-infected.

Clean wounds are uninfected operative wounds in which no inflammation is present and where the respiratory, alimentary, genital, or uninfected urinary tracts are not entered.

Clean-contaminated wounds involve controlled entry into the respiratory, alimentary, genital, or urinary tracts without unusual contamination. This category includes surgeries involving the biliary tract, appendix, vagina, and oropharynx, provided there is no active infection or major breach in technique.

Contaminated wounds include open, fresh accidental injuries, operations with major breaks in sterile technique, gross spillage from the gastrointestinal tract, or incisions encountering acute non-purulent inflammation or necrotic tissue without pus.

Dirty-infected wounds comprise old traumatic wounds with retained devitalized tissue or those involving established infection or perforated viscera, where organisms were present in the operative field prior to surgery.[4]

Among surgical patients, SSIs remain the most common hospital-acquired infection, accounting for approximately 38% of cases. Despite strict adherence to aseptic precautions, a certain degree of contamination is inevitable in most surgical wounds. However, infection is uncommon when contamination is minimal, tissue handling is gentle, perfusion and oxygenation are adequate, and dead space is avoided.[5]

The role of antibiotic prophylaxis in surgery has expanded considerably over the past two decades. Current recommendations suggest administering a single intravenous dose of a cephalosporin, such as cefazolin, prior to incision in elective clean procedures involving prosthetic material and in clean-contaminated surgeries. Additional doses are generally reserved for procedures exceeding two to three hours in duration.[6]

Surgical site infection remains a leading cause of postoperative morbidity and mortality. However, with thorough preoperative assessment and appropriate preventive strategies involving surgeons, nursing staff, patients, and the perioperative team, the majority of SSIs are preventable.

This study was undertaken to study the incidence and prevalence of surgical site infection and evaluate the various risk factors associated with surgical site infection in tertiary care centre in Haryana, India.

METHODS

Study design

This hospital based prospective observational study was conducted in the Department of Surgery, Postgraduate Institute of Medical Sciences, Rohtaky between a period of May 2024 to May 2025. A sample size of 150 patients was recruited for the study.

Inclusion criteria

All patients between the ages of 18 and 80 years undergoing emergency surgery with surgical site infection were included in the study.

Exclusion criteria

Patients aged less than 18 years or more than 80 years, those undergoing clean or elective procedures, and those undergoing emergency surgery without surgical site infection were excluded from the study.

All patients who fit into the inclusion criteria were included in the study. Ethical approval was taken from the institutional ethics committee. After recording the detailed history, clinical examination and relevant investigations, patients were explained about the disease, treatment and possible side effects. After informed consent, the patient was subjected to surgery. Operative findings were recorded. The patient was observed for SSI as per CDC guidelines for up to 30 days. The swabs were taken after removal of old antiseptic dressing and from the site of maximum contamination. The swabs were collected in sterile manner and stored in 47 sterile test tubes and were transported to the microbiology lab within a period of 1 hour after which they were processed. The growth of organisms were studied till upto 3 days after which the final result was studied. Factors responsible that were recorded included: age, sex, co-morbidities, previous history of surgery, BMI, duration of surgery, type of surgery, day of wound infection, micro-organism isolated, presence of anemia, blood transfusion, South Hampton score, duration of hospital stay, the postoperative day on which surgical site infection occurred was noted.

Statistical analysis

Data was recorded into Microsoft Excel 2019 and exported into SPSS v21.0 (IBM, USA) for statistical analysis. Categorical data was expressed as frequency and percentage, and compared using the Chi-square test.

RESULTS

In this study of 150 patients, the association between various patient characteristics and the presence of surgical site infection (SSI) was analyzed. Age did not show a statistically significant association with SSI (p=0.093), although the highest proportions of SSI cases were observed in the 21–30 years (25%) and 31–40 years (23.52%) age groups. Similarly, no significant difference was found between males and females regarding SSI occurrence (p=0.341), with females representing the majority in both groups. The presence of comorbidities also did not significantly correlate with SSI (p=0.854), nor did a history of previous abdominal surgery (p=0.325). Body mass index categories were not associated with SSI (p=0.955), despite a larger proportion of underweight patients among SSI cases.

