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Comparative Prospective Study of Surgical Site Infection in Emergency and Elective Open Abdominal Surgery

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Abstract

Background

Surgical site infection (SSI) is a major postoperative complication following open abdominal surgery. This study compared 30-day SSI occurrence after emergency and elective surgery and evaluated microbiological findings, postoperative outcomes, and associated factors.

Methods

This prospective comparative observational study included 100 adults undergoing open abdominal surgery at a tertiary care hospital over 18 months. Patients were consecutively recruited into elective (n = 50) and emergency (n = 50) groups and followed for 30 days. Categorical variables were compared using chi-square or Fisher's exact tests. Relative risks (RRs), crude odds ratios, and adjusted odds ratios (AORs) were calculated.

Results

SSI occurred in 30 patients (30.0%), including 19 (38.0%) in the emergency group and 11 (22.0%) in the elective group (RR = 1.73, 95% CI: 0.94-3.19; p = 0.081). Mortality was higher after emergency surgery (32.0% vs. 10.0%; RR = 3.20, 95% CI: 1.29-7.94; p = 0.007). *Escherichia coli* was the most frequently isolated organism (13/30, 43.3%), followed by *Staphylococcus aureus* (10/30, 33.3%), *Klebsiella* spp. (4/30, 13.3%), and *Pseudomonas aeruginosa* (2/30, 6.7%); one culture showed no growth. Antimicrobial susceptibility classification was sensitive in 24 cases (80.0%) and resistant in six (20.0%). Neither culture distribution (p = 0.073), susceptibility classification (p = 0.641), nor clinical response (p = 0.156) differed significantly between groups. Multivariable analysis found no statistically significant association between SSI and emergency surgery (AOR = 1.95, 95% CI: 0.78-4.92), male sex (1.69, 0.60-4.74), diabetes (0.73, 0.13-4.19), addiction history (1.21, 0.33-4.46), or age (0.99 per year, 0.96-1.01).

Conclusion

SSI was more frequent after emergency surgery, but the difference was not statistically significant. Mortality was significantly higher in the emergency group. Larger prospective studies using standardized SSI definitions and antimicrobial susceptibility methods are needed.

Categories: General Surgery, Epidemiology/Public Health, Infectious Disease
Keywords: antibiotic susceptibility, elective surgery, emergency surgery, open abdominal surgery, postoperative wound infection, ssi

Introduction

Surgical site infection (SSI) is a major healthcare-associated infection contributing to postoperative morbidity, prolonged hospitalization, increased healthcare costs, reoperation, and mortality [1]. The Centers for Disease Control and Prevention (CDC) defines SSI according to the anatomical site involved and the applicable postoperative surveillance period [2].

Open abdominal surgery carries a substantial risk of SSI because of gastrointestinal bacterial contamination, procedural complexity, and the potential for contaminated or dirty wounds. Commonly isolated pathogens include *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella* spp., and *Pseudomonas aeruginosa.* Increasing antimicrobial resistance among these organisms further complicates treatment and highlights the importance of microbiological surveillance and antimicrobial stewardship [3].

A systematic review estimated a 30-day SSI incidence of approximately 11% among general surgical

patients, although rates vary by procedure, wound contamination, and surgical urgency [4]. Emergency abdominal surgery may carry a higher infection risk because of conditions such as intestinal perforation, obstruction, trauma, and peritonitis, which can limit opportunities for preoperative optimization [5].

In low- and middle-income countries, including India, delayed presentation, malnutrition, diabetes, inappropriate antimicrobial use, and resource constraints may further increase SSI risk. A prospective study at a rural teaching hospital in Central India reported a 39% incidence of superficial SSI following abdominal surgery and identified several associated factors, including diabetes, anemia, prolonged operative duration, contaminated or dirty wounds, and emergency surgery [6]. The American Society of Anesthesiologists Physical Status Classification System is also relevant to preoperative risk assessment [7].

Evidence-based preventive measures include appropriate antimicrobial prophylaxis, glycemic control, maintenance of normothermia, surgical care bundles, intraoperative wound protection, and postoperative wound surveillance. However, evidence directly comparing SSI incidence, microbiological profiles, antimicrobial susceptibility, and postoperative outcomes between emergency and elective open abdominal surgery remains limited, particularly in the Indian setting [8].

Therefore, this study compared 30-day SSI occurrence following emergency and elective open abdominal surgery and evaluated microbiological findings, antimicrobial susceptibility patterns, postoperative outcomes, and factors associated with SSI. The study hypothesized that SSI occurrence would be higher following emergency than elective open abdominal surgery.

Materials And Methods

Study design and setting

This prospective comparative observational study was conducted in the Department of General Surgery, Dhiraj General Hospital, Sumandeep Vidyapeeth, Vadodara, Gujarat, India, from 1 November 2024 to 28 February 2026. The study compared the occurrence of SSI following elective and emergency open abdominal surgery. The primary outcome was the occurrence of SSI within 30 days after surgery. Secondary outcomes included the microbiological profile and antimicrobial susceptibility of SSI isolates, postoperative clinical outcomes, and patient-related factors associated with SSI.

Sampling and sample-size calculation

Eligible adult patients undergoing open abdominal surgery were recruited consecutively into the elective and emergency surgery groups until 50 patients had been enrolled in each group. Recruitment stopped separately for each group when its prespecified target was reached, resulting in a total sample of 100 patients.

The sample size was calculated using the single-proportion formula:

$$n = \frac{Z^2 P(1-P)}{d^2}$$

assuming a 95% confidence level (Z = 1.96), an anticipated proportion of 50% (P = 0.50), and an absolute precision of 10% (d = 0.10). The calculated sample size was approximately 96, which was rounded to 100. This calculation was intended to estimate a single proportion and was not a formal power calculation for between-group comparisons or multivariable regression.

