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Original Article

Incidence and Risk Factors of Surgical Site Infections Following Clean-Contaminated Abdominal Surgeries: A Prospective Observational Cohort Study at a Tertiary Care Hospital

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ABSTRACT

Background: Surgical site infection remains a major cause of postoperative morbidity after abdominal surgery, particularly in tertiary-care settings where emergency presentation, wound contamination, prolonged operative duration, and inconsistent perioperative practices may increase infection risk. Objective: To determine the 30-day incidence, clinical pattern, and independent predictors of surgical site infection among adults undergoing abdominal surgery at a tertiary-care hospital in Multan, Pakistan. Methods: This prospective observational cohort study was conducted from 1 June 2023 to 31 May 2024 at Nishtar Hospital, Multan. Adult patients undergoing elective or emergency abdominal surgery with clean-contaminated or higher-contamination operative fields were followed until postoperative day 30. Surgical site infection was defined using CDC criteria. Patient-related, procedural, and perioperative variables were analyzed, and multivariable logistic regression was used to identify independent predictors. Results: Among 246 patients, 58 developed surgical site infection, giving a 30-day incidence of 23.6%. Superficial incisional infection was most common, accounting for 55.2% of cases, followed by deep incisional infection in 27.6% and organ-space infection in 17.2%. Independent predictors included open surgical approach (aOR 3.12, 95% CI 1.42–6.85), emergency surgery (aOR 2.82, 95% CI 1.53–5.19), ASA grade ≥III (aOR 2.34, 95% CI 1.18–4.63), inappropriate antibiotic timing (aOR 2.05, 95% CI 1.12–3.75), and operative duration >120 minutes (aOR 1.96, 95% CI 1.08–3.55). Mean hospital stay was longer among patients with surgical site infection than those without infection. Conclusion: Surgical site infection affected nearly one-quarter of abdominal surgery patients in this cohort. Emergency surgery, open approach, higher ASA grade, prolonged operative duration, and inappropriate antibiotic prophylaxis timing were key predictors, supporting targeted infection-prevention strategies and structured postoperative surveillance. Keywords: Surgical site infection, abdominal surgery, antibiotic prophylaxis, emergency surgery, open surgery, postoperative complications, Pakistan.

INTRODUCTION

Surgical site infections are among the most frequent healthcare-associated infections after operative care and remain an important cause of postoperative morbidity, prolonged hospitalization, reoperation, antimicrobial use, and increased healthcare expenditure, particularly in low- and middle-income healthcare systems where infection-prevention resources and surveillance systems are often limited (1). Abdominal surgery carries a disproportionately high risk of postoperative infection because many procedures involve controlled or uncontrolled entry into the gastrointestinal or genitourinary tract, exposing the surgical wound to endogenous bacterial flora. The risk is especially relevant in clean-contaminated and higher-contamination abdominal procedures, where microbial exposure, patient vulnerability, procedural complexity, and perioperative infection-control practices interact to determine postoperative wound outcomes (2).

The reported incidence of surgical site infection after abdominal surgery varies widely across settings, surgical specialties, surveillance methods, and wound-contamination classes. Rates are generally lower in high-resource surgical systems with standardized prophylaxis, active surveillance, and established infection-prevention bundles, whereas substantially higher rates have been reported from resource-constrained settings where emergency presentation, delayed optimization, prolonged operative time, limited access to minimally invasive surgery, and inconsistent antibiotic timing may be more common (3,4). International evidence has consistently identified emergency surgery, higher American Society of Anesthesiologists physical status grade, prolonged operative duration, open surgical approach, contaminated wounds, diabetes mellitus, poor nutritional status, and inappropriate antimicrobial prophylaxis as important predictors of surgical site infection (5,6). However, the relative contribution of these factors differs between institutions and populations, making local surveillance essential for designing targeted prevention strategies.

In Pakistan, tertiary-care public hospitals manage a large volume of elective and emergency abdominal surgeries, often in patients with delayed presentation, comorbid disease, anemia, hypoalbuminemia, or limited preoperative optimization. Despite this high-risk clinical environment, prospective local data using standardized postoperative surveillance remain limited. Many available studies are retrospective, limited to selected procedures, or lack detailed perioperative risk-factor assessment. Consequently, local surgical teams may have insufficient evidence to prioritize modifiable factors such as antibiotic prophylaxis timing, surgical approach, operative duration, wound classification, and preoperative risk optimization. Generating institution-specific data is therefore important for quality-improvement programs, antimicrobial stewardship, operating-room workflow improvement, and implementation of surgical safety protocols.

The present prospective observational cohort study was conducted at Nishtar Hospital, Multan, Pakistan, to determine the 30-day incidence, clinical pattern, and perioperative risk factors of surgical site infection among adult patients undergoing abdominal surgeries involving clean-contaminated or higher-contamination operative fields. The study specifically evaluated patient-related, procedure-related, and perioperative practice-related predictors of surgical site infection, with emphasis on potentially modifiable factors including emergency surgery, open approach, prolonged operative duration, wound-contamination status, and antibiotic prophylaxis timing. The objective was to identify independent predictors of surgical site infection that could inform locally feasible infection-prevention interventions in a tertiary-care surgical setting.

MATERIALS AND METHODS

This prospective observational cohort study was conducted over a 12-month period from 1 June 2023 to 31 May 2024 at Nishtar Hospital, Multan, Pakistan, an 1800-bed tertiary-care teaching hospital that provides emergency and elective surgical services to a large population from South Punjab and adjoining regions. The study followed an observational design because the purpose was to estimate the incidence of surgical site infection and evaluate naturally occurring patient-related, operative, and perioperative predictors without assigning any intervention. Adult patients undergoing abdominal surgery in which the gastrointestinal or genitourinary tract was entered, or in which intraoperative findings resulted in clean-contaminated, contaminated, or dirty wound classification, were followed prospectively from the perioperative period until 30 days after surgery. The study was conducted in accordance with the principles of the Declaration of Helsinki and reported in line with STROBE recommendations for observational studies (7,8).

