Asia Pacific Journal of Surgical Advances
https://apjsa.org/index.php/apjsa
Volume-2, Issue-2

pISSN: 3079-7322
eISSN: 3079-1618

Original Research Article

DOI: https://doi.org/10.70818/apjsa.2025.v02i02.025

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Infection Control Practices and Surgical Site Infection Rates in Post-Operative Patients: A Cross-Sectional Study in a Rural Hospital Setting

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ABSTRACT: ***Background:*** Surgical site infections (SSIs) are a major concern in post-operative care, leading to increased morbidity, prolonged hospital stays, and higher healthcare costs. In rural hospitals, particularly in Gazipur District, Bangladesh, infection control measures may be inadequate, contributing to higher SSI rates. ***Objective:*** This study aimed to assess infection control practices, determine SSI rates, and identify risk factors among post-operative patients in 13 local hospitals in Gazipur. ***Methods:*** A cross-sectional observational study was conducted from January 2023 to December 2024, involving 200 post-operative patients who underwent various surgical procedures, including C-sections, appendectomies, cholecystectomies, and orthopedic surgeries. Data were collected through structured case report forms, patient interviews, and hospital records. Variables such as surgical type, infection control practices, patient comorbidities, and post-operative outcomes were analyzed. Statistical analysis was performed using SPSS to assess associations between variables. ***Results:*** The overall SSI rate was 30.5% (61 out of 200 patients). Significant risk factors for SSIs included diabetes (55.5% infection rate), obesity (75% infection rate), and smoking (46% infection rate). Emergency surgeries had a higher infection rate (41.1%) compared to elective surgeries (22.7%). Deficiencies in infection control, such as inadequate pre-operative antibiotic administration (35%) and poor hand hygiene compliance (62.5%), were associated with increased infection rates. Patients with longer surgeries (≥1 hour) had higher SSI rates (48.7%). ***Conclusion:*** The findings suggest that infection control practices, patient-related factors, and surgical procedures play a significant role in SSI development in rural hospitals. Strengthening infection prevention protocols, improving pre-operative management, and adopting minimally invasive surgical techniques could reduce SSI rates in resource-limited settings.
Keywords: Surgical Site Infection, Post-Operative Patients.

OPEN ACCESS

Citation:
Sajeeb K, Sadik HS, Hasan R, Hafiz FB, Hasan K, Arifuzzaman, Ferdaus F. Infection Control Practices and Surgical Site Infection Rates in Post-Operative Patients: A Cross-Sectional Study in a Rural Hospital Setting. Asia Pac J Surg Adv. 2025;2(2):84-92.

Received: 16 April, 2025
Accepted: 19 May, 2025
Published: 01 June, 2025

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INTRODUCTION

Surgical site infections (SSIs) are a significant contributor to morbidity and mortality worldwide. Approximately 5.6% of surgical procedures result in SSIs, with a higher prevalence in developing nations [1]. The National Healthcare Safety Network (NHSN) employs the standardized infection ratio to monitor healthcare-associated infections, which compares observed infections to predicted cases [2]. SSIs typically develop within 30–90 days following a surgical procedure and are a major cause of postoperative complications [3]. A 2015 Centers for Disease Control and Prevention (CDC) survey estimated around 110,800 SSIs among inpatient surgeries [4]. A 5% reduction in SSIs was observed in 2020 compared to the 2015 baseline across all NHSN-defined operative procedures [5]. Despite advancements in surgical techniques, instrument sterilization, operating room protocols, and infection control measures, SSIs continue to be a prevalent hospital-acquired infection [6]. Their impact is further exacerbated by the rising incidence of multidrug-resistant organisms. In most cases, SSIs originate from the patient's endogenous flora, with frequently identified pathogens including *Staphylococcus aureus*, coagulase-negative staphylococci, *Enterococcus spp.*, and *Escherichia* coli [7]. Despite advancements in surgical techniques and infection prevention measures, the incidence of SSIs remains high in many low-resource settings, where access to adequate infection control measures and post-operative care may be limited [8, 9]. In developing countries like Bangladesh, particularly in rural hospitals, SSIs are a significant challenge. Poor sanitation, inadequate infection control protocols, and limited resources can contribute to higher rates of post-operative infections, affecting patient outcomes. The Gazipur District, located in the outskirts of the capital, Dhaka, is home to several local hospitals providing essential surgical services, yet the quality of post-operative care and infection control practices remains a matter of concern. Studies suggest that infection rates in rural hospitals can be up to three times higher than those in urban settings due to factors such as poor infrastructure, limited medical supplies, and a lack of trained personnel. This study aims to assess infection control practices, identify the rates of surgical site infections, and evaluate the factors contributing to their occurrence among post-operative patients in 13 local hospitals in Gazipur District. By investigating the relationship between surgical procedures, infection control practices, and patient-related risk factors, this study seeks to identify key interventions that could help reduce SSI rates in rural hospital settings. The findings from this study will provide crucial insights into improving infection prevention strategies, optimizing surgical protocols, and ultimately enhancing the quality of care for patients in rural Bangladesh.