Participant enrollment and study flow

Adult patients undergoing open abdominal surgery were assessed for eligibility and consecutively enrolled until the predefined quota of 50 elective and 50 emergency cases was reached (total N = 100). Because screening logs were not systematically archived during pre-admission triage, the exact number of ineligible or non-consenting individuals prior to enrollment could not be retrospectively reconstructed. All 100 enrolled participants were followed prospectively for 30 days post-surgery, with cohort progression illustrated in Figure *1*.

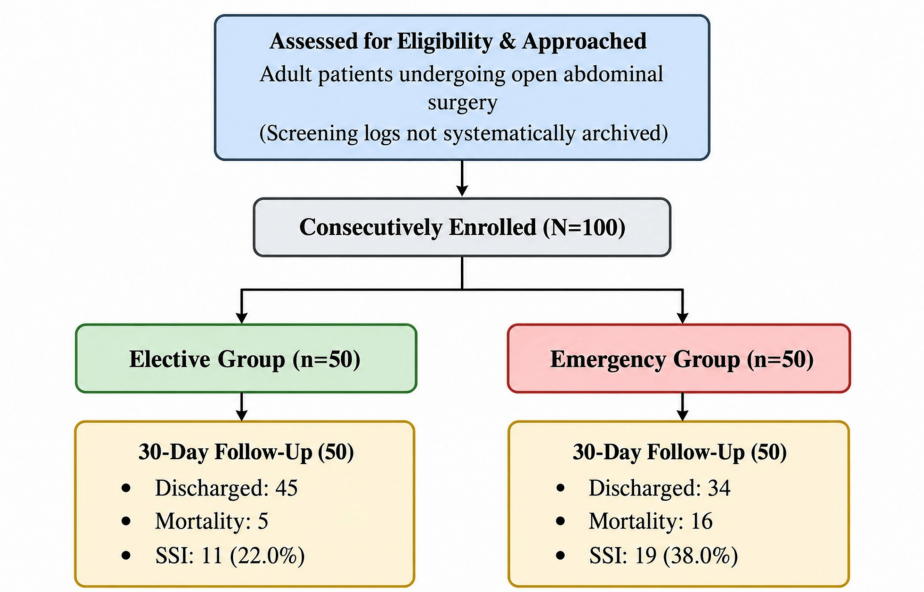


FIGURE 1: Participant flowchart illustrating recruitment, cohort allocation, and 30-day postoperative outcomes.

Screening logs prior to formal enrollment were not systematically maintained. All 100 enrolled patients were retained for the full 30-day follow-up analysis.

SSI: surgical site infection

Inclusion and exclusion criteria

Patients aged 18 years or older who underwent elective or emergency open abdominal surgery during the study period and provided written informed consent were eligible for inclusion.

Patients were excluded if they had a pre-existing SSI at the operative site, underwent re-exploration for an indication unrelated to SSI, were discharged against medical advice, declined participation, or lacked complete 30-day SSI follow-up.

Because exclusion of patients with incomplete follow-up may introduce selection bias, the number and reasons for exclusion should be reported. Patients who died before completing the 30-day follow-up should be documented separately rather than automatically classified as having incomplete follow-up. SSI status before death and the timing and cause of death, where available, should be recorded.

Diagnostic and operational definitions

SSI was diagnosed clinically in accordance with CDC/NHSN criteria [2] within 30 days post-surgery, defined by the presence of at least one of the following: purulent drainage from the incision, deliberate opening of the wound by a surgeon in the presence of local inflammatory signs (erythema, localized warmth, edema, or pain/tenderness), or isolation of an organism from an aseptically collected wound exudate/swab.

Addiction history was defined as patient-reported chronic, regular consumption of substances, specifically encompassing daily tobacco use (smoking bidis/cigarettes or smokeless chewing tobacco) and/or regular alcohol consumption, as documented during admission clinical history taking.

Clinical improvement (response to treatment) was defined as the visible reduction of local inflammatory signs (resolution of erythema, swelling, and pain), cessation of purulent wound discharge, progression of healthy granulation tissue, and afebrile status following targeted or broad-spectrum antimicrobial administration and wound care, without requiring unplanned wound revision or secondary re-exploration.

Data collection

Data were collected prospectively using a structured case-record proforma developed for the study (Appendices). Information was obtained from patient interviews, clinical examinations, operative notes, inpatient records, microbiology reports, and discharge summaries.

The recorded variables included age, sex, previous abdominal surgery, smoking and alcohol history, other relevant exposure histories, and comorbidities. Operative variables included the indication for surgery, operative diagnosis, procedure performed, surgical urgency, and the interval between hospital admission and surgery.

Postoperative variables included SSI occurrence, the date or postoperative day of diagnosis, duration of hospital stay, discharge status, in-hospital mortality, microbiological culture results, antimicrobial susceptibility patterns, and clinical response to antimicrobial treatment.

Although operative duration and intraoperative wound contamination class (clean, clean-contaminated, contaminated, dirty) were included on the initial data collection proforma, these parameters were intermittently documented across emergency theater logbooks and case records. Due to missing data exceeding 40% for these specific fields, they could not be reliably tabulated or entered into multivariable regression models without introducing substantial measurement bias.

All patients underwent routine preoperative clinical evaluation and laboratory investigations according to institutional protocols. These included complete blood count, fasting or random blood glucose estimation, renal function tests, and additional investigations when clinically indicated.

Past medical history and comorbidities were recorded as separate variables. The past-history categories included the relevant recorded histories, while comorbidities were documented according to the conditions present in each patient. Comorbidity categories were not mutually exclusive; therefore, a patient with more than one comorbidity could be counted in multiple categories. Consequently, the frequencies and percentages for individual comorbidities should be interpreted as condition-specific counts and may not sum to the total number of patients. Diabetes mellitus and hypertension were recorded separately, including cases in which both conditions were present.