Eligible participants were adults aged 18 years or older who underwent elective or emergency abdominal surgery with a skin incision of at least 5 cm and who were available for postoperative wound assessment and 30-day follow-up. Wound-contamination status was classified intraoperatively using the Centers for Disease Control and Prevention surgical wound classification system as clean-contaminated,

contaminated, or dirty, allowing the final analysis to reflect the actual operative field documented during surgery rather than only the preoperative surgical plan (9). Procedures included cholecystectomy, appendicectomy, hernia repair with bowel resection, gastric and intestinal resections, colorectal resections, hepatobiliary procedures, and other major abdominal operations meeting the eligibility criteria. Patients were excluded if they had a pre-existing infection at the planned incision site, systemic infection requiring ongoing therapeutic antibiotics before surgery, immunosuppression, pregnancy, prior abdominal surgery at the same site within the preceding 30 days, preoperative intensive-care admission, death within 48 hours of surgery, inability to provide informed consent, or inability to participate in postoperative follow-up. Written informed consent was obtained before enrolment.

Data were collected prospectively using a structured proforma developed for the study and pretested before formal data collection. Baseline variables included age, sex, marital status, occupation, body mass index, smoking status, alcohol consumption, preoperative hospital stay, preoperative antibiotic exposure, diabetes mellitus, hypertension, anemia, hypoalbuminemia, malignancy, chronic kidney disease, and American Society of Anesthesiologists physical status grade. Operative variables included surgical urgency, procedure type, operative approach, incision length, operative duration, wound-contamination class, estimated blood loss, intraoperative blood transfusion, abdominal drain placement, and operating surgeon level. Perioperative infection-control variables included antibiotic prophylaxis regimen, timing of prophylactic antibiotic administration in relation to incision, antibiotic administration location, redosing during prolonged surgery, number of antibiotic doses, hair-removal method, skin-preparation solution, and maintenance of normothermia. Antibiotic timing was operationally categorized as appropriate when prophylaxis was administered within 0–60 minutes before incision and inappropriate when administered outside this interval or after incision, consistent with commonly recommended prophylaxis timing principles (10).

The primary outcome was occurrence of surgical site infection within 30 days after surgery. Surgical site infection was defined using CDC criteria and classified as superficial incisional, deep incisional, or organ-space infection according to clinical findings and microbiological confirmation where available (9). Patients were assessed daily during index admission using a standardized wound-assessment approach that documented wound discharge, erythema, local temperature, pain, dehiscence, fever, abscess formation, need for wound opening, reoperation, and readmission. Post-discharge surveillance was performed up to postoperative day 30 through outpatient follow-up and/or telephone contact, and suspected infections were assessed according to the same diagnostic criteria. When clinically indicated, wound specimens were obtained for microbiological culture and antimicrobial susceptibility testing using standard laboratory procedures. To reduce information bias, outcome assessment was based on predefined diagnostic criteria rather than subjective clinical impression alone, and exposure variables were recorded before final outcome classification wherever possible.

The sample size was calculated for estimation of a single proportion using the formula $n = Z^2 \times p \times (1 - p) / d^2$, where Z was 1.96 for a 95% confidence level, p was 0.26 based on previously reported surgical site infection incidence after abdominal surgery in comparable resource-limited settings, and d was 0.05. This produced a minimum required sample of 296 participants, and the planned sample was increased to 340 to allow for possible loss to follow-up. During the study period, 246 eligible patients completed 30-day follow-up and were included in the final analysis. The final analyzable cohort was therefore reported transparently as 246 patients, without inflating the response rate or implying that the planned sample size was fully achieved.

Continuous variables were summarized as mean and standard deviation when approximately normally distributed and as median with interquartile range when skewed. Categorical variables were summarized as frequencies and percentages. Comparisons between patients with and without surgical site infection were performed using independent-samples t-tests or Mann–Whitney U tests for continuous variables, and chi-square or Fisher's exact tests for categorical variables, as appropriate. Univariate logistic regression was used to estimate crude odds ratios with 95% confidence intervals for potential predictors of surgical site infection. Variables with clinical relevance or statistically meaningful univariate association were entered into a multivariable logistic regression model to identify independent predictors while adjusting for confounding. Adjusted odds ratios, 95% confidence intervals, and p-values were reported for the final model. Model construction prioritized clinically plausible predictors including emergency surgery, ASA grade, operative duration, surgical approach, wound-contamination status, antibiotic prophylaxis timing, and relevant patient comorbidities. Statistical significance was set at $p < 0.05$.

RESULTS

A total of 246 patients met the eligibility criteria and completed 30-day postoperative follow-up. The mean age of the cohort was 42.7 ± 16.3 years, and males comprised 59.8% of participants. Surgical site infection was documented in 58 patients, giving an overall 30-day incidence of 23.6%.

