Surgical Site Infection in Elective General Surgical Procedures

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ABSTRACT

Objective To determine the frequency of surgical site infection (SSI) and identify the associated risk factors in elective clean and clean-contaminated general surgical procedures.

Study design This was a retrospective cohort study.

Place & Duration of study Department of General Surgery, East Surgical Ward, Mayo Hospital Lahore, from January 2024 to January 2025.

Methods The data of all patients aged >12 years who were operated electively under clean and clean-contaminated category of surgical procedures, were included. All patients had standardized perioperative management according to institutional elective surgery and surgical site infection prevention protocols. Risk factor analysis was restricted to patients who completed 30 days and 90 days (in case of implant) follow-up. Data on demographics, comorbid conditions, category of wound, and outcomes were collected. SSI was defined according to CDC/NHSN criteria. Statistical analysis was performed using SPSS version 26.0 and R software. Continuous variables were compared using Student's t-test and categorical variables using Chi-square or Fisher's exact test. Multivariable analysis was performed using Firth bias-reduced logistic regression. A p-value <0.05 was considered significant.

Results A total of 620 cases were identified; Among patients with completed follow-up (n = 397), SSI occurred in 53 (13.4%) patients. Superficial incisional SSI was the most common subtype (64.2%). The difference in length of hospital stay between SSI and non-SSI groups was not statistically significant (p=0.23). Approximately one-third of SSI cases required readmission. On multivariable Firth regression, none of the examined patient-level variables (age, sex, diabetes mellitus, obesity, smoking, or wound class) demonstrated an independent association with SSI.

Conclusion The frequency of SSI in elective clean and clean-contaminated surgery remained substantial in our setting. The absence of independent patient-level predictors suggests that operating theatre environment and perioperative factors may play an important role and warrant further investigation.

Key words Surgical site infection, Elective surgery, Clean wound, Clean contaminated wound.

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INTRODUCTION:

Surgical site infection remains one of the most common complications in surgical practices and contribute substantially to postoperative morbidity, prolonged hospital stay, increased healthcare costs, and patient dissatisfaction worldwide.[1,2] Despite advances in aseptic techniques, antimicrobial prophylaxis, and perioperative care, SSI continues to pose a significant challenge, particularly in low- and middle-income countries (LMICs).[3,4]

Globally, the incidence of SSI after elective surgical procedures in high-income settings is reported to range between 2% and 5%, depending on procedure type and surveillance methodology. However, studies from LMICs, including Pakistan, consistently report higher rates, often exceeding 10%, reflecting differences in resource availability, infection control practices, and surveillance systems. These variations highlight the need for continuous local surveillance and context-specific quality improvement initiatives.[5,6]

Several patient-related factors such as diabetes mellitus, obesity, smoking, advanced age, and wound classification have been traditionally associated with increased SSI risk. Nevertheless, the relative contribution of these factors may vary depending on case mix, surgical setting, and perioperative practices. In homogeneous elective cohorts, particularly those limited to clean and clean-contaminated procedures, the predictive value of individual patient factors may be masked.[7,8] Understanding the current pattern of SSI is essential for guiding targeted infection prevention strategies and optimizing perioperative care pathways. The present study was conducted to determine the frequency of surgical site infection in elective clean and clean-contaminated general surgical procedures and to evaluate the associated risk factors in a tertiary care setting.

METHODS:

Study design, place & duration: This retrospective cohort study was conducted in the Department of General Surgery, East Surgical Ward, Mayo Hospital Lahore affiliated with King Edward Medical University. The data from January 2024 to January 2025 were retrieved and analyzed.

Ethical considerations: IRB approval was taken to conduct the study (No. 642/RC/KEMU – August 28, 2025).

Inclusion and exclusion criteria: The records of all the patients aged 12 years and above who underwent elective clean and clean-contaminated general surgical procedures whose complete data as well as postoperative follow-up available, were included. Patients who were operated in emergency were excluded.

Sample size estimation: A total of 620 procedures were performed. However, 397 patients completed 30-days and 90 days (in case of implant) follow-up. The present study was based upon this cohort only.

Study protocol: All patients underwent standardized perioperative management according to institutional elective surgery and surgical site infection prevention protocols. Preoperatively, patients were kept nil per oral as per standard fasting guidelines. Hair removal, when required, was performed using a razor by the patient one day before surgery according to existing unit practice. A clean OR kit was provided to patients in morning before surgery. The operative field was prepared using water-based povidone-iodine 10% antiseptic solution following standard aseptic technique. A dedicated sterile operating theatre (OT) instrument set was used for each procedure, and operating room cleanliness was maintained. Intravenous prophylactic antibiotics were administered within 60-minutes prior to surgical incision. Intraoperative normothermia and hemodynamic stability were maintained as per routine anesthesia protocols, and glycemic control was optimized in diabetic patients.