Definition and assessment of surgical site infection

Patients were evaluated for SSI during their inpatient stay and at scheduled outpatient follow-up visits through physical wound examination and review of clinical charts. When infection was suspected, wound exudate or purulent material was collected aseptically for microbiological investigation.

Although CDC/National Healthcare Safety Network (NHSN) criteria categorize SSI into superficial incisional, deep incisional, and organ/space infections, primary clinical records did not consistently document tissue depth planes. Consequently, reliable retrospective segregation into these anatomical subtypes was not feasible, and SSI was analyzed as a single composite binary outcome.

Microbiological assessment and antimicrobial susceptibility

Wound swabs or purulent exudates collected aseptically from suspected surgical sites were inoculated onto blood agar and MacConkey agar plates and incubated aerobically at 37°C for 24-48 hours. Bacterial identification followed routine standard biochemical tests (including catalase, coagulase, indole, citrate, and oxidase tests). In vitro antimicrobial susceptibility testing was conducted using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar in accordance with applicable Clinical and Laboratory Standards Institute (CLSI) M100 guidelines. Isolates were tested against institutional routine panels encompassing beta-lactams, cephalosporins, aminoglycosides, fluoroquinolones, and carbapenems. Because routine laboratory reporting provided composite binary categorizations (sensitive vs. resistant) without archiving individual zone diameters or standardized multi-agent minimum inhibitory concentration (MIC) breakpoints for retrospective audit, antimicrobial susceptibility is reported as overall category-level sensitivity as documented in the primary hospital microbiology records.

Outcome measures

The primary outcome was the occurrence of SSI within 30 days following surgery. Secondary outcomes included comparison of SSI occurrence between elective and emergency surgery, assessment of patient-related factors associated with SSI, description of bacterial organisms isolated from infected surgical sites, evaluation of antimicrobial susceptibility patterns, assessment of clinical response to antimicrobial treatment, and documentation of in-hospital mortality and discharge outcomes. In-hospital mortality was assessed separately from 30-day postoperative mortality; the latter was considered only if deaths occurring after discharge were systematically ascertained during the 30-day follow-up period.

Data quality assurance and follow-up

Completed case-record forms were reviewed periodically for completeness and internal consistency. Recorded information was cross-verified against operative notes, inpatient case sheets, microbiology reports, and discharge summaries. Missing observations were documented and were not statistically imputed.

All 100 enrolled patients completed the 30-day surveillance period. Post-discharge follow-up was conducted through scheduled outpatient clinical visits, review of hospital readmission records, and structured telephone contact. Patients who died before day 30 were retained in the primary cohort, and their survival status was documented as postoperative mortality. Complete-case analysis was applied for all multivariable models.

Statistical analysis

Data were entered into Microsoft Excel 2016 (Microsoft Corporation, Redmond, WA) and analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY). Categorical variables were summarized as frequencies and percentages. Comparisons between elective and emergency surgery groups were performed using Pearson's chi-square test when its assumptions were satisfied and Fisher's exact test when expected cell counts were sparse. Relative risks (RRs) with 95% confidence intervals (CIs) were calculated for postoperative outcomes, using elective surgery as the reference group. Associations between selected patient characteristics and SSI were assessed using univariable binary logistic regression, with crude odds ratios (ORs) and 95% CIs reported. For two-by-two tables containing zero cell counts, the Haldane-Anscombe correction (addition of 0.5 to each cell) was used to estimate crude ORs and their 95% CIs where appropriate. Fisher's exact test was used for significance testing in sparse contingency tables. Corrected OR estimates were interpreted cautiously because of their potential imprecision. Variables meeting the prespecified selection criterion of ($p < 0.20$) in univariable analysis, together with clinically relevant variables, were considered for multivariable binary logistic regression. The final model included sex, surgical urgency, diabetes mellitus, previous addiction history, and age. Adjusted odds ratios (AORs), 95% CIs, regression coefficients, and corresponding p-values were reported. A two-sided p-value of less than 0.05 was considered statistically significant.

Ethical considerations

The study protocol was approved by the Institutional Ethics Committee of Sumandeep Vidyapeeth (Approval No. SVIEC/ON/MEDI/BNPG23/AUG/24/50). The committee meeting was held on 29 August 2024, and the formal approval letter was issued on 28 October 2024, with an outward date of 29 October 2024.

Written informed consent was obtained from all participants before enrollment. Patient confidentiality was maintained throughout the study, and the study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

Results

The study enrolled 100 patients who underwent open abdominal surgery, including 50 elective and 50 emergency procedures.

Baseline demographic and clinical characteristics are presented in Table *1*. Patients aged 51-60 years were most common in the elective group (13, 26.0%), whereas those aged above 60 years predominated in the emergency group (16, 32.0%). Age distribution did not differ significantly between groups ($\chi^2 = 10.9$, $p = 0.053$). Male patients accounted for 28 (56.0%) elective and 38 (76.0%) emergency cases, showing a significant difference ($\chi^2 = 4.46$, $p = 0.035$). No significant past history was recorded in 40 (80.0%) elective and 32 (64.0%) emergency patients (Fisher's exact test, $p = 0.082$). Previous abdominal surgery was reported in five (10.0%) and three (6.0%) patients, respectively ($p = 0.461$), while previous addiction history was reported in three (6.0%) and 9 (18.0%), respectively ($p = 0.065$). Comorbidity distribution did not differ significantly between groups (Fisher's exact test, $p = 0.352$).