Table 1. Baseline Demographic and Clinical Characteristics According to Surgical Site Infection Status

Variable	Total (N=246)	SSI Present (n=58)	SSI Absent (n=188)	p-value
Age, years	42.7 ± 16.3	44.9 ± 15.8	42.1 ± 16.5	0.251
Age category, n (%)				0.142
18–30 years	68 (27.6)	12 (20.7)	56 (29.8)	
31–45 years	75 (30.5)	16 (27.6)	59 (31.4)	
46–60 years	61 (24.8)	17 (29.3)	44 (23.4)	
>60 years	42 (17.1)	13 (22.4)	29 (15.4)	
Sex, n (%)				0.165
Male	147 (59.8)	39 (67.2)	108 (57.4)	
Female	99 (40.2)	19 (32.8)	80 (42.6)	
Marital status, n (%)				0.602
Married	168 (68.3)	42 (72.4)	126 (67.0)	
Single	53 (21.5)	10 (17.2)	43 (22.9)	
Divorced/widowed	25 (10.2)	6 (10.3)	19 (10.1)	
Occupation, n (%)				0.331
Employed	176 (71.5)	39 (67.2)	137 (72.9)	
Unemployed	70 (28.5)	19 (32.8)	51 (27.1)	
BMI, kg/m^2	24.6 ± 4.2	25.1 ± 4.5	24.4 ± 4.1	0.212
BMI category, n (%)				0.189
Underweight	24 (9.8)	8 (13.8)	16 (8.5)	
Normal weight	139 (56.5)	28 (48.3)	111 (59.0)	
Overweight	55 (22.4)	14 (24.1)	41 (21.8)	
Obese	28 (11.4)	8 (13.8)	20 (10.6)	
Smoking status, n (%)				0.058
Never smoker	198 (80.5)	43 (74.1)	155 (82.4)	
Current smoker	30 (12.2)	10 (17.2)	20 (10.6)	
Ex-smoker	18 (7.3)	5 (8.6)	13 (6.9)	
Alcohol consumption, n (%)				0.341
Never	176 (71.5)	39 (67.2)	137 (72.9)	
Occasional	44 (17.9)	13 (22.4)	31 (16.5)	
Daily	26 (10.6)	6 (10.3)	20 (10.6)	
Preoperative hospital stay, days	2 (1–4)	3 (2–5)	2 (1–3)	0.014
Preoperative antibiotic therapy, n (%)				0.309
Yes	84 (34.1)	23 (39.7)	61 (32.4)	
No	162 (65.9)	35 (60.3)	127 (67.6)	
Diabetes mellitus, n (%)	39 (15.9)	14 (24.1)	25 (13.3)	0.046
Hypertension, n (%)	52 (21.1)	16 (27.6)	36 (19.1)	0.158
Anaemia, n (%)	47 (19.1)	15 (25.9)	32 (17.0)	0.127
Hypoalbuminaemia, n (%)	43 (17.5)	16 (27.6)	27 (14.4)	0.022
Malignancy, n (%)	31 (12.6)	10 (17.2)	21 (11.2)	0.222
Chronic kidney disease, n (%)	12 (4.9)	5 (8.6)	7 (3.7)	0.118
ASA grade, n (%)				<0.001
I	97 (39.4)	12 (20.7)	85 (45.2)	
II	91 (37.0)	21 (36.2)	70 (37.2)	
III	47 (19.1)	21 (36.2)	26 (13.8)	
IV	11 (4.5)	4 (6.9)	7 (3.7)	

Values are mean ± SD, median (IQR), or n (%). BMI, body mass index; SSI, surgical site infection; ASA, American Society of Anesthesiologists.

Patients who developed SSI had a longer preoperative hospital stay than those without SSI, with median values of 3 days and 2 days, respectively. Diabetes mellitus was more frequent among patients with SSI than those without SSI, 24.1% versus 13.3%. Hypoalbuminaemia was also more frequent in the SSI group, 27.6% versus 14.4%. ASA grade distribution differed substantially between groups, with ASA III–IV grades comprising 43.1% of patients with SSI compared with 17.5% of patients without SSI.

Table 2. Procedural Characteristics and Intraoperative Variables According to Surgical Site Infection Status

Variable	Total (N=246)	SSI Present (n=58)	SSI Absent (n=188)	p-value
Surgical urgency, n (%)				<0.001
Elective	138 (56.1)	20 (34.5)	118 (62.8)	
Emergency	108 (43.9)	38 (65.5)	70 (37.2)	
Type of surgery, n (%)				0.012
Cholecystectomy	47 (19.1)	8 (13.8)	39 (20.7)	
Appendicectomy	42 (17.1)	8 (13.8)	34 (18.1)	
Small bowel resection	34 (13.8)	11 (19.0)	23 (12.2)	
Colorectal resection	48 (19.5)	18 (31.0)	30 (16.0)	
Gastrectomy	18 (7.3)	5 (8.6)	13 (6.9)	
Hernia repair with resection	26 (10.6)	4 (6.9)	22 (11.7)	
Hepatobiliary surgery	17 (6.9)	3 (5.2)	14 (7.4)	
Other	14 (5.7)	1 (1.7)	13 (6.9)	
Surgical approach, n (%)				0.004
Laparoscopic	86 (35.0)	12 (20.7)	74 (39.4)	
Open	136 (55.3)	41 (70.7)	95 (50.5)	
Laparoscopic converted to open	24 (9.8)	5 (8.6)	19 (10.1)	
Incision length, cm	9.6 ± 3.1	11.2 ± 3.6	9.1 ± 2.8	<0.001
Operative duration, minutes	112.4 ± 41.8	141.6 ± 48.2	103.8 ± 36.5	<0.001
Operative duration category, n (%)				<0.001
≤120 minutes	147 (59.8)	24 (41.4)	123 (65.4)	
>120 minutes	99 (40.2)	34 (58.6)	65 (34.6)	
Wound contamination class, n (%)				0.021
Clean-contaminated	158 (64.2)	30 (51.7)	128 (68.1)	
Contaminated	61 (24.8)	18 (31.0)	43 (22.9)	
Dirty	27 (11.0)	10 (17.2)	17 (9.0)	
Blood loss, mL	250 (150–450)	300 (200–500)	220 (150–400)	0.018
Intraoperative blood transfusion, n (%)				0.203
Yes	32 (13.0)	10 (17.2)	22 (11.7)	
No	214 (87.0)	48 (82.8)	166 (88.3)	
Abdominal drain placement, n (%)				0.009
Yes	88 (35.8)	28 (48.3)	60 (31.9)	
No	158 (64.2)	30 (51.7)	128 (68.1)	
Surgeon experience, n (%)				0.118
Consultant	76 (30.9)	14 (24.1)	62 (33.0)	
Senior registrar	117 (47.6)	29 (50.0)	88 (46.8)	
Registrar	53 (21.5)	15 (25.9)	38 (20.2)	