Postoperatively, Oral intake was resumed once bowel sounds were audible and the patient was clinically stable. The primary dressing was inspected and opened after 48-hours if not soaked or clinically indicated earlier. Postoperative antibiotics were administered as indicated. Patients were discharged with instructions related to wound care and regular bath. Patients were followed for 30 days and 90 days in case of implant (mesh hernioplasty) for SSI surveillance. Data were retrieved from operative registers, patients' medical records, postoperative follow-up documentation, and by contacting patients on phone using a structured proforma.

Statistical analysis: Variables recorded included demographics (age, sex), comorbid conditions (diabetes mellitus, obesity, smoking status), operative variables (CDC wound class of procedures - superficial incisional, deep incisional, and organ/space infection.), and outcomes (surgical site infection, length of hospital stay, readmission, and re-operation).

Data were analyzed using SPSS version 26.0 and R software where appropriate. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Comparisons between SSI and non-SSI groups were performed using Student's t-test for continuous variables and Chi-square test or Fisher's exact test for categorical variables. Multivariable analysis was performed using Firth bias-reduced logistic regression to account for small event counts and potential separation. Antibiotic prophylaxis was excluded from multivariable modeling due to lack of variability (administered in all patients). Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were reported. A p-value < 0.05 was considered statistically significant.

RESULTS:

Among patients with completed follow-up (n = 397), SSI occurred in 53 (13.4%) subjects. Superficial incisional infection constituted the majority of cases (n=34 – 64.2%), followed by deep incisional (n=15 – 28.3%) and organ/space infections (n=4 – 7.5%). The mean age of the patients who developed SSI was comparable to those without SSI. Female patients had higher SSI rate than males. However, the difference was not statistically significant. Similarly, diabetes mellitus, obesity, smoking status, and CDC wound class showed no significant association with SSI on univariate analysis (table I). Overall, none of the evaluated patient-related variables demonstrated a statistically significant relationship with SSI occurrence (table II).

On adjusted analysis, none of the examined variables (age, sex, diabetes mellitus, obesity, smoking status, or wound class) demonstrated an independent association with SSI (table III).

Patients who developed SSI experienced a small but measurable increase in length of hospital stay compared with non-SSI patients but the difference in length of hospital stay between SSI (3.7±1.7 days) and non-SSI groups (3.4±1.6 days) was not statistically significant (p=0.23). Additionally, approximately one-third of SSI cases required

Table I: Univariable Comparisons (n = 397)

Variable	SSI (n = 53)	No SSI (n = 344)	p-value
Age (years, mean ± SD)	39.4 ± 15.2	41.5 ± 13.7	0.345
Male sex, n (%)	19 (35.8%)	147 (42.7%)	0.426
Diabetes mellitus, n (%)	17 (32.1%)	91 (26.5%)	0.490
Obesity, n (%)	11 (20.8%)	80 (23.3%)	0.820
Smoking, n (%)	4 (7.5%)	34 (9.9%)	0.774
Clean-contaminated wound (vs Clean), n (%)	26 (49.1%)	191 (55.5%)	0.464

Table II: Descriptive Analysis of Risk Factors by SSI Status

Variable	Category	SSI (n = 53)	No SSI (n = 344)	SSI rate (%)
Age (years)	Mean ± SD	39.4 ± 15.2	41.5 ± 13.7	—
Sex	Female	34	197	14.7
	Male	19	147	11.5
Diabetes	Yes	17	91	15.7
	No	36	253	12.5
Obesity	Yes	11	80	12.1
	No	42	264	13.7
Smoking	Yes	04	34	10.5
	No	49	310	13.7
Wound Class	Clean (Class I)	27	153	15.0
Wound Class	Clean-contaminated (Class II)	26	191	12.0

Table III: Multivariable adjusted analysis (Firth penalized logistic regression; n = 397)

Variable	Adjusted OR	95% CI	p-value
Age (per year)	0.99	0.97–1.01	0.377
Male sex	0.77	0.40–1.50	0.448
Diabetes mellitus	1.35	0.71–2.57	0.358
Obesity	0.90	0.45–1.81	0.763
Smoking	0.96	0.31–2.97	0.937
Clean-contaminated (vs Clean)	0.74	0.41–1.33	0.312