Characteristic	Category	Elective (n = 50), n (%)	Emergency (n = 50), n (%)	Total (N = 100), n (%)	Test Statistic	p-value
Age group (years)	Below 20	2 (4.0)	2 (4.0)	4 (4.0)	10.9	0.053
	21-30	4 (8.0)	11 (22.0)	15 (15.0)		
	31-40	8 (16.0)	9 (18.0)	17 (17.0)		
	41-50	12 (24.0)	9 (18.0)	21 (21.0)		
	51-60	13 (26.0)	3 (6.0)	16 (16.0)		
	Above 60	11 (22.0)	16 (32.0)	27 (27.0)		
Sex	Female	22 (44.0)	12 (24.0)	34 (34.0)	4.46	0.035
	Male	28 (56.0)	38 (76.0)	66 (66.0)		
Past history	No significant past history	40 (80.0)	32 (64.0)	72 (72.0)	Fisher exact test	0.082
	Past addiction history	4 (8.0)	10 (20.0)	14 (14.0)		
	History of trauma	1 (2.0)	5 (10.0)	6 (6.0)		
	Abdominal surgery	5 (10.0)	3 (6.0)	8 (8.0)		
Previous addiction history	No	47 (94.0)	41 (82.0)	88 (88.0)	3.41	0.065
	Yes	3 (6.0)	9 (18.0)	12 (12.0)		
Previous abdominal surgery	No	45 (90.0)	47 (94.0)	92 (92.0)	0.543	0.461
	Yes	5 (10.0)	3 (6.0)	8 (8.0)		
Comorbidity	Tuberculosis-related conditions	1 (2.0%)	2 (4.0%)	3 (3.0%)	Fisher exact test	0.352
	Pancreatitis	2 (4.0%)	0 (0.0%)	2 (2.0%)		
	Asthma	2 (4.0%)	0 (0.0%)	2 (2.0%)		
	Colorectal malignancy (carcinoma rectum)	1 (2.0%)	2 (4.0%)	3 (3.0%)		
	Endometrial carcinoma	3 (6.0%)	0 (0.0%)	3 (3.0%)		
	Ovarian carcinoma	1 (2.0%)	0 (0.0%)	1 (1.0%)		
	Diabetes mellitus	2 (4.0%)	6 (12.0%)	8 (8.0%)		
	Hypertension	1 (2.0%)	6 (12.0%)	7 (7.0%)		
	Sickle cell anemia	1 (2.0%)	0 (0.0%)	1 (1.0%)		
	Nil (no comorbidity recorded)	36 (72.0%)	34 (68.0%)	70 (70.0%)		

TABLE 1: Comparison of demographic characteristics, past history, previous abdominal surgery, and comorbidities between patients undergoing elective and emergency open abdominal surgery (N = 100).

Categorical variables are presented as frequencies and percentages. Past-history categories and comorbidity categories may overlap; patients with multiple recorded conditions could contribute to more than one category. Therefore, the counts for individual comorbidities should not be summed to estimate the number of unique patients with comorbidity. Comparisons between elective and emergency surgery groups were performed using Pearson's chi-square test or Fisher's exact test, as appropriate. A p-value < 0.05 was considered statistically significant.

Postoperative outcomes are summarized in Table 2. SSI occurred in 30 patients (30.0%), including 19 (38.0%) in the emergency surgery group and 11 (22.0%) in the elective surgery group (RR = 1.73, 95% CI: 0.94-3.19; Pearson's $\chi^2 = 3.05$, p = 0.081). Overall, 79 patients were discharged alive (45 (90.0%) elective vs. 34 (68.0%) emergency). Postoperative mortality was significantly higher after emergency surgery (16 (32.0%) vs. 5 (10.0%); RR = 3.20, 95% CI: 1.29-7.94; Pearson's $\chi^2 = 7.29$, p = 0.007). All 100 patients completed 30-day follow-up.

Outcome	Elective (n = 50), n (%)	Emergency (n = 50), n (%)	Relative Risk (95% CI)	Pearson's χ^2	p-value
Surgical site infection					
No SSI	39 (78.0)	31 (62.0)	Reference	3.05	0.081
SSI	11 (22.0)	19 (38.0)	1.73 (0.94-3.19)		
Postoperative outcome					
Discharged alive	45 (90.0)	34 (68.0)	Reference	7.29	0.007
Death	5 (10.0)	16 (32.0)	3.20 (1.29-7.94)		

TABLE 2: Comparison of postoperative SSI and clinical outcome between elective and emergency open abdominal surgery.

Data are presented as frequencies and percentages. Pearson's chi-square test was used to compare categorical outcomes between the elective and emergency surgery groups. RRs and 95% CIs were calculated using the elective group as the reference category. A two-sided p-value < 0.05 was considered statistically significant.

CI, confidence interval; RR, relative risk; SSI, surgical site infection

Factors associated with SSI are presented in Table 3. Emergency surgery was associated with higher odds of SSI than elective surgery (crude OR = 2.17; 95% CI: 0.90-5.24; p = 0.126), although the association was not statistically significant. Female patients had lower odds of SSI than male patients (OR = 0.48; 95% CI: 0.18-1.28; p = 0.171). Previous abdominal surgery was also associated with lower odds of SSI (OR = 0.31; 95% CI: 0.04-2.64; p = 0.429). No statistically significant associations were observed for tuberculosis, malignancy, infectious disease, or previous addiction history. The corresponding crude ORs were 2.43, 0.14, 0.24, and 1.80, respectively. All associations had p-values greater than 0.05.