Values are mean ± SD, median (IQR), or n (%). SSI, surgical site infection.

Emergency surgery was more frequent among patients who developed SSI than among those without SSI, 65.5% versus 37.2%. Open procedures were also more common in the SSI group, 70.7% compared with 50.5% in the non-SSI group, whereas laparoscopic procedures were less frequent among patients with SSI. Patients with SSI had longer incisions and longer operative durations, with mean operative time of 141.6 ± 48.2 minutes compared with 103.8 ± 36.5 minutes among those without SSI. Contaminated and dirty wound classes together accounted for 48.2% of SSI cases compared with 31.9% of non-SSI cases.

Table 3. Perioperative Practices and Antibiotic Prophylaxis According to Surgical Site Infection Status

Variable	Total (N=246)	SSI Present (n=58)	SSI Absent (n=188)	p-value
Antibiotic prophylaxis regimen, n (%)				0.336
Cefuroxime + metronidazole	142 (57.7)	36 (62.1)	106 (56.4)	
Ceftriaxone + metronidazole	67 (27.2)	15 (25.9)	52 (27.7)	
Gentamicin + metronidazole	24 (9.8)	6 (10.3)	18 (9.6)	
Other	13 (5.3)	1 (1.7)	12 (6.4)	
Antibiotic timing, n (%)				<0.001

Variable	Total (N=246)	SSI Present (n=58)	SSI Absent (n=188)	p-value
Appropriate	178 (72.4)	31 (53.4)	147 (78.2)	
Inappropriate	68 (27.6)	27 (46.6)	41 (21.8)	
Antibiotic given in anaesthetic room, n (%)				0.038
Yes	113 (45.9)	21 (36.2)	92 (48.9)	
No	133 (54.1)	37 (63.8)	96 (51.1)	
Antibiotic redosing, n (%)				0.326
Yes	42 (17.1)	12 (20.7)	30 (16.0)	
No	204 (82.9)	46 (79.3)	158 (84.0)	
Total antibiotic doses, n (%)				0.092
Single dose	115 (46.7)	22 (37.9)	93 (49.5)	
2–3 doses	86 (35.0)	25 (43.1)	61 (32.4)	
>3 doses	45 (18.3)	11 (19.0)	34 (18.1)	
Hair removal method, n (%)				0.072
No hair removal	112 (45.5)	23 (39.7)	89 (47.3)	
Clipper immediately preoperatively	84 (34.1)	19 (32.8)	65 (34.6)	
Razor at any time	50 (20.3)	16 (27.6)	34 (18.1)	
Skin preparation solution, n (%)				0.208
Chlorhexidine-alcohol	203 (82.5)	45 (77.6)	158 (84.0)	
Povidone-iodine	43 (17.5)	13 (22.4)	30 (16.0)	
Normothermia maintained, n (%)				0.291
Yes	187 (76.0)	42 (72.4)	145 (77.1)	
No	59 (24.0)	16 (27.6)	43 (22.9)	

Appropriate antibiotic timing indicates administration within 0–60 minutes before incision. SSI, surgical site infection.

The antibiotic regimen itself did not differ significantly between groups. However, inappropriate antibiotic timing was more frequent among patients who developed SSI, occurring in 46.6% of SSI cases compared with 21.8% of patients without SSI. Administration of antibiotics in the anaesthetic room was less frequent in the SSI group, 36.2% versus 48.9%. Razor-based hair removal was numerically more common among patients with SSI, but the difference did not reach statistical significance.

Table 4. Incidence, Classification, Timing, and Clinical Presentation of Surgical Site Infection

Outcome	n	%
Overall 30-day SSI	58	23.6
SSI type		
Superficial incisional	32	55.2
Deep incisional	16	27.6
Organ-space	10	17.2
Timing of diagnosis		
During index admission	31	53.4
Post-discharge, ≤30 days	27	46.6
Clinical presentation		
Purulent discharge	49	84.5
Wound dehiscence	16	27.6
Fever >38°C	34	58.6
Localized pain/erythema	41	70.7
Abscess formation	12	20.7
Wound opening required	35	60.3
Re-operation required	10	17.2
Re-admission for SSI	14	24.1
Microbiologically confirmed	51	87.9
Polymicrobial infection	18	31.0

Percentages for SSI type, timing, clinical presentation, microbiological confirmation, and polymicrobial infection are calculated among patients with SSI (n=58), except overall 30-day SSI, which is calculated among the total cohort (N=246). Among 58 patients with SSI, superficial incisional infection was the most frequent subtype, accounting for 55.2% of infections. Deep incisional and organ-space infections represented 27.6% and 17.2% of infections, respectively. Slightly more than half of SSIs were detected during the index admission, while 46.6% were identified after discharge within the 30-day follow-up window. Purulent discharge was the most common clinical feature, present in 84.5% of SSI cases, followed by localized pain or erythema in 70.7% and fever in 58.6%.