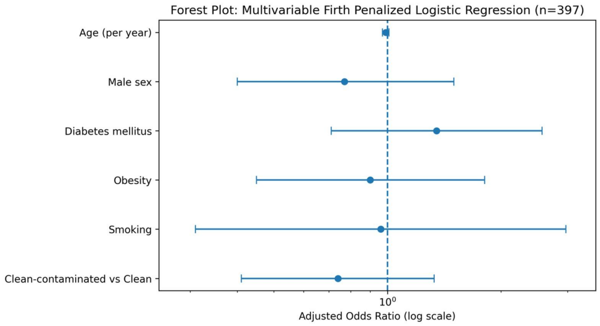

Fig: I: Forest plot: Multivariable Firth Penalized Logistic Regression

hospital readmission (n=17 – 32.1%), while re-operation was required in a minority of patients (n=3 – 5.7%). The forest plot demonstrates adjusted odds ratios with 95% confidence intervals for variables included in the multivariable Firth logistic regression model. None of the examined variables showed an independent association with surgical site infection (Figure I).

DISCUSSION:

In this retrospective cohort of elective general surgical procedures with completed follow-up the frequency of surgical site infection was 13.4%. This rate is higher than those typically reported from high-income surveillance systems where it is between 2% and 5%.[9] However, the observed burden in our setting is consistent with reports from low- and middle-income countries where SSI remains a significant postoperative complication and may affect 10 -15% of surgical patients.[10] Within Pakistan, previously published elective general surgery studies have reported SSI rates broadly comparable to our findings. Shafi et al reported SSI of 12.5% in elective general surgical procedures.[11] However, Farid et al reported an overall SSI frequency of 4.9% in elective settings.[12] Other researchers also reported almost similar pattern from all over Pakistan.[13,14]

A key finding of our study was failure to establish association of patient-level variables (age, sex, diabetes, obesity, smoking, or wound class) as independent predictors of SSI. The use of Firth regression was methodologically appropriate given sparse cells and is recommended to reduce small-sample bias in logistic models.[15] Number of studies have demonstrated associations between diabetes mellitus, obesity, and SSI risk, particularly in heterogeneous or emergency cohorts.[16,17] However, our study population was restricted to elective clean and clean-contaminated procedures, which likely reduced the biological variability and attenuated measurable patient-level effects. Studies incorporating contaminated or dirty emergency procedures frequently report stronger independent predictors of SSI, as these cohorts typically exhibit higher baseline microbial burden, increased physiological variability, and reduced opportunity for preoperative optimization.[18.]

Although CDC wound classification is a well-established predictor of SSI risk, the crude rates in our cohort did not show higher infection in clean-contaminated compared with clean wounds. The higher crude SSI rate observed in clean procedures likely reflects case-mix differences and volume distribution rather than true biological risk.[17,18] Superficial incisional SSI constituted the majority of infections in our study, mirroring local surveillance data where superficial infections consistently represent the largest proportion of SSI events.[3,11] Although patients who developed SSI demonstrated a modest increase in length of hospital stay, the difference was not statistically significant. This finding contrasts with several reports showing significantly prolonged hospitalization among SSI patients, which may be explained by the elective nature of our cohort and the predominance of superficial infections. Additionally, approximately one-third of SSI cases required readmission, while re-operation was necessary in a small number of patients as reported in another study.[19]

In this study as no independent patient-level predictors were identified, attention should shift towards modifiable system-level determinants. WHO and CDC guidance emphasizes that operating theatre discipline, antimicrobial timing, skin preparation, perioperative normothermia, glycemic control, and sterile processing quality are critical drivers of SSI risk.[20] Future research should therefore focus on operating theatre environment, process compliance, and quality-improvement interventions. Such work aligns with international SSI prevention frameworks and may yield meaningful reductions in infection rates even in resource-constrained settings.[21]

Limitations of the study: This study provided contemporary surveillance data on surgical site infection from a high-volume tertiary care general surgery unit. However, several limitations identified include the retrospective single-center design that limits causal inference and generalizability. Secondly, some potentially important operative and environmental variables like duration of surgery, operating theatre traffic, surgeon experience, perioperative temperature control, and glycemic optimization and others were not found in the dataset. Finally, the relatively homogeneous elective cohort may have attenuated detectable differences between traditional patient-level risk factors.

CONCLUSION:

The frequency of surgical site infection remained high. No independent patient-level predictors were identified on multivariable analysis, suggesting that perioperative process measures, operating theatre environment, and system-level factors may play a more prominent role in SSI occurrence.

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