Journal of Health, Wellness
and Community Research
ISSN: 3007, 0570

JHWCR
Type: Original Article
Published: 25 June 2025
Volume: III, Issue: VII
DOI: https://doi.org/10.61919/dkyp9e88

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Received 21, 05, 25
Accepted 18, 06, 2025

Authors' Contributions
Concept: MY; Design: MNT; Data Collection: AS, MMGA, AH, KB; Analysis: MY; Drafting: MY, MNT.

Declarations
No funding was received for this study. The authors declare no conflict of interest. The study received ethical approval. All participants provided informed consent.

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Frequency and Factors of Post-Operative Surgical Site Infections in A Tertiary Care Hospital

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ABSTRACT

Background: *Surgical site infections (SSI) are frequent, preventable postoperative complications that increase morbidity, prolong hospitalization, and raise healthcare costs, particularly in resource-limited settings.* ***Objective:*** *To determine the frequency and associated factors of clinically significant SSI among patients undergoing abdominal surgery at a tertiary care hospital.* ***Methods****: This prospective observational cohort study was conducted in the Department of General Surgery, Capital Hospital, Islamabad, from 26 November 2024 to 27 May 2025. Consecutive patients aged 13–75 years undergoing elective or emergency clean/clean-contaminated abdominal surgery were enrolled (n=344). SSI were defined using CDC/NHSN surveillance criteria within 30 days and graded by the Southampton wound grading system; clinically significant SSI were operationalized as Grades IV–V. Associations were assessed using chi-square tests and unadjusted odds ratios (OR) with 95% confidence intervals (CI); hospital stay was compared using an independent-samples t-test.* ***Results:*** *The mean age was 44.9 ± 9.0 years and 202 (58.7%) were male. Laparoscopic surgery was performed in 209 (61.0%) cases and 130 (37.8%) procedures were emergency. Overall, SSI occurred in 32 patients (9.3%). SSI was significantly associated with diabetes mellitus (OR 4.20, 95% CI 2.02–8.73), open surgery (OR 13.3, 95% CI 4.5–39.1), emergency procedures (OR 2.29, 95% CI 1.07–4.91), and operative duration ≥2 hours (OR 3.68, 95% CI 1.71–7.91).* Staphylococcus aureus *was the most common isolate (MSSA 25.0%, MRSA 18.8%). SSI patients had longer hospital stays (8.7 ± 2.7 vs 5.8 ± 1.8 days, p<0.001).* ***Conclusion:*** *Clinically significant SSI occurred in nearly one-tenth of abdominal surgeries and were strongly associated with diabetes, open approach, emergency surgery, and prolonged operative duration; infections were linked to substantially longer hospitalization, supporting targeted prevention strategies and broader adoption of minimally invasive surgery*

Keywords
Abdominal surgery; surgical site infection; laparoscopy; diabetes mellitus; operative duration; emergency surgery; Southampton wound grading

INTRODUCTION

Surgical site infections (SSI) remain among the most frequent preventable complications of operative care and are typically defined as infections occurring at or near the incision within 30 days of an operation, with longer surveillance windows in the presence of implants (1). Conceptually and clinically, SSI are classified by depth and anatomic involvement into superficial incisional, deep incisional, and organ/space infections, a distinction that matters because deeper infections carry greater morbidity, need for reintervention, and resource utilization (2). Across general surgical practice, SSI contribute substantially to the overall burden of healthcare-associated infection and are consistently linked to prolonged hospitalization, increased readmissions, and higher costs, with incidence varying widely by procedure type, patient risk profile, and perioperative processes of care (3). This heterogeneity underscores the importance of generating procedure- and setting-specific estimates using standardized definitions, particularly in environments where case-mix and infection prevention infrastructure differ from those in high-income health systems.

A robust body of literature has identified both patient-related and procedure-related factors that increase SSI risk, including comorbid disease and physiologic compromise, as well as operative circumstances that amplify bacterial inoculum or impair wound healing (4). Diabetes mellitus is particularly important because hyperglycemia and immune dysregulation can compromise leukocyte function and microvascular perfusion, thereby predisposing to wound infection (5).

