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ORIGINAL ARTICLE

Incidence and Predictors of Surgical Site Infections in General Surgery Departments of Public Sector Hospitals

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ABSTRACT
Background: Surgical site infections (SSIs) are among the most common healthcare-associated infections and, in particular, are common in low and middle-income countries. They are with patient morbidity, prolonged hospital stay, and increased antimicrobial resistance. The purpose of this study was to find out the incidence and predictors of SSIs in general surgery patients of the public sector hospitals of Pakistan.
Methods: The study between January 2022 and December 2022 was a prospective observational study carried out at Nawaz Sharif Social Security Teaching Hospital, Lahore, and PIMS Islamabad. A total of 90 patients of both elective and emergency general surgical procedures were enrolled. Demographics, comorbidities, ASA classification, wound class, preoperative stay, biochemical markers (hemoglobin, albumin), and intraoperative variables were collected. CDC criteria were used to diagnose SSIs within 30 days. Independent predictors were identified using logistic regression.
Results: The incidence of SSIs among the 16 patients was 17.8%. Superficial infections (56.2%), deep 25%, and 18.8% organ space. Increased SSI risk was significantly associated with diabetes mellitus (aOR = 3.67; 95% CI: 1.99 – 5.35; $p < 0.001$). In addition, the classification of dirty wound also independently predicted infection (aOR = 2.55; 95% CI: 1.13–4.98; $p = 0.040$). Patients who received delayed antibiotic prophylaxis had an increased rate of SSI (37%) compared with those who received timely antibiotic prophylaxis (9.5%). Infected patients had more hypoalbuminemia and anemia, but not independently significant.
Conclusion: SSIs are a common problem in public sector surgical practice. Among key predictors are diabetes and dirty wounds. Taking antibiotics on time, keeping blood sugar under control, and doing aseptic surgical handling are all important to reducing the risks of postoperative infections.
Keywords: Surgical site infection, general surgery, diabetes, wound classification, public hospital, Pakistan

INTRODUCTION
Surgical Site Infections (SSIs) are one of the most common and preventable surgical complications around the globe and constitute a major category of hospital-acquired infections (HAIs) [1]. According to the World Health Organization (WHO), up to one-third of patients who undergo surgical procedures in low and middle-income countries (LMICs) will develop an SSI, while the rate is 2 to 5 percent in high-income countries. These infections not only compromise patient safety but also lengthen hospital stays, increase antimicrobial usage, increase healthcare costs, and contribute to higher morbidity and mortality rates, particularly in resource-constrained health care systems like that of Pakistan [2].

The burden of SSIs is particularly magnified in public sector hospitals in South Asia, where overcrowded facilities, inadequate infection control protocols, under-resourced surgical theaters, and inconsistent use of evidence-based prophylactic measures are common. Furthermore, many patients have comorbidities, including diabetes mellitus, malnutrition, and obesity, all of which have been identified to increase the risk of SSI. The risk is compounded by emergency surgical interventions, which are commonly performed under suboptimal aseptic conditions.

In previous studies conducted in various parts of the world, it has been shown that SSIs have a multifactorial etiology and include patient related factors (such as age, nutritional status, glycemic control), procedural factors (such as class of wound, duration of surgery, surgical technique), and hospital factors (such as timing of antibiotic prophylaxis, sterilization practices, hand hygiene compliance) [3]. Nevertheless, there is a severe lack of local epidemiological data pertaining to public sector hospitals in Pakistan—hospitals that care for the majority of the population and where infection control surveillance is not performed consistently[4].

In addition, international SSI risk indices such as the National Nosocomial Infections Surveillance (NNIS) system can be used to stratify surgical risk, but the applicability of these models in an under-resourced healthcare environment may not be complete. Guidelines informed by local challenges and patient profiles are urgently needed to guide therapy and risk-stratify patients[5]. In order to achieve this, multicentric studies based in real-world clinical environments of the public health system of Pakistan are required[6].

The current Study aimed to estimate the incidence of SSIs in general surgery departments in the major public sector hospitals and to identify independent predictors associated with these infections, this study was planned. The findings of this study are meant to be used to guide future preventive strategies, strengthen infection control protocols, and contribute to improving surgical outcomes within Pakistan's public healthcare infrastructure through national surveillance efforts[7, 8].

MATERIALS AND METHODS
This was a prospective, observational study in the general surgery departments of two major public sector tertiary care hospitals within Pakistan at Nawaz Sharif Social Security Teaching Hospital, Multan Road, Lahore, and Pakistan Institute of Medical Sciences (PIMS), Islamabad, from January 2022 to December 2022. These hospitals are high-volume centers that provide elective and emergency surgical services to a diverse population of the urban and semi-urban regions.

Ethical approval of the study was obtained from the institutions' Institutional Review Boards (IRBs) before the study was initiated. All participants gave written informed consent after being informed of the nature and purpose of the study. The study was performed according to the Declaration of Helsinki and national ethical guidelines.

Ninety patients between 18 and 75 years of age undergoing general surgical procedures were enrolled. It included both elective as well as emergency cases. Patients lost to follow-up within 30 days after surgery, patients with pre-existing surgical site infection or known immunosuppressive conditions (e.g., HIV/AIDS, malignancy on chemotherapy, chronic steroid therapy) were excluded.