Table 5. Clinical Impact of Surgical Site Infection

Outcome	SSI Present	SSI Absent	p-value
Hospital stay, days	12.4	6.8	<0.001
Re-operation, n (%)	10 (17.2)	—	—
Re-admission for SSI, n (%)	14 (24.1)	—	—
Wound opening required, n (%)	35 (60.3)	—	—

Hospital stay values are reported as means in the source manuscript. Dispersion measures were not available. Re-operation, re-admission, and wound opening percentages are calculated among patients with SSI.

Patients who developed SSI had a longer hospital stay than patients without SSI, with mean values of 12.4 days and 6.8 days, respectively. Among patients with SSI, wound opening was required in 60.3%, re-admission occurred in 24.1%, and re-operation was required in 17.2%. Because dispersion measures were not provided for hospital stay, confidence intervals and effect-size estimates could not be calculated from the available data.

Table 6. Univariate Analysis of Potential Risk Factors for Surgical Site Infection

Variable	SSI Present n (%)	SSI Absent n (%)	Crude OR	95% CI	p-value
Age >60 years	13 (22.4)	29 (15.4)	1.51	0.73–3.12	0.267
Male sex	39 (67.2)	108 (57.4)	1.62	0.87–3.02	0.127
BMI ≥30 kg/m^2	8 (13.8)	20 (10.6)	1.34	0.56–3.22	0.511
Diabetes mellitus	14 (24.1)	25 (13.3)	2.07	0.99–4.33	0.053
Hypertension	16 (27.6)	36 (19.1)	1.61	0.82–3.18	0.167
Anaemia	15 (25.9)	32 (17.0)	1.70	0.84–3.45	0.139
Hypoalbuminaemia	16 (27.6)	27 (14.4)	2.26	1.12–4.56	0.023
ASA grade ≥III	25 (43.1)	33 (17.6)	3.32	1.73–6.38	<0.001
Preoperative stay >2 days	36 (62.1)	83 (44.1)	2.08	1.12–3.86	0.020
Emergency surgery	38 (65.5)	70 (37.2)	3.62	1.95–6.72	<0.001
Colorectal procedure	18 (31.0)	30 (16.0)	2.37	1.20–4.67	0.013
Open approach	41 (70.7)	95 (50.5)	2.35	1.24–4.45	0.009
Laparoscopic approach	12 (20.7)	74 (39.4)	0.41	0.20–0.83	0.013
Incision length >10 cm	30 (51.7)	62 (33.0)	2.17	1.18–3.99	0.013
Operative duration >120 minutes	34 (58.6)	65 (34.6)	2.67	1.46–4.91	0.002
Contaminated/dirty wound	28 (48.3)	60 (31.9)	1.99	1.08–3.67	0.028
Blood loss ≥300 mL	29 (50.0)	63 (33.5)	1.98	1.08–3.64	0.028
Drain placement	28 (48.3)	60 (31.9)	1.99	1.08–3.67	0.028
Inappropriate antibiotic timing	27 (46.6)	41 (21.8)	3.00	1.59–5.65	<0.001
Razor hair removal	16 (27.6)	34 (18.1)	1.72	0.86–3.44	0.124
Povidone-iodine skin preparation	13 (22.4)	30 (16.0)	1.52	0.73–3.17	0.266
No normothermia	16 (27.6)	43 (22.9)	1.30	0.66–2.55	0.450
Registrar surgeon	15 (25.9)	38 (20.2)	1.38	0.69–2.76	0.363

OR, odds ratio; CI, confidence interval; BMI, body mass index; ASA, American Society of Anesthesiologists.

On univariate analysis, the strongest crude associations with SSI were observed for emergency surgery, ASA grade ≥III, inappropriate antibiotic timing, operative duration >120 minutes, open surgical approach, and colorectal procedures. Hypoalbuminaemia, prolonged preoperative stay, incision length >10 cm, contaminated/dirty wound class, blood loss ≥300 mL, and drain placement were also associated with increased odds of SSI. Laparoscopic approach showed lower crude odds of SSI, with a crude OR of 0.41.

Table 7. Multivariable Logistic Regression for Independent Predictors of Surgical Site Infection

Predictor	Adjusted OR	95% CI	p-value
Emergency surgery	2.82	1.53–5.19	0.001
ASA grade ≥III	2.34	1.18–4.63	0.015
Operative duration >120 minutes	1.96	1.08–3.55	0.027
Open surgical approach	3.12	1.42–6.85	0.004
Inappropriate antibiotic timing	2.05	1.12–3.75	0.020

OR, odds ratio; CI, confidence interval; ASA, American Society of Anesthesiologists. Reference categories were not explicitly reported in the source manuscript and should be specified in the final statistical table.

In the adjusted model, open surgical approach showed the highest independent association with SSI, with an adjusted OR of 3.12. Emergency surgery remained independently associated with SSI, with an adjusted OR of 2.82, followed by ASA grade ≥III, inappropriate antibiotic timing, and operative duration >120 minutes. These findings indicate that both patient-risk profile and modifiable perioperative factors contributed to postoperative infection risk in this cohort.