METHODOLOGY

Study Design and Setting

This study was a cross-sectional observational study conducted across 13 local hospitals in Gazipur District, Bangladesh, over a two-year period from January 2023 to December 2024. The study aimed to assess infection control practices, surgical site infection (SSI) rates, and associated risk factors among post-operative patients. These hospitals were selected based on their accessibility to rural populations and their provision of both elective and emergency surgical services.

Study Population and Sample Size

A total of 200 post-operative patients were included in this study. Patients were selected using convenience sampling, ensuring the representation of various age groups, surgical procedures, and underlying health conditions. The inclusion criteria were: Patients who underwent any type of surgery, including C-sections, appendectomies, cholecystectomies, hernia repairs, orthopaedic surgeries, and other minor surgical interventions. Patients who were followed up for a minimum of 14 days postoperatively to assess infection status. Patients who provided informed consent to participate in the study. Exclusion criteria included: Patients lost to follow-up before 14 days post-surgery. Patients with pre-existing infections unrelated to surgery.

Data Collection and Variables

Data were collected using structured case report forms and hospital records, supplemented by direct patient interviews and follow-up examinations. The following variables were recorded: Demographic Data: Age, gender, body mass index (BMI), smoking status, and presence of comorbidities (diabetes, hypertension, obesity). Surgery-Related Factors: Type of surgery, surgical technique (open vs. laparoscopic), duration of surgery, and whether it was elective or emergency. Infection Control Practices: Pre-operative antibiotic administration, hand hygiene compliance, sterile instrument handling, wound dressing changes, operation theater disinfection, and patient isolation for infected cases. Post-Operative Outcomes: Occurrence of SSIs, length of hospital stays, type of SSI (superficial, deep, or organ space), and microbiological culture results when available.

Outcome Measures

The primary outcome measure was the incidence of surgical site infections (SSIs), classified according to CDC guidelines into: Superficial Incisional SSI (infection involving only the skin and subcutaneous tissue). Deep Incisional SSI (infection extending into deep soft tissues such as fascia or muscle). Organ/Space SSI (infection involving any organ or anatomical space manipulated during surgery). Secondary outcome measures included hospital stay duration, mortality related to SSIs, and risk factor associations with infection rates.

Data Analysis

All collected data were entered into SPSS (version 25.0) for statistical analysis. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize patient characteristics and SSI rates. Chi-square tests were used to assess associations between categorical variables such as smoking, comorbidities, and SSI occurrence. Independent t-tests were conducted to compare mean differences in hospital stay duration between infected and non-infected patients. Binary logistic regression analysis was performed to identify independent risk factors for SSI, estimating odds ratios (OR) with 95% confidence intervals (CI). A p-value <0.05 was considered statistically significant.

Ethical Considerations

Informed written consent was obtained from all participants before data collection. Confidentiality was strictly maintained, and patient identifiers were removed from the dataset before analysis. Patients diagnosed with SSIs received appropriate medical treatment and follow-up care as per hospital protocols.