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A structured pretested proforma was used to collect the data. Demographic, clinical, biochemical, and intraoperative data were recorded, including age, sex, diabetes mellitus, obesity, smoking status, American Society of Anesthesiologists (ASA) classification, preoperative hospital stay duration, hemoglobin, serum albumin, type of surgery, duration, emergency vs. elective, wound classification based on CDC guidelines, drain use, and timing of antibiotic prophylaxis. Clean, contaminated, and dirty wound classes were considered.

SSI was diagnosed within 30 days postoperatively diagnosed according to the Centers for Disease Control and Prevention (CDC) criteria. Diagnosis was made by the treating surgeon, or organisms were isolated on wound swabs or found in purulent discharge, or there was local pain or swelling, or the presence of a loose wound discharge. During hospitalization and for 30 days after surgery, patients were followed, and outpatient visits were made.

Wound swabs were collected under sterile conditions and sent to the microbiology laboratory for culture and sensitivity testing in patients suspected of having an infection. The Kirby Bauer disk diffusion method was used to determine antimicrobial susceptibility of bacteria identified, and the results were recorded following CLSI guidelines.

SPSS version 26.0 was used to analyze the data. Means and standard deviations of continuous variables were expressed, and frequencies and percentages of categorical variables. The Chi-square test for categorical variables and independent t-tests for continuous variables were used to assess associations of variables with SSI. Binary logistic regression was run to determine independent predictors of SSIs. We entered the multivariate model with the variables with $p < 0.1$ from univariate analysis. Statistically significant values were considered to have a p-value less than 0.05. aORs with 95% CI were presented for the Results.

RESULTS

The study included a total of 90 patients who were undergoing general surgical procedures. The mean age was 46.2 ± 13.1 years, and there were 52 (57.8%) males and 38 (42.2%) females. Among the total population, 23 patients (25.6%) had a history of diabetes mellitus known, and 14 (15.6%) were obese (BMI ≥ 30 kg/m²). 22 (24.4%) of patients were active smokers by their smoking status. The patients were classified by the American Society of Anesthesiologists (ASA) classification, with 53 (58.9%) ASA Class II, 22 (24.4%) Class I, and 15 (16.7%) ASA Class III. Twenty patients (22.2%) had a prolonged preoperative hospital stay (>7 days). Additional laboratory biomarkers included a mean hemoglobin level of 12.73 ± 1.74 g/dL and a mean albumin level of 3.84 ± 0.59 g/dL, with some patients having hypoalbuminemia and mild anemia. In Table 1, all demographic and biochemical variables are summarized as shown in table 1.

Table 1: Demographic, Comorbid, and Biochemical Characteristics of Patients (N = 90)

Variable	Frequency (%) / Mean ± SD
Age (years)	46.2 ± 13.1
Gender	
Male	52 (57.8%)
Female	38 (42.2%)
Diabetes Mellitus	23 (25.6%)
Obesity (BMI ≥ 30)	14 (15.6%)
Smoker	22 (24.4%)
ASA Classification	
Class I	22 (24.4%)
Class II	53 (58.9%)
Class III	15 (16.7%)
Pre-op Stay >7 Days	20 (22.2%)
Hemoglobin (g/dL)	12.73 ± 1.74
Albumin (g/dL)	3.84 ± 0.59

Overall, surgical site infection (SSI) incidence was 17.8% (n = 16). Among these, 4 had deep incisional infection, 9 were superficial, and 3 were organ or space infection. Wound classification had a great impact on the frequency of SSIs. As for clean wounds, 2 of 28 patients (7.1%) developed SSIs; the rate was 15.6% for clean contaminated, 44.4% for contaminated, and peaked at 75.0% for dirty. Table 2 presents these associations.

Table 2: Incidence of SSI by Wound Classification

Wound Classification	Total Cases	SSI Cases	SSI Rate (%)
Clean	28	2	7.1%
Clean-contaminated	32	5	15.6%
Contaminated	18	8	44.4%
Dirty	12	9	75.0%

Antibiotic timing significantly influenced SSI rates. Only 6 (9.5%) of those patients who received timely prophylaxis (within 1 hour before incision) developed SSI. Accordingly, patients with delayed or postoperative antibiotics had a much higher rate of 37.0% (10 cases), as shown in Table III as shown in table 3.

Table 3: Association Between Antibiotic Timing and SSI Incidence

Antibiotic Timing	SSI Cases	Total Patients	SSI Rate (%)
Timely (<1 hr)	6	63	9.5%
Delayed/Post-op	10	27	37.0%

Regarding microbiological culture, all 16 SSI cases yielded positive results. Staphylococcus aureus was the It was most frequently isolated organism (43.8%, 7 cases), including two cases of MRSA. It was isolated in 5 cases (31.2%) Escherichia coli and in 3 cases (18.8%) Pseudomonas aeruginosa. One patient had Klebsiella pneumoniae. Resistance was demonstrated for ampicillin and first-generation cephalosporins for most organisms, whereas they were susceptible to piperacillin-tazobactam, carbapenems, and vancomycin.