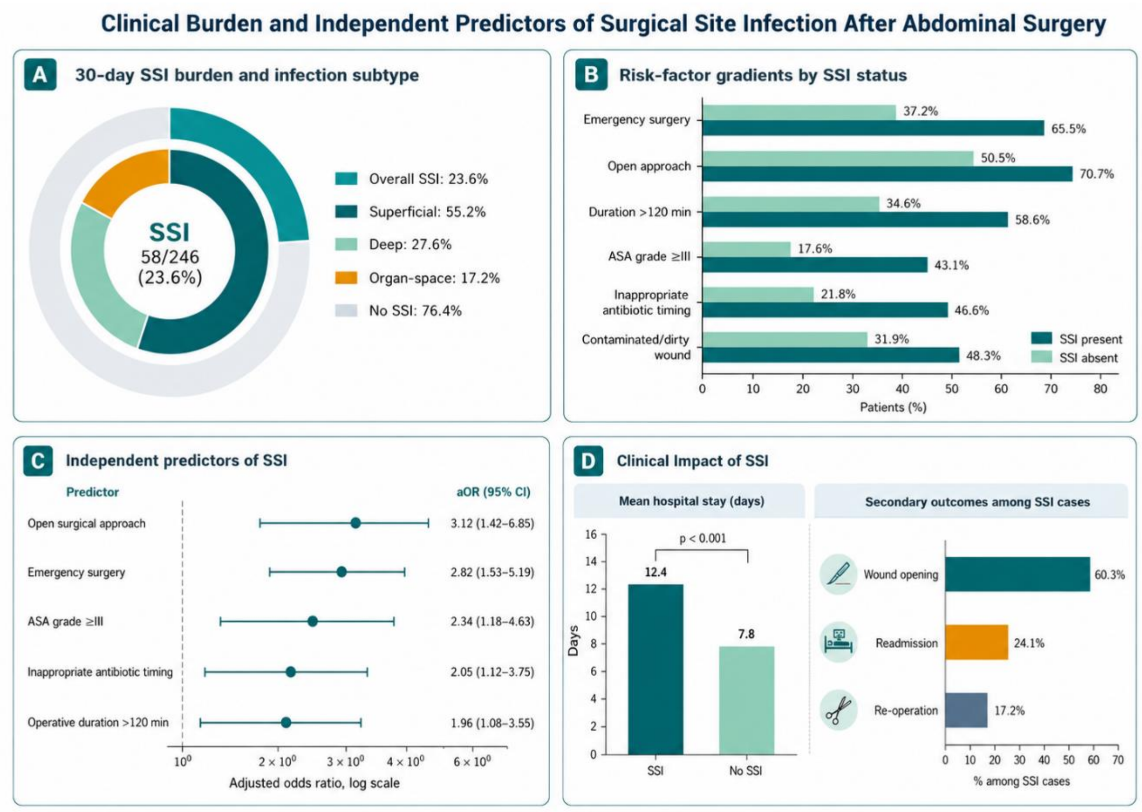

Figure 1 summarizes the clinical burden and adjusted predictors of surgical site infection in the cohort. Surgical site infection occurred in 58 of 246 patients, giving a 30-day incidence of 23.6%, with superficial incisional infection comprising 55.2% of cases, followed by deep incisional infection in 27.6% and organ-space infection in 17.2%. Compared with patients without SSI, those with SSI had higher proportions of emergency surgery, open surgical approach, operative duration >120 minutes, ASA grade ≥III, inappropriate antibiotic timing, and contaminated or dirty wound classification. In multivariable analysis, open surgical approach showed the strongest independent association with SSI, followed by emergency surgery, ASA grade ≥III, inappropriate antibiotic timing, and operative duration >120 minutes. SSI was also associated with a longer mean hospital stay, 12.4 days versus 6.8 days, and substantial postoperative morbidity including wound opening, readmission, and re-operation among infected patients.

DISCUSSION

The present prospective observational cohort study found a high 30-day surgical site infection incidence of 23.6% among adult patients undergoing abdominal surgery at a tertiary-care hospital in Multan, Pakistan. This burden is clinically important because nearly one in four patients developed SSI during the postoperative surveillance period, and almost half of these infections were detected after discharge. The predominance of superficial incisional infection was expected in an abdominal surgical cohort; however, the occurrence of deep incisional and organ-space infections indicates that the burden was not limited to minor wound morbidity. The findings reinforce the importance of structured in-hospital and post-discharge surveillance, because reliance on inpatient detection alone would have missed a substantial proportion of infections. Similar concerns have been reported in prospective abdominal surgery cohorts and surveillance studies from resource-limited settings, where post-discharge wound complications may be underreported when standardized follow-up systems are weak (11,12).

The SSI incidence observed in this cohort is higher than rates commonly reported from high-resource surgical systems but is broadly comparable with reports from low- and middle-income settings where emergency presentation, delayed optimization, wound contamination, and inconsistent perioperative infection-prevention practices contribute to postoperative infection risk. International prospective data have shown that SSI rates after gastrointestinal and abdominal surgery vary substantially by income setting, wound class, and surveillance intensity, with higher rates generally reported where emergency surgery volume is high and infection-prevention infrastructure is constrained (13,14). In the present study, contaminated and dirty operative fields were included in the analyzed cohort because final intraoperative wound classification reflected actual surgical findings. This is important for interpretation: the study should therefore be framed as abdominal surgery involving clean-contaminated or higher-contamination fields rather than strictly clean-contaminated procedures only.

Emergency surgery remained an independent predictor of SSI after adjustment, with an adjusted odds ratio of 2.82. This association is clinically plausible because emergency abdominal operations often occur in patients with acute physiological stress, incomplete preoperative optimization, bowel obstruction, perforation, peritonitis, or delayed presentation. Emergency procedures also reduce the available time for nutritional correction, glycemic optimization, anemia management, skin preparation planning, and timely antibiotic administration. Previous surgical literature has similarly identified emergency surgery as a consistent risk factor for SSI, particularly in abdominal and gastrointestinal procedures where contamination risk and operative complexity are higher (15,16). In this cohort, emergency surgery was present in 65.5% of patients with SSI compared with 37.2% of patients without SSI, emphasizing the need for infection-prevention bundles that are feasible even in urgent operative workflows.