Table 1: Association of patient characteristics with presence of surgical site infection on microbiological isolation (n=150).

Patient characteristics		SSI present	SSI absent	P value
		N (%)	N (%)	
Age of the patient in years	11–20	9 (13.23)	12 (17.64)	0.093
	21–30	17 (25)	13 (19.11)	
	31–40	16 (23.52)	9 (13.23)	
	41–50	12 (17.64)	16 (23.52)	
	51–60	8 (11.76)	13 (19.11)	
	61–70	5 (7.35)	12 (17.64)	
	Above 70	1 (1.47)	7 (10.29)	
Sex of the patient	Male	16 (23.52)	25 (36.76)	0.341
	Female	52 (76.47)	57 (83.82)	
Comorbidity	Present	28 (41.17)	35 (51.47)	0.854
	Absent	40 (58.82)	47 (69.11)	
Previous abdominal surgery	Present	5 (7.35)	10 (14.7)	0.325
	Absent	63 (92.64)	72 (105.88)	
Body mass index	Underweight	29 (42.64)	37 (54.41)	0.955
	Normal	26 (38.23)	30 (44.11)	
	Overweight	10 (14.7)	14 (20.58)	
	Obese	3 (4.41)	1 (1.47)	
Duration of surgery in minutes	60–119	3 (4.41)	19 (27.94)	0.003
	120–179	28 (41.17)	29 (42.64)	
	180–239	22 (32.35)	27 (39.7)	
	≥ 240 minutes	15 (22.05)	7 (10.29)	
Type of surgery	Contaminated	0 (0)	4 (5.88)	0.148
	Clean contaminated	16 (23.52)	22 (32.35)	
	Clean	52 (76.47)	56 (82.35)	
Anemia	Present	34 (50)	38 (55.88)	0.655
	Absent	34 (50)	44 (64.7)	
Blood transfusion	Needed	33 (48.52)	25 (36.76)	0.024
	Not needed	35 (51.47)	57 (83.82)	
Southampton score	2	7 (10.29)	18 (26.47)	<0.001
	3	27 (39.7)	51 (75)	
	4	30 (44.11)	11 (16.17)	
	5	3 (4.41)	2 (2.94)	
Duration of hospital stay (days)	<7	4 (5.88)	7 (10.29)	0.064
	7-13	18 (26.47)	30 (44.11)	
	14-20	13 (19.11)	9 (13.23)	
	≥21	12 (17.64)	5 (7.35)	

A significant association was observed between duration of surgery and SSI (p=0.003). Surgeries lasting 60–119 minutes had fewer SSIs (4.41%), whereas longer surgeries lasting 240 minutes or more demonstrated a higher proportion of infections (22.05%). The type of surgery (contaminated, clean-contaminated, or clean) was not significantly related to SSI (p=0.148). Likewise, anemia did not significantly influence SSI rates (p=0.655). However, the need for blood transfusion was significantly associated with the presence of SSI (p=0.024), with nearly half (48.52%) of patients with SSI requiring transfusion compared to 36.76% in those without SSI. Among patients with SSI, the highest proportion had a Southampton score of 4 (44.11%), followed by scores of 3 (39.70%), 2 (10.29%), and 5 (4.41%). In contrast, among those without SSI, most had a Southampton score of 3 (75.00%), while fewer had scores of 2 (26.47%), 4 (16.17%), or 5 (2.94%). A statistically significant association was noted between higher Southampton scores and SSI occurrence (p<0.001).

Regarding hospital stay, the majority of SSI cases had durations of 7–13 days (26.47%) or 14–20 days (19.11%), whereas SSI-absent cases were most frequent in the 7–13 day group (44.11%). Prolonged hospital stays (≥21 days) were more common among patients with SSI (17.64%) than those without (7.35%). However, this difference did not reach statistical significance (p=0.064).