Characteristic	Category	No SSI (n = 70), n (%)	SSI (n = 30), n (%)	Total (N = 100), n (%)	Crude OR	95% CI	p-value
Age group (years)	Below 20 (Reference)	1 (1.4)	3 (10.0)	4 (4.0)	1	Reference	0.214
	21-30	8 (11.4)	7 (23.3)	15 (15.0)	0.29	0.02-3.48	
	31-40	13 (18.6)	4 (13.3)	17 (17.0)	0.1	0.01-1.28	
	41-50	16 (22.9)	5 (16.7)	21 (21.0)	0.1	0.01-1.24	
	51-60	13 (18.6)	3 (10.0)	16 (16.0)	0.08	0.01-1.02	
	Above 60	19 (27.1)	8 (26.7)	27 (27.0)	0.14	0.01-1.56	
Gender	Male (Reference)	43 (61.4)	23 (76.7)	66 (66.0)	1	Reference	0.171
	Female	27 (38.6)	7 (23.3)	34 (34.0)	0.48	0.18-1.28	
Type of surgery	Elective (Reference)	39 (55.7)	11 (36.7)	50 (50.0)	1	Reference	0.126
	Emergency	31 (44.3)	19 (63.3)	50 (50.0)	2.17	0.90-5.24	
Previous abdominal surgery	No (Reference)	63 (90.0)	29 (96.7)	92 (92.0)	1	Reference	0.429
	Yes	7 (10.0)	1 (3.3)	8 (8.0)	0.31	0.04-2.64	
Malignancy	No (Reference)	63 (90.0)	30 (100.0)	93 (93.0)	1	Reference	0.099
	Yes	7 (10.0)	0 (0.0)	7 (7.0)	0.14*	0.01-2.51*	
Tuberculosis	No (Reference)	68 (97.1)	28 (93.3)	96 (96.0)	1	Reference	0.581
	Yes	2 (2.9)	2 (6.7)	4 (4.0)	2.43	0.33-18.10	
Infectious disease	No (Reference)	66 (94.3)	30 (100.0)	96 (96.0)	1	Reference	0.313
	Yes	4 (5.7)	0 (0.0)	4 (4.0)	0.24*	0.01-4.64*	
Previous addiction history	No (Reference)	63 (90.0)	25 (83.3)	88 (88.0)	1	Reference	0.338
	Yes	7 (10.0)	5 (16.7)	12 (12.0)	1.8	0.52-6.21	
Diabetes mellitus	No (Reference)	64 (91.4)	28 (93.3)	92 (92.0)	1	Reference	1.000*
	Yes	6 (8.6)	2 (6.7)	8 (8.0)	0.76	0.14-4.13	

TABLE 3: Univariable analysis of patient-related factors associated with SSI following open abdominal surgery (N = 100).

This table presents the univariable analysis of selected patient-related characteristics and their association with surgical site infection (SSI) among 100 patients undergoing open abdominal surgery. Categorical variables are expressed as frequencies and percentages in the SSI (n = 30) and non-SSI (n = 70) groups. Crude odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using 2 × 2 contingency tables, with specified reference categories. Pearson's chi-square test or Fisher's exact test was used, as appropriate. For variables with zero cell counts, a 0.5 continuity correction (*Haldane-Anscombe correction) was applied to estimate ORs and corresponding 95% CIs. Overall p-values for age groups represent comparisons across all age categories. Approximate Wald CIs should be interpreted cautiously because of sparse data. Fisher's exact test was used for diabetes mellitus. A two-sided p-value < 0.05 was considered statistically significant.

Among the eight patients with diabetes mellitus, two (25.0%) developed SSI, compared with 28 of 92 (30.4%) patients without diabetes. The association was not statistically significant (Fisher's exact test, p = 1.000; crude OR = 0.76). However, the small number of patients with diabetes limits the precision of this estimate, and the findings should not be interpreted as evidence that diabetes reduces SSI risk.

Microbiological findings, antibiotic sensitivity, and treatment responses are presented in Table 4. Among the 30 patients with SSI, *Escherichia coli* was the most frequently isolated organism (13, 43.3%), followed by *Staphylococcus aureus* (10, 33.3%), *Klebsiella* spp. (4, 13.3%), and *Pseudomonas aeruginosa* (2, 6.7%); no growth was reported in one case (3.3%). The distribution of microorganisms did not differ significantly between the elective and emergency groups (Fisher's exact test, p = 0.073). Antibiotic sensitivity was

observed in 24 (80.0%) patients, while 6 (20.0%) showed resistance, with no significant difference between groups (Fisher's exact test, p = 0.641). Regarding treatment response, 16 (53.3%) patients improved clinically, whereas 14 (46.7%) were non-responsive. The difference in treatment response between the elective and emergency groups was not statistically significant ($\chi^2 = 2.01$, p = 0.156).

Variable	Elective n (%) (n = 11)	Emergency n (%) (n = 19)	Total n (%) (N = 30)	Test Statistic	p-value
Microorganisms isolated from surgical site infections					
Escherichia coli	8 (72.7)	5 (26.3)	13 (43.3)		
Klebsiella spp.	1 (9.1)	3 (15.8)	4 (13.3)		
No growth	0 (0.0)	1 (5.3)	1 (3.3)	Fisher exact test	0.073
Pseudomonas aeruginosa	0 (0.0)	2 (10.5)	2 (6.7)		
Staphylococcus aureus	2 (18.2)	8 (42.1)	10 (33.3)		
Antibiotic sensitivity					
Sensitive	8 (72.7)	16 (84.2)	24 (80.0)	Fisher exact test	0.641
Resistant	3 (27.3)	3 (15.8)	6 (20.0)		
Response to treatment					
Responsive	4 (36.4)	12 (63.2)	16 (53.3)	$\chi^2 = 2.01$	0.156
Non-responsive	7 (63.6)	7 (36.8)	14 (46.7)		

TABLE 4: Microbiological findings, antibiotic susceptibility, and treatment response among patients with SSI (n = 30).

Antibiotic susceptibility analysis was performed only among patients who developed surgical site infection (n = 30). Values are presented as n (%). Percentages for the elective and emergency groups were calculated using the number of SSI cases within each group (elective = 11; emergency = 19). Total percentages were calculated using all SSI cases (N = 30). Comparisons of treatment response between elective and emergency surgery groups were performed using Pearson's chi-square test. Fisher's exact test was used to compare antibiotic susceptibility and microorganism distribution because of sparse cell counts. A p-value < 0.05 was considered statistically significant.