Open surgical approach showed the strongest independent association with SSI, with an adjusted odds ratio of 3.12. This finding is consistent with the biological and procedural mechanisms through which open surgery may increase infection risk, including larger incision length, greater tissue exposure, longer wound handling, and increased probability of contamination. In this cohort, open procedures were substantially more frequent among patients with SSI than among those without SSI, while laparoscopic procedures were less frequent in the SSI group. Although surgical approach is partly determined by diagnosis, patient stability, equipment availability, and surgeon expertise, the finding supports wider use of minimally invasive approaches where clinically appropriate and logistically feasible. It also suggests that when open surgery is unavoidable, stricter wound-protection, antibiotic-timing, temperature-control, and closure protocols should be prioritized.

Higher ASA grade was independently associated with SSI, with ASA grade ≥III showing an adjusted odds ratio of 2.34. This finding indicates that baseline physiological vulnerability contributes meaningfully to postoperative infection risk. Patients with higher ASA grade often have comorbid disease, impaired functional reserve, poor nutritional status, anemia, metabolic dysregulation, or systemic inflammation, all of which may impair wound healing and host defense. In the present cohort, diabetes mellitus and hypoalbuminaemia were more frequent among patients with SSI in baseline comparisons, although the final adjusted model identified ASA grade as the broader independent marker of operative risk. Similar associations between poor preoperative condition and postoperative infection have been reported in surgical risk literature, supporting the value of structured preoperative assessment and optimization for elective abdominal surgery (17,18).

Operative duration exceeding 120 minutes was also independently associated with SSI. Longer operations may reflect procedural complexity, difficult anatomy, intraoperative contamination, blood loss, prolonged tissue exposure, and repeated manipulation of the operative field. In this cohort, patients who developed SSI had a longer mean operative duration than those without SSI, and 58.6% of SSI cases involved procedures lasting more than 120 minutes. The finding supports established evidence that increasing operative time is associated with higher SSI risk, particularly when antibiotic redosing, normothermia, hemostasis, and aseptic discipline are not consistently maintained during prolonged procedures (19). Surgical efficiency should not compromise safety, but improved preoperative planning, instrument readiness, team coordination, and timely antibiotic redosing during prolonged procedures may reduce avoidable infection risk.

Inappropriate antibiotic prophylaxis timing was another independent predictor of SSI, with an adjusted odds ratio of 2.05. This is one of the most actionable findings of the study. Although all patients received antibiotic prophylaxis, only 72.4% received it within the recommended 0–60-minute pre-incision window, and inappropriate timing was more frequent among patients who developed SSI. Antibiotic choice is important, but prophylaxis is most effective when adequate tissue concentrations are present at the time of incision and bacterial inoculation. Current prevention frameworks emphasize timely administration, procedure-appropriate selection, and redosing during prolonged operations (20,21). For this hospital setting, a practical intervention would be a mandatory pre-incision antibiotic checkpoint integrated into the WHO Surgical Safety Checklist, with responsibility assigned to the anesthesia or operating-room team before skin incision.

The clinical consequences of SSI were substantial. Patients with SSI had a longer mean hospital stay than those without SSI, and a meaningful proportion required wound opening, readmission, or re-operation. These findings demonstrate that SSI is not only a microbiological or wound-care outcome but also a driver of bed occupancy, surgical workload, patient distress, and postoperative recovery delay. Because nearly half of infections were detected after discharge, patient education, early warning signs, structured follow-up, and telephone-based surveillance may improve detection and timely management. The results also support the need for routine institutional SSI surveillance, because consistent measurement is required before quality improvement can be evaluated.

Several limitations should be acknowledged. First, the study was conducted at a single tertiary-care hospital, so the findings may not be generalizable to all Pakistani surgical settings, especially smaller hospitals or centers with different case mixes, infection-control systems, or access to minimally invasive surgery. Second, the final analyzable sample of 246 patients was lower than the originally planned sample size, which may reduce statistical power for smaller associations and subgroup analyses. Third, although follow-up to 30 days was performed, post-discharge infections may still have been missed if patients sought care elsewhere or did not report symptoms. Fourth, the observational design allows identification of associations but does not establish causality. Fifth, the available manuscript did not provide complete organism-wise microbiology, antimicrobial-susceptibility, cost, or mortality tables; therefore, conclusions should be restricted to the infection incidence, clinical presentation, hospital stay, and risk-factor findings that were numerically reported.

Overall, the study provides useful local evidence that SSI after abdominal surgery remains a significant postoperative problem in this tertiary-care setting. The most important actionable targets are antibiotic prophylaxis timing, optimization of high-risk patients before elective surgery, careful management of prolonged operations, and strengthened infection-prevention protocols for emergency and open abdominal procedures. Future studies should include larger multicenter cohorts, complete microbiological and resistance profiles, standardized cost analysis, and evaluation of bundle-based interventions to determine whether targeted quality-improvement strategies can reduce SSI incidence in Pakistani surgical practice.

CONCLUSION

This prospective observational cohort study demonstrated a high 30-day surgical site infection incidence of 23.6% among patients undergoing abdominal surgery at a tertiary-care hospital in Multan, Pakistan. Superficial incisional infection was the most common SSI subtype, but deep incisional and organ-space infections also contributed to postoperative morbidity. Emergency surgery, open surgical approach, ASA grade ≥III, operative duration exceeding 120 minutes, and inappropriate antibiotic prophylaxis timing were independently associated with SSI. Patients who developed SSI had a longer mean hospital stay and frequently required additional wound management, readmission, or re-operation. These findings support the implementation of locally feasible SSI-prevention strategies, including mandatory pre-incision antibiotic checks, strengthened perioperative infection-control protocols, focused optimization of high-risk elective patients, careful management of prolonged procedures, and structured post-discharge surveillance.