Antibiogram

A total of 60 bacterial isolates were included in the antibiogram analysis. The isolates comprised both Gram-negative and Gram-positive organisms, with *Klebsiella pneumoniae*, *Escherichia coli*, and *Pseudomonas aeruginosa* forming the predominant Gram-negative pathogens, while *Staphylococcus aureus* and *Enterococcus faecalis* represented the Gram-positive isolates.

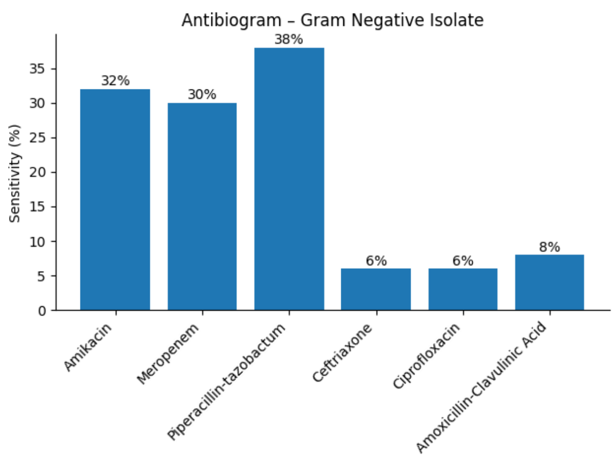

Figure 1: Antibiogram of Gram-negative organisms.

Gram-negative isolates

Among Gram-negative organisms, piperacillin–tazobactam demonstrated the highest overall susceptibility, followed by carbapenems (meropenem). *Pseudomonas aeruginosa* showed excellent sensitivity to piperacillin–tazobactam (100%) and high sensitivity to meropenem, whereas susceptibility to fluoroquinolones and third-generation cephalosporins was markedly reduced.

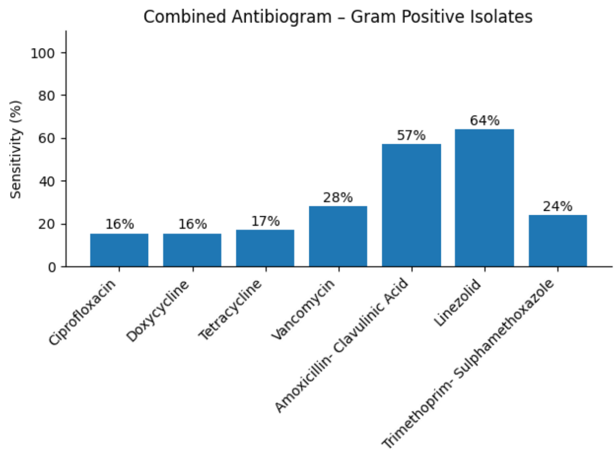

Figure 2: Antibiogram of Gram-positive organisms.

Gram-positive isolates

Gram-positive organisms displayed comparatively better susceptibility profiles. *Staphylococcus aureus* demonstrated moderate sensitivity to vancomycin and piperacillin–tazobactam, while sensitivity to fluoroquinolones and tetracyclines was limited. *Enterococcus faecalis* showed low to moderate susceptibility to commonly tested antibiotics, with vancomycin retaining clinical utility.

Overall, Gram-negative isolates exhibited higher antimicrobial resistance when compared to Gram-positive isolates. Fluoroquinolones and third-generation cephalosporins showed poor efficacy across both groups, whereas β-lactam/β-lactamase inhibitor combinations and carbapenems remained the most effective agents, particularly for Gram-negative infections.