After adjustment for sex, type of surgery, diabetes mellitus, previous addiction history, and age, none of the variables was independently associated with SSI. Male sex was associated with higher odds of SSI than female sex, although the association was not statistically significant (AOR = 1.69; 95% CI: 0.60-4.74; β = 0.522; Z = 0.989; p = 0.323). Emergency surgery also showed higher odds of SSI compared with elective surgery, but this association was not statistically significant (AOR = 1.95; 95% CI: 0.78-4.92; β = 0.670; Z = 1.423; p = 0.155). Diabetes mellitus was not significantly associated with SSI (AOR = 0.73; 95% CI: 0.13-4.19; β = -0.309; Z = -0.348; p = 0.728). Similarly, previous addiction history was not significantly associated with SSI (AOR = 1.21; 95% CI: 0.33-4.46; β = 0.186; Z = 0.279; p = 0.780). Age, modeled as a continuous variable, was also not significantly associated with SSI (AOR = 0.99 per one-year increase; 95% CI: 0.96-1.01; β = -0.012; Z = -0.896; p = 0.370) (Table *5*).

Predictor	Adjusted OR	95% CI	β	SE	p-value
Male vs. female	1.69	0.60-4.74	0.5219	0.5278	0.323
Emergency vs. elective surgery	1.95	0.78-4.92	0.67	0.4707	0.155
Diabetes mellitus: yes vs. no	0.73	0.13-4.19	-0.3093	0.8891	0.728
Previous addiction history: yes vs. no	1.21	0.33-4.46	0.1862	0.6676	0.78
Age, per one-year increase	0.99	0.96-1.01	-0.0121	0.0135	0.37

TABLE 5: Multivariable binary logistic regression analysis of factors associated with SSI following open abdominal surgery.

Values are presented as regression coefficients (β), standard errors (SE), Z statistics, adjusted odds ratios (AORs), 95% confidence intervals (CIs), and p-values. SSI was the dependent variable, coded as SSI = Yes vs. SSI = No. The multivariable binary logistic regression model included sex, type of surgery, diabetes mellitus, previous addiction history, and age (modeled as a continuous variable). Female sex, elective surgery, absence of diabetes mellitus, and absence of previous addiction history were used as reference categories. AORs and 95% CIs were calculated by exponentiating the regression coefficients and their corresponding confidence limits. Model fit was assessed using deviance = 117, Akaike information criterion (AIC) = 129, Bayesian information criterion (BIC) = 144, McFadden R^2 = 0.0458, Cox-Snell R^2 = 0.0544, and likelihood-ratio χ^2 = 5.60, df = 5, p = 0.347. A two-sided p-value < 0.05 was considered statistically significant.

The multivariable model had a deviance of 117, an Akaike information criterion (AIC) of 129, and a Bayesian information criterion (BIC) of 144. The McFadden R^2 and Cox-Snell R^2 values were 0.0458 and 0.0544, respectively. The overall model was not statistically significant (likelihood-ratio χ^2 = 5.60, df = 5, p = 0.347).

Discussion

The present study compared patients undergoing elective and emergency open abdominal surgery to evaluate postoperative outcomes, SSI, associated clinical factors, and microbiological findings. Although several baseline characteristics were comparable between the groups, sex distribution differed significantly, with a higher proportion of males in the emergency group. Age distribution, previous abdominal surgery, past medical history, and comorbidity distribution did not differ significantly between the groups. Khan et al. [9] similarly noted demographic variations when evaluating postoperative SSI across general surgical procedures, while Li et al. [10] reported a median age of 54 years with males comprising approximately 59% of their emergency cohort. Variations in institutional catchment demographics, patient selection, and surgical case mix must be taken into account when comparing these baseline findings.

The overall 30-day SSI occurrence in the present cohort was 30.0% (30/100). Infection developed in 19 patients (38.0%) undergoing emergency surgery compared with 11 patients (22.0%) undergoing elective procedures. Although the RR of developing SSI was higher following emergency surgery (RR = 1.73, 95% CI: 0.94-3.19), the difference did not achieve statistical significance (Pearson's χ^2= 3.05, p = 0.081). Khan et al. [9] reported SSI incidences of 20.3% following emergency operations and 9.2% after elective procedures, whereas Gillespie et al. [4], in a large global meta-analysis, documented a pooled 30-day general surgical SSI rate of approximately 11%, with higher infection frequencies consistently observed in urgent surgical settings. While our observed SSI rate aligns with the elevated risk seen in acute surgical cohorts, our primary clinical records did not document precise tissue depth planes, preventing anatomical stratification into superficial, deep, and organ/space infections. Consequently, our rate represents a composite clinical outcome and should be compared cautiously with studies specifically evaluating superficial incisional infections alone, such as the 39% incidence reported in Central India by Borle and Mekhla [6].

Postoperative 30-day mortality was significantly higher in the emergency group than in the elective group (32.0% vs. 10.0%; RR = 3.20, 95% CI: 1.29-7.94; Pearson's χ^2= 7.29, p = 0.007). This notable mortality disparity underscores the heightened physiological compromise, septic shock, delayed presentation, and acute hemodynamic instability commonly encountered in emergency laparotomies. These findings are congruent with Negruț et al. [11], who documented markedly worse survival outcomes in emergency vs. elective colorectal resections, and Shinall et al. [12], who demonstrated that acute operative stress substantially amplifies postoperative mortality among frail patients. Nonetheless, because underlying disease severity scores and acute physiological derangements were not formally stratified, illness severity and acute surgical indications likely contributed substantially to this observed mortality gap.