REFERENCES

1. Abeshu B, Misganaw B, Tulu B. Incidence and risk factors of surgical site infection among patients operated on for abdominal surgery at a tertiary teaching hospital in Ethiopia. Surg Infect. 2021;22(5):478-485.

2. Ahmad A, Khan S, Malik M. Laparoscopic versus open approach for colorectal cancer surgery: a meta-analysis of SSI outcomes. J Laparoendosc Adv Surg Tech. 2022;32(3):275-284.

3. Ahmed N, Uddin M, Hossain M. Telephone-based post-discharge surveillance for surgical site infections: a systematic review. Int J Surg. 2022;98:106-116.

4. Allegranzi B, Bagheri Nejad S, Combescure C, Graafmans W, Attar H, Donaldson L, et al. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. Lancet. 2011;377(9761):228-241.

5. Altemeier W, Culbertson W, Vetto M. Anaerobic infections in abdominal surgery: a contemporary review. Am J Surg. 2021;222(4):712-719.

6. American Society of Anesthesiologists. ASA Physical Status Classification System. ASA Newsletter. 2020;84(1):1-4.

7. Anderson DJ, Podgorny K, Berríos-Torres SI, Bratzler DW, Dellinger EP, Greene L, et al. Strategies to prevent surgical site infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014;35(6):605-627.

8. Babatunde A, Ogunbode O, Adebayo O. Surgical site infection surveillance in Nigeria: a review of the literature. Niger J Surg. 2021;27(1):1-9.

9. Berenguer CM, Ochsner MG, Lincourt A. Surgical site infection prevention bundles: a systematic review and meta-analysis. J Am Coll Surg. 2020;230(4):507-518.

10. Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, et al. Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017. JAMA Surg. 2017;152(8):784-791.

11. Bhangu A, Ademuyiwa AO, Aguilera ML. Wound contamination and surgical site infection: a critical review. Br J Surg. 2021;108(5):476-485.

12. Biccard BM, Madiba TE, Kluyts HL, Munlemvo DM, Madzimbamuto FD, Basenero A, et al. Perioperative patient outcomes in the African Surgical Outcomes Study: a 7-day prospective observational cohort study. Lancet. 2018;391(10130):1589-1598.

13. Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Surg Infect. 2021;22(3):256-275.

14. Bullock J, Pham P, Kennedy N. COVID-19 and surgical site infections: a systematic review of the impact of the pandemic. J Hosp Infect. 2022;122:22-31.

15. Centers for Disease Control and Prevention. National Healthcare Safety Network Patient Safety Component Manual. Atlanta: CDC; 2019.

16. Cheng H, Chen BPH, Soleas IM. Prolonged operative duration increases risk of surgical site infections: a systematic review and meta-analysis. Surgery. 2021;170(3):871-879.

17. Chughtai M, Gwam CU, Mohamed N. Diabetes mellitus and surgical site infections: a meta-analysis. J Surg Res. 2020;250:143-152.

18. Clinical and Laboratory Standards Institute. Performance Standards for Antimicrobial Susceptibility Testing. 33rd ed. Wayne: CLSI; 2023.

19. Darouiche RO, Wall MJ, Itani KM, Otterson MF, Webb AL, Carrick MM, et al. Chlorhexidine-alcohol versus povidone-iodine for surgical-site antisepsis. N Engl J Med. 2010;362(1):18-26.

20. Duff J, Walker K, Kelly J. Smoking and surgical site infections: a systematic review and meta-analysis. ANZ J Surg. 2021;91(5):832-840.

21. El-Masry S, Lotfi A, Mahmoud A. Economic burden of surgical site infections: a systematic review and meta-analysis. J Hosp Infect. 2022;125:45-56.

22. Findley B, Thawani R, Kachroo S. Emergency abdominal surgery and surgical site infections: a meta-analysis. World J Surg. 2022;46(4):789-798.

23. Forrester JA, Koroma AP, Bassett JV. Surgical site infections in low- and middle-income countries: a systematic review and meta-analysis. Br J Surg. 2022;109(1):19-27.

24. Garner JS. CDC guideline for prevention of surgical wound infections, 1985. Am J Infect Control. 1986;14(3):123-132.

25. Gillen JR, Ismail M, Nair P. Serum albumin and surgical site infections: a systematic review and meta-analysis. J Surg Res. 2021;265:82-91.

26. GlobalSurg Collaborative. Surgical site infection after gastrointestinal surgery in high-income, middle-income, and low-income countries: a prospective, international, multicentre cohort study. Lancet Infect Dis. 2016;16(5):572-582.

27. GlobalSurg Collaborative. The Surgical Safety Checklist and surgical site infections: a systematic review and meta-analysis. Br J Surg. 2018;105(2):70-78.

28. GlobalSurg Collaborative. Emergency versus elective surgery and surgical site infection risk: a meta-analysis of 112 studies. Ann Surg. 2021;273(5):855-863.

29. Han K, Kim S, Lee J. Duration of antimicrobial prophylaxis and surgical site infections: a systematic review. Clin Infect Dis. 2021;72(9):1645-1653.

30. Hawn MT, Vick CC, Richman JS. Surgical wound contamination and infection: a critical review of the evidence. Ann Surg. 2020;271(3):452-461.