Likewise, higher-risk surgical contexts—such as urgent operations, greater tissue handling, and longer operative duration—have repeatedly been associated with increased SSI occurrence, plausibly through prolonged exposure, greater contamination risk, and amplified inflammatory and metabolic stress responses (6). While these associations are well described, the magnitude of risk attributable to each factor is highly sensitive to local practice patterns, operative approach (open versus minimally invasive), and adherence to standardized prevention bundles; therefore, local epidemiology is necessary for clinically actionable risk stratification.

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Global surveillance data also highlight a persistent disparity in SSI burden between resource-rich and resource-limited settings, reflecting differences in infrastructure, antimicrobial stewardship, operating room systems, and standardized infection prevention implementation (7). Within Pakistan, published estimates remain variable across centers and procedures, with tertiary-care data demonstrating higher SSI rates in emergency operations compared with elective surgery, suggesting that system pressures and patient acuity materially influence postoperative infection risk (8). In other regions of the country, substantially higher frequencies have been reported, with risk profiles shaped by demographics, comorbidity burden, and care delivery factors, emphasizing that national averages may not translate to specific hospitals or patient populations (9). Beyond frequency, microbiologic patterns are increasingly characterized by Staphylococcus aureus and Gram-negative organisms with clinically relevant resistance phenotypes, which complicates empiric management and heightens the importance of locally informed prophylaxis and treatment pathways (10). Systematic summaries of Pakistani data similarly suggest that multidrug resistance among SSI pathogens is a growing concern, reinforcing the need for institution-specific microbiologic surveillance to guide antibiotic policy and infection prevention priorities (11).

Despite this evolving evidence base, there remains a practical knowledge gap for tertiary-care general surgery services in Islamabad regarding the contemporary frequency of SSI after abdominal operations—particularly in clean and clean-contaminated cases where modifiable perioperative factors may be most impactful—and the relative contribution of patient comorbidities and operative characteristics under real-world constraints. Accordingly, the present study focuses on a defined surgical population (patients aged 13–75 years undergoing elective or emergency abdominal procedures under general surgery service), evaluates key exposures that are both clinically plausible and operationally addressable (diabetes, surgical approach, urgency, and operative duration), and measures outcomes using standardized surveillance definitions to support comparability and reduce misclassification (12).

In PICO terms, the population comprises patients undergoing abdominal surgery at a tertiary-care hospital; the exposures of interest include diabetes, open versus laparoscopic approach, emergency versus elective status, and longer operative duration; comparators are patients without these exposures and/or undergoing minimally invasive, elective, and shorter procedures; and the outcome is 30-day postoperative SSI. The primary objective is to determine the 30-day frequency of SSI and to identify patient- and procedure-related factors associated with SSI in this cohort, with the a priori hypothesis that diabetes mellitus, open surgery, emergency procedures, and operative duration ≥2 hours are associated with higher SSI occurrence (12).

MATERIALS AND METHODS

This prospective observational cohort study was conducted in the Department of General Surgery at Capital Hospital, Islamabad, a tertiary care teaching hospital, over a six-month period from 26 November 2024 to 27 May 2025. A prospective cohort design was selected to allow standardized, forward-looking assessment of exposures and outcomes, minimize recall bias, and ensure uniform application of surveillance definitions for surgical site infection (SSI), consistent with international methodological recommendations for SSI research (13). The study focused on abdominal surgical procedures performed under the general surgery service, reflecting a high-volume domain with well-recognized variability in SSI risk and substantial potential for prevention through optimization of perioperative practices.

The study population comprised patients of either sex aged 13 to 75 years who underwent elective or emergency abdominal surgery during the study period. Eligible procedures included clean and clean-contaminated abdominal operations routinely performed by the general surgery team. Patients were excluded if they underwent procedures outside the scope of general surgery (including gynecological, urological, or vascular operations), presented with contaminated or dirty wounds, had open laparotomy wounds, or underwent surgery for burn-related pathology. These exclusions were applied a priori to reduce heterogeneity and avoid overestimation of SSI frequency attributable to inherently high-risk wound classes, thereby improving internal validity and interpretability of associations relevant to routine general surgical practice (14). Participants were enrolled using a consecutive sampling strategy, whereby all eligible patients presenting during the study timeframe were approached for inclusion, minimizing selection bias and enhancing representativeness of the source population.