A multivariate logistic regression model was applied to identify predictors of SSIs. Additionally, dirty wound classification (aOR 2.55; 95% CI 1.13–4.98; p 0.040) and diabetes mellitus (aOR 3.67; 95% CI 1.99–5.35; $p < 0.001$) were significant independent predictors of SSI. In univariate analysis, obesity, preoperative hospital stay, emergency surgery, and delayed antibiotic timing were associated, but were not statistically significant afterward. Table 4 shows the full regression model as shown in table 4.

Table 4: Multivariate Logistic Regression Analysis for Predictors of SSI

Predictor	Adjusted Odds Ratio (aOR)	95% CI	p-value
Diabetes Mellitus	3.67	1.99 – 5.35	<0.001
Dirty Wound Classification	2.55	1.13 – 4.98	0.040
Obesity	0.57	0.13 – 2.04	0.667
Pre-op Stay >7 Days	0.36	0.13 – 2.07	0.675
Emergency Surgery	1.19	0.78 – 3.15	0.238
Surgery Duration (mins)	0.99	0.95 – 1.02	0.464
Drain Used	1.40	0.55 – 2.85	0.587
Timely Antibiotic Prophylaxis	0.34	0.07 – 1.22	0.251

This confirms that diabetes mellitus and dirty surgical wounds are the most important independent predictors of SSIs in the context of public sector general surgery departments. Low albumin and anemia also seem to trend with higher infection rates and were not independently predictive of SSI in this sample.

DISCUSSION

In this study incidence and predictors of surgical site infections (SSI) among general surgical patients admitted in two public sector hospitals in Pakistan were assessed. This study's overall SSI rate of 17.8% is comparable to infection rates reported in other low and middle-income countries (LMICs), in which SSIs often constitute more than 15% of the total surgical packages due to limited infection control resources and inconsistent implementation of surgical safety protocols. This is in line with the ongoing challenge of nosocomial infection in public health care settings in Pakistan and specific patient and procedural risk factors, which would require focused intervention[9].

Diabetes mellitus was a strong predictor of SSI with a relative risk of 3.6. This observation is in agreement with global literature in which diabetic patients are known to be at risk for infection due to impaired wound healing, compromised microvascular, and reduced immune response[10]. This finding is consistent with the need to have rigorous preoperative glycemic control protocols, which are inconsistently followed in resource-limited hospitals[11].

Dirty wound classification was another key predictor; the risk of infection was more than double when wounds were dirty. These cases have high contamination burden, extensive tissue handling, and often exceed the host's defense capacity, and the intraoperative lapses in sterility, especially in emergency operations, are common. Aseptic techniques need to be reinforced, and prolonged postoperative antibiotic coverage should be limited to cases where indicated[12, 13].

Univariate analysis had trends of higher SSI risk with obesity, prolonged hospital stay, and emergency surgery, but these did not attain statistical significance in the multivariate model. However, the clinical relevance of these variables cannot be denied since they were found to be related in earlier studies[14]. However, prophylactic antibiotics administered before incision were associated with a markedly lower infection rate (9.5% vs. 37%), confirming WHO and CDC guidelines of administration within one hour before incision. Although it is not significant in adjusted analysis, the practical significance remains strong because the protective trend implies real-world benefit[15].

From a microbiological point of view, Staphylococcus aureus, including MRSA, E. coli, and Pseudomonas, follow the typical profile for SSIs in general surgery. In particular, the resistance patterns observed (including toward first-generation cephalosporins and ampicillin) underscore the importance of institution-specific antibiograms and antimicrobial stewardship in surgical practice[16].

Assuming that their high prevalence in infected patients contributes to their role, low serum albumin and anemia did not individually predict SSIs, though they both were biochemical indicators. These are overall nutritional and immunologic status, parameters known to be determinants of postoperative healing. Therefore, preoperative optimization, including nutritional supplementation, should be an integral part of the planning of surgery[17].

Preoperative risk assessment with variables ASA class, comorbidity status, and biochemical markers is also emphasized in this study. These tools could stratify high-risk patients for more aggressive perioperative surveillance and targeted prophylaxis[18].

Limitations of this study include a small sample size and the limitation of being applied only to two public hospitals, thus limiting generalizability. In addition, it precludes assessing causality due to the design. Nevertheless, the study's validity is supported by the multicenter approach and the detailed analysis of biochemical and microbiological factors[19].

Future research should determine the implementation and audit of SSI prevention bundles in the Pakistani public sector hospitals. In addition, national SSI surveillance systems are urgently needed to monitor the incidence trends, antibiotic resistance, and compliance with infection control practices[20].

CONCLUSION

This study detects a high incidence of surgical site infections in public sector general surgery departments and associations of diabetes mellitus and dirty wound exposure as the strongest predictors. Lower infection rates were related to timely antibiotic prophylaxis and surgical sterility adherence, suggesting a modifiable effect. This provides an opportunity for improving institutional policy in perioperative risk assessment, infection control training, and antimicrobial stewardship to reduce the SSI burden in the public healthcare sector of Pakistan.

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