In the univariable analysis, emergency surgery showed a trend toward increased odds of SSI (crude OR = 2.17, 95% CI: 0.90-5.24, p = 0.126), whereas female sex was associated with lower crude odds (OR = 0.48, 95% CI: 0.18-1.28, p = 0.171). Previous abdominal surgery (OR = 0.31) and addiction history (OR = 1.80) did not show statistically significant associations. Among the eight patients with diabetes mellitus, two developed

an SSI (25.0%) compared with 28 of 92 non-diabetic patients (30.4%; Fisher's exact test, p = 1.000, crude OR = 0.76). This estimate should not be interpreted as evidence of a protective biological effect; rather, it reflects wide CIs resulting from sparse event counts in a small diabetic subset. Similarly, zero SSI events among patients with recorded malignancy and infectious diseases yielded wide, unstable odds ratios that preclude causal inference.

After controlling for sex, surgical urgency, diabetes mellitus, previous addiction history, and age in multivariable binary logistic regression, none of these variables retained an independent statistically significant association with SSI. Although emergency surgery (AOR = 1.95, 95% CI: 0.78-4.92, p = 0.155) and male sex (AOR = 1.69, 95% CI: 0.60-4.74, p = 0.323) demonstrated elevated point estimates, statistical significance was limited by the modest overall sample size. Other recognized procedural determinants - most notably operative duration and intraoperative wound contamination class (clean, clean-contaminated, contaminated, dirty) - could not be evaluated in the regression model because missing entries exceeded 40% in routine emergency operating room logbooks. Previous studies by Xu et al. [13] and Alkaaki et al. [14] emphasize that wound contamination and prolonged operative time are among the strongest independent predictors of abdominal SSI; their omission in our final statistical model leaves open the potential for residual confounding.

Microbiologically, *Escherichia coli* was the most predominant pathogen, accounting for 43.3% (13/30) of all positive wound cultures, followed by *Staphylococcus aureus* (33.3%, 10/30), *Klebsiella* spp. (13.3%, 4/30), and *Pseudomonas aeruginosa* (6.7%, 2/30), with one specimen yielding no bacterial growth. Although *Escherichia coli* was proportionately more frequent in elective cases (72.7% vs. 26.3%) and *Staphylococcus aureus* in emergency cases (42.1% vs. 18.2%), the overall distribution of pathogens did not differ significantly between cohorts (p = 0.073). These findings are consistent with reports by Misha et al. [15] and Erinmez et al. [16], who highlighted the predominance of enteric Gram-negative bacilli following abdominal surgery. The prominent presence of *Staphylococcus aureus* in our emergency cohort likely reflects acute skin barrier breach, emergent wound handling, or environmental exposure during resuscitation.

Antimicrobial susceptibility testing indicated that 80.0% (24/30) of isolates were sensitive to the tested antimicrobial panels, while 20.0% (6/30) exhibited resistance, with no significant difference between surgical groups (p = 0.641). These findings must be interpreted in light of local hospital testing methods; routine laboratory documentation recorded overall categorical status (sensitive vs. resistant) without archiving quantitative zone diameters or MICs. While Mohamed et al. [17] and Seid et al. [18] documented high rates of multidrug-resistant pathogens in emergency surgical cohorts, the smaller number of culture-confirmed infections in our study limits comprehensive characterization of specific resistance phenotypes.

Regarding therapeutic response, 53.3% of infected patients (16/30) achieved clinical improvement following targeted antimicrobial therapy and bedside wound management, whereas 46.7% (14/30) demonstrated persistent signs of infection during surveillance. Response rates did not differ significantly by operative urgency (p = 0.156). Achieving wound resolution in open abdominal surgery is multifactorial, requiring not only appropriate antimicrobial coverage but also nutritional support, glycemic stabilization, and regular drainage or debridement. These clinical outcomes reinforce the importance of structured preventive care bundles, timely perioperative antibiotic prophylaxis, and active postoperative wound surveillance, as highlighted by Isand et al. [8], Filardi et al. [19], and Calderwood et al. [20].

In summary, SSI occurred more frequently after emergency open abdominal surgery than elective surgery, although this difference was not statistically significant, whereas postoperative mortality was significantly higher in the emergency cohort. *Escherichia coli* and *Staphylococcus aureus* accounted for the majority of wound infections. Because statistical power was limited by the cohort size of 100 patients and missing documentation prevented analysis of operative duration and wound class, our findings should be considered exploratory. Future prospective studies with larger multi-center cohorts, systematic screening documentation, standardized wound depth classification, and complete quantitative microbiological profiling are warranted to further clarify risk factors and optimize surgical infection prevention.

Limitations

The present study has several limitations that should be considered when interpreting the findings. First, it was conducted at a single tertiary care teaching hospital, which may limit the generalizability of the results to other healthcare settings with different patient populations, surgical practices, and infection prevention and control protocols. Second, the sample size was relatively small (N = 100), with a predetermined allocation of 50 patients undergoing elective surgery and 50 undergoing emergency surgery. Although participants were recruited consecutively within the respective groups, this allocation may not reflect the actual distribution of elective and emergency open abdominal surgeries at the hospital. Consequently, the overall SSI proportion of 30.0% (30/100) represents the study sample and should not be interpreted as the cumulative incidence among all open abdominal surgeries performed at the facility. Third, the sample size was calculated using a single-proportion formula to estimate SSI proportion with prespecified precision; it was not powered for between-group hypothesis testing or multivariable regression. Multivariable estimates must therefore be considered exploratory, particularly given wide CIs and sparse data for certain predictors. Fourth, pre-enrollment screening logs were not systematically archived during emergency triage and routine

admissions, precluding retrospective reconstruction of excluded or non-consenting individuals. Fifth, only open abdominal procedures were evaluated; thus, findings cannot be extrapolated to laparoscopic or robotic interventions. Sixth, although operative duration and wound contamination classification were included on the initial study proforma, documentation in operative theater registers was inconsistent (with missing data exceeding 40%), preventing their reliable tabulation or entry into regression models; other recognized risk factors, including ASA physical status, body mass index, nutritional status, and prophylaxis timing, were likewise not assessed, leaving potential for residual confounding. Seventh, primary clinical records lacked consistent anatomical depth demarcation, precluding reliable subclassification into superficial incisional, deep incisional, and organ/space infections. Eighth, microbiological data were limited to conventional aerobic culture and categorical susceptibility reporting (sensitive vs. resistant) without recorded inhibition zone diameters, MICs, or molecular characterization of resistance mechanisms. Finally, patient surveillance was restricted to 30 days postoperatively; longer-term sequelae, including incisional hernia, functional quality of life, readmission, and financial burden, were not evaluated.