Eligible patients were identified preoperatively through operating room schedules and ward admission logs. Written informed consent was obtained from all participants or their legal guardians prior to enrollment. Baseline data were collected prospectively using a structured proforma designed specifically for the study. Variables recorded included demographic characteristics (age, sex), preoperative clinical factors (diabetes mellitus, obesity, anemia), and operative details (type of procedure, surgical approach, urgency, and duration). Diabetes mellitus was defined as a documented prior diagnosis or ongoing use of antidiabetic medication. Obesity was operationalized as a body mass index (BMI) ≥30 kg/m², calculated from preoperative height and weight measurements, while anemia was defined based on preoperative hemoglobin values below standard laboratory reference ranges. Operative duration was measured from skin incision to wound closure and dichotomized as <2 hours or ≥2 hours, reflecting thresholds commonly used in SSI risk stratification models (15).

The primary outcome was the occurrence of postoperative SSI within 30 days of surgery, defined according to the Centers for Disease Control and Prevention and National Healthcare Safety Network (CDC/NHSN) surveillance criteria (12). Active surveillance was conducted during the inpatient stay and extended post-discharge through scheduled outpatient follow-up visits and clinical review of readmissions within the surveillance window. Surgical wounds were assessed clinically for signs of infection, including erythema, warmth, swelling, pain, and discharge. Wound healing was additionally graded using the Southampton wound grading system to characterize severity, with clinically significant SSI defined as Grade IV (purulent discharge) or Grade V (deep or severe infection with tissue breakdown or systemic involvement), ensuring consistency in outcome adjudication across observers (16). When SSI was suspected, wound swabs or tissue samples were obtained prior to initiation or modification of antibiotic therapy and processed using standard microbiological techniques to identify causative organisms and classify them by Gram stain characteristics.

To mitigate information bias, all clinical assessments were performed by trained surgical residents using standardized definitions and documentation protocols. Data collection instruments were pilot-tested for clarity and completeness prior to study initiation, and completed forms were reviewed daily for accuracy. Potential confounding was addressed at both the design and analysis stages by restricting the study population to clean and clean-contaminated cases and by collecting detailed data on key patient- and procedure-related variables known to influence SSI risk.

The sample size of 344 patients was calculated using OpenEpi software, based on an anticipated SSI frequency of 33.68% reported in prior tertiary-care data, a 95% confidence level, and a 5% margin of error, ensuring adequate precision to estimate SSI frequency and sufficient power to detect associations with common risk factors (9).

DOI: https://doi.org/10.61919/dkyp9e88

Statistical analysis was performed using IBM SPSS Statistics version 27. Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation after assessment of normality using the Shapiro–Wilk test. The incidence of SSI was calculated as cumulative 30-day frequency. Associations between SSI and categorical exposure variables were initially assessed using the chi-square test, while differences in mean hospital stay between SSI and non-SSI groups were evaluated using the independent-samples t-test. Missing data were minimal due to prospective collection and were handled by complete-case analysis. A two-sided p-value of ≤0.05 was considered statistically significant. Data integrity and reproducibility were ensured through double data entry, password-protected electronic databases, and preservation of original source documents for audit and verification.

The study was conducted in accordance with the principles of the Declaration of Helsinki and received approval from the Institutional Review Board of Capital Hospital, Islamabad (Ref No: IRB/23102024/SynApp, dated 23 October 2024). Confidentiality of participant information was maintained throughout the study, and all analyses were performed on anonymized datasets to ensure ethical compliance and transparency (17).