In summary, longer surgical duration and the requirement for blood transfusion were significantly linked to increased SSI rates, while other factors including age, sex, comorbidities, BMI, previous surgery, type of surgery, and anemia showed no significant association. Overall, Gram-negative isolates exhibited higher antimicrobial resistance when compared to Gram-positive isolates. Fluoroquinolones and third-generation cephalosporins showed poor efficacy across both groups, whereas β-lactam/β-lactamase inhibitor combinations and carbapenems remained the most effective agents, particularly for Gram-negative infections.

DISCUSSION

The present study evaluated the risk factors, microbiological profile, and antimicrobial susceptibility patterns of surgical site infection (SSI) following emergency surgical procedures in 150 patients undergoing surgery at Pt. BD Sharma Institute of Medical Sciences, Rohtak. The study aimed to determine the incidence of SSI, identify associated risk factors, and analyze the bacterial profile with development of an antibiogram. Immunocompromised patients, those not meeting age criteria, patients without SSI, and those lost to follow-up were excluded after obtaining informed consent.

SSI is defined as an infection occurring within 30 days of surgery or within one year after prosthetic implantation.[2] It remains a major cause of postoperative morbidity, prolonged hospitalization, and increased healthcare costs.[3] Its occurrence is influenced by patient-related factors such as age, diabetes, obesity, smoking, alcoholism, hypoalbuminemia, and vascular disease, as well as surgery-related factors including wound contamination, duration of surgery, antimicrobial prophylaxis, surgical technique, and operating room practices.[7,8] Although many SSIs are preventable, institution-specific studies remain essential to identify local microbial flora and antibiotic susceptibility patterns.

Age

The mean age of patients was 41.46±17.93 years, with the largest proportion belonging to the 21–30-year age group (20%). Similar findings were reported by Setty et al, whereas Cheng et al and Mohan et al observed higher SSI incidence among older patients, suggesting that age-related risk may vary across populations.[9-11]

Gender

Males constituted 72.66% of cases, consistent with findings by Setty et al and Mohan et al, while Cheng et al reported no significant gender difference.[9-11]

Comorbidities

Smoking (25.33%) and chronic alcoholism (22.66%) were the most frequent comorbidities, followed by tuberculosis and diabetes mellitus. Previous studies have similarly demonstrated increased SSI risk among smokers, alcohol users, and diabetic patients.[9,12-14]

Previous surgery

Only 10% of patients had a history of previous abdominal surgery. Alemayehu et al reported that prior surgery approximately doubled the risk of SSI, likely due to disruption of tissue barriers and colonization by resistant organisms.[15]

Body mass index

The mean BMI was 19.88 kg/m^2, with 44% of patients being underweight. Similar observations by Setty et al and Thapa et al suggest that both underweight and overweight patients may have an increased risk of SSI.[9,16]

Duration and type of surgery

The mean duration of surgery was 160.67 minutes, with most procedures lasting 120–179 minutes. Longer operative duration has consistently been associated with higher SSI rates.[16] Contaminated surgeries constituted 72% of procedures, supporting previous evidence that SSI risk increases with wound contamination.[17-19]

Timing of SSI

Most wound infections developed on postoperative day 3 (50.66%), followed by day 2 (25.33%). Similar findings have been reported by Narula et al, Rajak et al and Setty et al emphasizing the importance of vigilant wound surveillance during the first 3–5 postoperative days.[9,20,21]

Microbiological profile

Bacterial growth was observed in 67 patients, with Gram-negative organisms accounting for 76% of isolates and Gram-positive organisms for 24%. Similar predominance of Gram-negative bacteria has been reported by Dessie et al, Gelaw et al and other recent studies.[22-24]

Among culture-positive cases, *Escherichia coli* (14.66%) was the most common isolate, followed by *Klebsiella* spp. (12.66%), *Enterococcus* spp., *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. Comparable organism profiles have been described by Cheng et al and Mohan et al.[10,11]