Conclusions

SSI was more frequent following emergency than elective open abdominal surgery, whereas postoperative mortality was substantially higher among patients undergoing emergency surgery. *Escherichia coli* was the most frequently isolated bacterium, followed by *Staphylococcus aureus*. Antimicrobial susceptibility findings indicated that most tested bacterial isolates were susceptible to the antimicrobial agents evaluated, although the clinical response to treatment varied. These findings highlight the clinical and microbiological characteristics of SSI following open abdominal surgery. Potential risk factors and adjusted associations require cautious interpretation because of the limited sample size, observational design, and sparse data in several categories. Larger, adequately powered prospective studies are needed to clarify factors associated with SSI and strengthen perioperative infection surveillance and preventive strategies.

Appendices

Section	Variable	Details/Response
Patient identification	Study ID	
	IPD registration no.	
	OPD no.	
	Date of admission	____ / ____ / _____
	Date of surgery	____ / ____ / _____
	Date of discharge/death	____ / ____ / _____
	Name	
	Age (years)	
	Sex	□ Male □ Female
	Height (cm)	
	Weight (kg)	
	BMI (kg/m²)	
	Address	
	Contact number	
	Occupation	
	Religion	
	Socioeconomic status	
	Chief complaints	
	Duration of symptoms	
	Previous abdominal surgery	□ Yes □ No
	Previous hospitalization	□ Yes □ No
	History of trauma	□ Yes □ No

Clinical history	History of tuberculosis	□ Yes □ No
	Smoking history	□ Yes □ No
	Alcohol consumption	□ Yes □ No
	Previous antibiotic use	□ Yes □ No
	Drug allergy	□ Yes □ No
	Other relevant history	
Comorbidities	Diabetes mellitus	□ Yes □ No
	Hypertension	□ Yes □ No
	Malignancy	□ Yes □ No
	Chronic liver disease	□ Yes □ No
	Chronic kidney disease	□ Yes □ No
	Asthma/COPD	□ Yes □ No
	Immunocompromised state	□ Yes □ No
	Pancreatitis	□ Yes □ No
	Other comorbidity	
Clinical examination	General physical examination	
	Pulse rate (/min)	
	Blood rressure (mmHg)	
	Temperature (°C)	
	Respiratory rate (/min)	
	Abdominal examination findings	
	Preoperative diagnosis	
Laboratory investigations	Hemoglobin	
	Total leukocyte count	
	Random blood sugar	
	Blood urea	
	Serum creatinine	
	Other relevant investigations	
Operative details	Type of surgery	□ Elective □ Emergency
	Operative diagnosis	
	Surgical procedure performed	
	Surgical incision	
	Time from admission to surgery	
	Wound classification	□ Clean □ Clean-contaminated □ Contaminated □ Dirty
	Duration of surgery (minutes)	

	Intraoperative findings	
Postoperative assessment	Surgical site infection (SSI)	□ Present □ Absent
	Postoperative day of SSI	
	Clinical features	□ Pain □ Redness □ Swelling □ Purulent discharge □ Wound dehiscence □ Fever
	Surgeon diagnosis of SSI	□ Yes □ No
Microbiological findings	Specimen collected	□ Pus □ Wound Swab □ Tissue
	Culture performed	□ Yes □ No
	Organism isolated	□ *Escherichia coli* □ *Staphylococcus aureus* □ *Klebsiella* spp. □ *Pseudomonas aeruginosa* □ Other _____
	Antibiotic susceptibility	□ Sensitive □ Resistant
Postoperative management	Broad-spectrum antibiotics given	□ Yes □ No
	Clinical response	□ Improved □ Persistent infection
	Additional surgical intervention	□ Yes □ No
	ICU admission	□ Yes □ No
Outcome	Length of hospital stay (days)	
	Final outcome	□ Discharged □ Death
	Cause of death (if applicable)	
	Completed 30-day follow-up	□ Yes □ No

TABLE 6: Structured case record proforma used for prospective data collection in patients undergoing elective and emergency open abdominal surgery.

The structured case record proforma was designed to prospectively collect standardized clinical and research data from patients undergoing elective or emergency open abdominal surgery. It comprised sections on patient identification, demographic characteristics, clinical history, lifestyle factors, comorbidities, physical examination, laboratory investigations, operative details, postoperative assessment, microbiological findings, postoperative management, and clinical outcomes. Operative variables included the type of surgery, operative diagnosis, surgical procedure, wound classification, duration of surgery, and intraoperative findings. Postoperative assessment documented the occurrence of surgical site infection (SSI), postoperative day of diagnosis, clinical features, surgeon-confirmed SSI, microbiological culture results, isolated organisms, antimicrobial susceptibility patterns, antibiotic treatment, clinical response, intensive care unit admission, length of hospital stay, discharge status or in-hospital mortality, and completion of the 30-day follow-up. The data collected using this proforma were used for descriptive analyses, comparative analyses, and multivariable logistic regression to evaluate factors associated with postoperative SSI.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Pratik Shaparia, Sadiyahparveen V. Saiyed, Surya Prakash, Sonik G. Shah

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Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Sumandeep Vidyapeeth Institutional Ethics Committee issued approval SVIEC/ON/MEDI/BNPG23/AUG/24/50. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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