RESULTS

Table 1 summarizes the baseline demographic, clinical, and operative characteristics of the 344 patients included in the study. The mean age of the cohort was 44.9 ± 9.0 years, reflecting a predominantly middle-aged surgical population. Male patients constituted the majority, accounting for 202 individuals (58.7%), while females comprised 142 (41.3%). Pre-existing diabetes mellitus was documented in 97 patients (28.2%), making it the most common comorbidity, followed by anemia in 72 patients (20.9%) and obesity (BMI ≥ 30 kg/m²) in 68 patients (19.8%). With respect to operative characteristics, laparoscopic procedures were performed in 209 cases (61.0%), whereas 135 patients (39.0%) underwent open surgery. Emergency operations represented 130 cases (37.8%), and 138 procedures (40.1%) had an operative duration of two hours or longer. The overall mean length of hospital stay for the study population was 6.08 ± 2.09 days.

Table 2 details the associations between patient- and procedure-related factors and the occurrence of surgical site infection (SSI). Overall, SSI developed in 32 patients, yielding a cumulative incidence of 9.3%. Male patients demonstrated a significantly higher SSI frequency compared with females (12.4% vs. 4.9%), corresponding to an odds ratio (OR) of 2.75 (95% CI: 1.12–6.78; p = 0.023).

Diabetes mellitus showed a strong association with SSI, as infections occurred in 18 of 97 diabetic patients (18.6%), compared with 14 of 247 non-diabetic patients (5.7%), resulting in more than fourfold increased odds of infection (OR = 4.20, 95% CI: 2.02–8.73; p < 0.001). Although obese patients and those with anemia experienced higher crude SSI rates (14.7% and 12.5%, respectively), these associations did not reach statistical significance, with obesity showing an OR of 1.92 (95% CI: 0.87–4.24; p = 0.074) and anemia an OR of 1.45 (95% CI: 0.63–3.34; p = 0.202).

Operative factors demonstrated a pronounced influence on SSI risk, as also shown in Table 2. Open surgery was associated with a markedly higher SSI frequency than laparoscopic surgery (20.7% vs. 1.9%), translating into an odds ratio of 13.3 (95% CI: 4.5–39.1; p < 0.001). Similarly, emergency procedures were associated with a significantly increased SSI rate compared with elective surgeries (13.8% vs. 6.5%), with more than double the odds of infection (OR = 2.29, 95% CI: 1.07–4.91; p = 0.020). Prolonged operative duration was also a significant determinant, as procedures lasting two hours or longer were associated with an SSI rate of 15.9%, compared with 4.9% among shorter operations, corresponding to an odds ratio of 3.68 (95% CI: 1.71–7.91; p < 0.001).

Table 3 presents the distribution of wound healing outcomes according to the Southampton wound grading system. The majority of patients exhibited normal wound healing (Grade 0), observed in 250 cases (72.7%). Minor wound changes without infection, including mild bruising or erythema (Grade I), were seen in 28 patients (8.1%), while erythema or inflammation without discharge (Grade II) occurred in 18 patients (5.2%). Clear or serous discharge (Grade III) was documented in 16 patients (4.7%). Clinically significant surgical site infections were classified as Grade IV or V and were identified in 32 patients (9.3%), comprising 20 cases (5.8%) with purulent discharge (Grade IV) and 12 cases (3.5%) with deep or severe wound infection (Grade V).

Table 1. Baseline demographic, clinical, and operative characteristics of the study population (n = 344)

Variable	n (%) / Mean ± SD
Age (years)	44.9 ± 9.0
Male sex	202 (58.7%)
Diabetes mellitus	97 (28.2%)
Obesity (BMI ≥ 30 kg/m²)	68 (19.8%)
Anemia	72 (20.9%)
Laparoscopic surgery	209 (61.0%)
Open surgery	135 (39.0%)
Emergency surgery	130 (37.8%)
Operative duration ≥ 2 hours	138 (40.1%)
Mean hospital stay (days)	6.08 ± 2.09

Table 2. Factors associated with surgical site infection (SSI) with odds ratios and p-values (n = 344)