Antibiotic susceptibility

Gram-negative isolates demonstrated high resistance to third-generation cephalosporins and fluoroquinolones, suggesting a high prevalence of ESBL-producing organisms. These findings are consistent with ICMR Antimicrobial Resistance Surveillance Network reports and the multicentric study by Gautam et al.[25-27] Piperacillin–tazobactam and meropenem retained relatively good activity, although declining carbapenem susceptibility remains a concern.[25,26] *Pseudomonas aeruginosa* also demonstrated good susceptibility to these agents, similar to reports by Soni et al and Goli et al.[28,29]

Gram-positive organisms showed comparatively better susceptibility. *Staphylococcus aureus* remained susceptible to vancomycin but demonstrated reduced sensitivity to fluoroquinolones and tetracyclines, consistent with reports by Mohanty et al and Rajaduraipandi et al.[30,31] *Enterococcus faecalis* exhibited limited susceptibility to commonly used antibiotics, similar to findings by Praharaj et al.[32]

Anemia and blood transfusion

Anemia was present in 48% of patients. Previous studies by Setty et al and Mohan et al have demonstrated a higher incidence of SSI among anemic patients.[9,11] Blood transfusion was required in 38.66% of patients, and previous studies by Higgins et al and Cheng et al have reported an increased SSI risk among transfused patients.[10,33]

Management of SSI

Aseptic dressing was the most common treatment modality (96.66%), while selected patients required antibiotic escalation, wound washing, suture removal, or abdominal binders depending on clinical severity.

Incidence of SSI

Among the 150 patients, 68 (45.3%) developed SSI, whereas 82 patients had wound discharge without bacterial growth on culture.

Southampton wound grading

Most patients had Southampton Grade 3 wounds (52%), followed by Grade 4 (27.3%). Similar observations by Janugade et al support the usefulness of the Southampton grading system for predicting SSI severity and guiding management.[34]

Hospital stay

The mean duration of hospitalization was 13.8±7.67 days. Prolonged hospital stay has consistently been associated with higher SSI rates, as reported by Regi et al, Narula et al and other studies.[20,35-37] This relationship is likely attributable to increased exposure to hospital-acquired pathogens during longer admissions.

Overall, the present study demonstrates that SSI following emergency surgery is influenced by multiple patient- and procedure-related factors, with contaminated surgeries, prolonged operative duration, smoking, anemia, and blood transfusion being important contributors. Gram-negative bacteria, particularly *E. coli* and *Klebsiella* spp., predominated, with significant antimicrobial resistance highlighting the need for continuous surveillance, antimicrobial stewardship, strict infection control practices, and institution-specific antibiotic policies.

Limitations

As this study has been carried out over a limited period of time with a limited number of patients, it could not have been large enough to be of reasonable precision. All the facts and figures mentioned here may considerably vary from those of large series covering a wide range of time, but still then, as the cases of this study were collected from a tertiary level hospital in our country, this study has some credentials in reflecting the facts in. The antibiogram was based on phenotypic susceptibility testing, and molecular characterization of resistance mechanisms (such as ESBL or carbapenemase production) was not performed.

CONCLUSION

Our study concluded that the mean BMI of the sample was 41.46±17.93 years. Past research has suggested that higher BMI has positive correlation with incisional SSI. Longer surgical duration and the requirement for blood transfusion were significantly linked to increased SSI rates, while other factors including age, sex, comorbidities, BMI, previous surgery, type of surgery, and anemia showed no significant association. Prolonged hospital stay did not reach statistical significance despite SSI being more common in patients with longer stay. Overall, the antibiogram highlights a predominance of multidrug-resistant Gram-negative pathogens, with poor efficacy of commonly used first-line agents such as fluoroquinolones and third-generation cephalosporins. The concordance of the present findings with national surveillance data reinforces the importance of periodic, institution-specific antibiogram generation to guide empirical antibiotic therapy. Such data are crucial for optimizing patient management and for strengthening antimicrobial stewardship initiatives.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Mani K, Arora BK, Ranga H, Mishra A, Choudhary R. Epidemiology, risk factors and microbiological profile of surgical site infections in emergency surgeries. Int Surg J 2026;13:1395-402.