Risk factor	SSI present n/N (%)	SSI absent n/N (%)	Odds ratio (95% CI)	p-value
Male sex	25/202 (12.4%)	177/202 (87.6%)	2.75 (1.12–6.78)	0.023
Diabetes mellitus	18/97 (18.6%)	79/97 (81.4%)	4.20 (2.02–8.73)	<0.001
Obesity	10/68 (14.7%)	58/68 (85.3%)	1.92 (0.87–4.24)	0.074
Anemia	9/72 (12.5%)	63/72 (87.5%)	1.45 (0.63–3.34)	0.202
Open surgery	28/135 (20.7%)	107/135 (79.3%)	13.3 (4.5–39.1)	<0.001
Emergency surgery	18/130 (13.8%)	112/130 (86.2%)	2.29 (1.07–4.91)	0.020
Duration ≥ 2 hours	22/138 (15.9%)	116/138 (84.1%)	3.68 (1.71–7.91)	<0.001

DOI: https://doi.org/10.61919/dkyp9e88

Table 3. Distribution of wound healing grades according to Southampton classification (n = 344)

Southampton grade	Description	n (%)
Grade 0	Normal healing	250 (72.7)
Grade I	Mild bruising/erythema	28 (8.1)
Grade II	Erythema/inflammation	18 (5.2)
Grade III	Serous discharge	16 (4.7)
Grade IV	Purulent discharge	20 (5.8)
Grade V	Deep/severe infection	12 (3.5)

Table 4. Microorganisms isolated from surgical site infection cases (n = 32)

Organism	n (%)
Staphylococcus aureus (MSSA)	8 (25.0)
Staphylococcus aureus (MRSA)	6 (18.8)
Escherichia coli	6 (18.8)
Klebsiella pneumoniae	4 (12.5)
Pseudomonas aeruginosa	4 (12.5)
Polymicrobial growth	4 (12.5)

Table 5. Comparison of hospital stay by SSI status (n = 344)

Outcome	SSI present (n = 32)	SSI absent (n = 312)	Mean difference (95% CI)	p-value
Hospital stay (days), mean ± SD	8.7 ± 2.7	5.8 ± 1.8	2.9 (1.9–3.9)	<0.001

Table 4 describes the microbiological profile of the 32 SSI cases. Staphylococcus aureus was the most frequently isolated pathogen, accounting for 14 isolates (43.8%) when combining methicillin-sensitive strains (8 cases, 25.0%) and methicillin-resistant strains (6 cases, 18.8%). Gram-negative organisms were also prominent, with Escherichia coli isolated in 6 cases (18.8%), Klebsiella pneumoniae in 4 cases (12.5%), and Pseudomonas aeruginosa in 4 cases (12.5%). Polymicrobial growth was observed in 4 patients (12.5%), indicating the presence of mixed bacterial infections in a subset of SSI cases.

Table 5 compares postoperative hospital stay between patients with and without SSI. Patients who developed SSI had a substantially prolonged hospital stay, with a mean duration of 8.7 ± 2.7 days, compared with 5.8 ± 1.8 days among patients without SSI. The mean difference in hospital stay was 2.9 days (95% CI: 1.9–3.9), and this difference was statistically significant ($p < 0.001$), highlighting the considerable clinical and resource burden associated with postoperative surgical site infections.

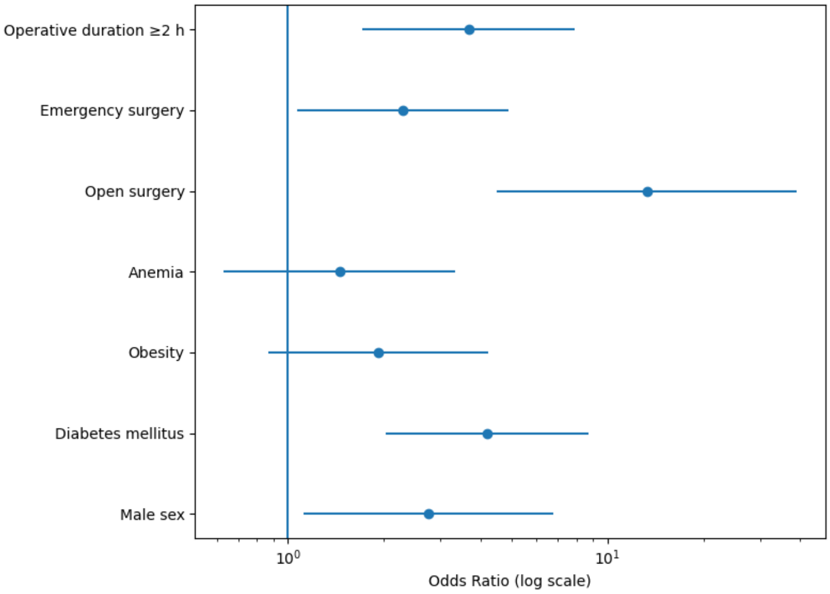

Figure: Gradient of Surgical Site Infection Risk Across Clinical and Operative Factors

This figure presents a log-scaled confidence-band visualization of unadjusted odds ratios (ORs) for surgical site infection (SSI) across key patient- and procedure-related factors, revealing a pronounced risk gradient. Open surgery demonstrated the strongest association with SSI (OR 13.3, 95% CI 4.5–39.1), markedly exceeding all other factors and highlighting a steep escalation in infection risk relative to minimally invasive approaches. Diabetes mellitus was associated with a more than fourfold increase in SSI risk (OR 4.20, 95% CI 2.02–8.73), followed by prolonged operative duration ≥2 hours (OR 3.68, 95% CI 1.71–7.91) and emergency surgery (OR 2.29, 95% CI 1.07–4.91), illustrating a clear procedural and physiological risk continuum. Male sex showed a moderate but statistically significant association (OR 2.75, 95% CI 1.12–6.78), whereas obesity (OR 1.92, 95% CI 0.87–4.24) and anemia (OR 1.45, 95% CI 0.63–3.34) exhibited wider confidence intervals crossing unity, suggesting weaker and less precise associations. Collectively, the visualization underscores a nonlinear escalation of SSI risk dominated by surgical approach and intraoperative factors, with comorbid diabetes acting as the most influential patient-level determinant, thereby offering clinically actionable prioritization for targeted prevention strategies.

DOI: https://doi.org/10.61919/dkyp9e88

DISCUSSION

The present prospective cohort study evaluated the frequency, determinants, and clinical impact of postoperative surgical site infections (SSI) following abdominal surgery in a tertiary care setting and demonstrated an overall 30-day SSI frequency of 9.3%. This rate is higher than those typically reported from high-income countries, where SSI incidence after abdominal surgery generally ranges between 0.5% and 5%, but remains lower than several reports from low- and middle-income countries, including prior Pakistani studies documenting frequencies exceeding 18–30% (18,19). The observed difference likely reflects heterogeneity in patient selection, wound class inclusion, operative approaches, and infection prevention practices. Notably, the exclusion of contaminated and dirty wounds in the present study may have contributed to a lower overall SSI burden compared with studies that included higher-risk wound classes, supporting the importance of contextualizing SSI rates by surgical case mix.

A key finding of this study was the strong association between surgical approach and SSI, with open surgery demonstrating a markedly higher risk compared with laparoscopic procedures. Patients undergoing open operations experienced more than a thirteenfold increase in odds of SSI, underscoring the protective effect of minimally invasive surgery. This finding aligns closely with international and regional evidence showing consistently lower SSI rates with laparoscopic techniques across a range of abdominal procedures, including appendectomy, cholecystectomy, and colorectal surgery (20–22). The reduced incision length, minimized tissue trauma, lower bacterial exposure, and attenuated inflammatory response associated with laparoscopy are plausible mechanisms underlying this effect (23). In resource-constrained healthcare systems, these findings carry important implications, as expanding access to laparoscopic surgery may yield substantial reductions in postoperative infectious morbidity.

Diabetes mellitus emerged as the most influential patient-related risk factor in this cohort, with diabetic patients exhibiting more than fourfold higher odds of developing SSI compared with non-diabetic patients. This association is well documented in the literature and is biologically plausible, given the effects of hyperglycemia on neutrophil function, collagen synthesis, and microvascular circulation, all of which impair wound healing and host defense (24). The magnitude of association observed in this study is comparable to that reported in prospective cohorts from both developed and developing settings, reinforcing the need for rigorous perioperative glycemic optimization as a cornerstone of SSI prevention Although obesity and anemia were associated with higher crude SSI frequencies, these relationships did not reach statistical significance, possibly due to limited power or overlap with other operative risk factors, a finding that has also been reported in studies with similar sample sizes

Operative urgency and duration were also significant determinants of SSI in the present analysis. Emergency procedures were associated with more than twice the odds of infection compared with elective surgeries, a finding consistent with prior evidence that emergency operations are often performed under suboptimal conditions, with limited preoperative optimization and higher levels of contamination and physiological stress Similarly, operative duration of two hours or longer was associated with nearly a fourfold increase in SSI risk, reflecting prolonged exposure of surgical wounds, increased tissue handling, and cumulative microbial burden These findings emphasize the importance of efficient operative workflow, adherence to antibiotic re-dosing protocols during prolonged surgeries, and meticulous intraoperative technique to mitigate infection risk.

The microbiological profile of SSI in this study was dominated by Staphylococcus aureus, including both methicillin-sensitive and methicillin-resistant strains, followed by Gram-negative organisms such as Escherichia coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa. This distribution mirrors patterns reported in other Pakistani and regional studies, where both Gram-positive cocci and multidrug-resistant Gram-negative bacilli contribute substantially to SSI burden The presence of MRSA and polymicrobial infections highlights the ongoing challenge of antimicrobial resistance and underscores the need for institution-specific antibiograms to inform prophylactic and therapeutic antibiotic strategies.

Beyond frequency and risk factors, the study demonstrated a clear clinical impact of SSI on postoperative recovery, with infected patients experiencing a mean hospital stay nearly three days longer than those without SSI. This finding is consistent with existing evidence that SSI significantly increase healthcare utilization, costs, and patient morbidity, even when infections are limited to the surgical site (31). In settings with constrained hospital capacity, reducing SSI rates through targeted interventions may therefore yield meaningful system-level benefits in addition to improving individual patient outcomes.

Several limitations should be considered when interpreting these findings. The single-center design may limit generalizability to other institutions with differing patient populations, surgical expertise, and infection control practices. Additionally, the analysis relied primarily on unadjusted associations, and residual confounding between operative factors such as emergency status, open approach, and operative duration cannot be fully excluded. Nonetheless, the prospective design, standardized outcome definitions, and complete 30-day follow-up strengthen the internal validity of the study and provide a robust foundation for quality improvement initiatives.

In summary, this study demonstrates that SSI remain a clinically significant complication of abdominal surgery in tertiary care settings, with risk strongly influenced by surgical approach, diabetes mellitus, emergency status, and operative duration. The findings reinforce the protective role of laparoscopic surgery, highlight the need for aggressive perioperative management of diabetic patients, and support system-level efforts to optimize operative efficiency and infection prevention protocols. Future multicenter studies incorporating multivariable risk modeling and standardized perioperative care bundles are warranted to further refine risk stratification and guide evidence-based strategies for reducing SSI burden in similar healthcare contexts

CONCLUSION

In this prospective cohort study, surgical site infections occurred in nearly one in ten patients undergoing abdominal surgery, representing a substantial clinical burden in a tertiary care setting. The risk of SSI was strongly associated with modifiable and non-modifiable factors, particularly open surgical approach, diabetes mellitus, emergency procedures, and prolonged operative duration, while laparoscopic surgery demonstrated a clear protective effect. Staphylococcus aureus remained the predominant pathogen, underscoring ongoing challenges related to antimicrobial resistance and infection control. Importantly, SSI were associated with significantly prolonged hospital stay, highlighting their impact on both patient outcomes and healthcare resource utilization. These findings emphasize the need for targeted preventive strategies, including wider adoption of minimally invasive techniques, rigorous perioperative glycemic control, optimization of operative efficiency, and institution-specific antimicrobial stewardship, to reduce the burden of SSI and improve surgical outcomes in similar healthcare environments.

DOI: https://doi.org/10.61919/dkyp9e88

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