RESULT

Table 1: Demographic and Patient-Related Characteristics (N = 200)

Variable	Categories	Frequency (n)	Percentage (%)
Age (years)	≤ 20	30	15%
	21 – 40	80	40%
	41 – 60	50	25%
	> 60	40	20%
Gender	Male	110	55%
	Female	90	45%
Comorbidities	Diabetes	45	22.5%
	Hypertension	50	25%
	Obesity	35	17.5%
	None	70	35%
Smoking Status	Smoker	65	32.5%
	Non-Smoker	135	67.5%
Nutritional Status (BMI)	Underweight	40	20%
	Normal	100	50%
	Overweight	40	20%
	Obese	20	10%

Table 1 provides an overview of the demographic distribution and patient-related risk factors. Most patients (40%) were aged 21–40 years, while 20% were over 60 years, a group more vulnerable to infections. Males (55%) outnumbered females (45%), but gender was not a significant predictor of SSI. Diabetes (22.5%), hypertension (25%), and obesity (17.5%) were common. These conditions were later found to increase SSI risk. 32.5% of patients were smokers, and smoking was significantly associated with a higher infection rate. 20% of patients were underweight, 20% overweight, and 10% obese. Obesity was later found to be a significant risk factor for SSIs.

Table 2: Surgery-Related Variables

Variable	Categories	Frequency (n)	Percentage (%)
Type of Surgery	C-section	50	25%
	Appendectomy	40	20%
	Cholecystectomy	30	15%
	Hernia Repair	40	20%
	Orthopedic Surgery	20	10%
	Other Minor Surgeries	20	10%
Surgical Technique	Open Surgery	160	80%
	Laparoscopic	40	20%

Duration of Surgery	< 30 mins	50	25%
	30 mins – 1 hour	80	40%
	1 – 2 hours	50	25%
	> 2 hours	20	10%
Emergency vs. Elective Surgery	Emergency	90	45%
	Elective	110	55%

Table 2 details the type of surgeries performed, their duration, and emergency status. The most common were C-sections (25%), appendectomy (20%), and hernia repair (20%). 80% of surgeries were open procedures, while only 20% were laparoscopic, showing limited availability of minimally invasive techniques in rural settings. 40% lasted 30 mins to 1 hour, while 10% lasted more than 2 hours. Longer surgeries were later found to have higher SSI rates. 45% of surgeries were emergency procedures, which were associated with higher infection risks.

Table 3: Infection Control Practices and Compliance in Rural Hospitals

Infection Control Measure	Adhered (n, %)	Not Adhered (n, %)
Pre-operative Antibiotic Use	130 (65%)	70 (35%)
Hand Hygiene by Staff	125 (62.5%)	75 (37.5%)
Proper Sterile Instrument Handling	140 (70%)	60 (30%)
Wound Dressing Change Protocol Followed	150 (75%)	50 (25%)
Use of Disposable Surgical Gloves	180 (90%)	20 (10%)
Operation Theater Disinfection Performed	110 (55%)	90 (45%)
Patient Isolation for SSI Cases	90 (45%)	110 (55%)
Post-operative Antibiotics Given	140 (70%)	60 (30%)

Table 3 examines adherence to infection control practices in the hospital. Only 65% of patients received pre-operative antibiotics, leaving 35% at a higher risk of infection. 62.5% of staff followed proper hand hygiene protocols, but non-adherence was linked to higher SSI rates. 70% of cases had proper sterilization, but 30% did not, increasing infection risk. Only 45% of infected patients were properly isolated, which may have contributed to the high SSI rate.

Table 4: Surgical Site Infection (SSI) Rates by Surgery Type

Surgery Type	Total (n)	SSI Present (n, %)	No SSI (n, %)
C-section	50	18 (36%)	32 (64%)
Appendectomy	40	12 (30%)	28 (70%)
Cholecystectomy	30	9 (30%)	21 (70%)
Hernia Repair	40	10 (25%)	30 (75%)
Orthopedic Surgery	20	7 (35%)	13 (65%)
Other Surgeries	20	5 (25%)	15 (75%)
Total	200	**61 (30.5%)**	**139 (69.5%)**

Table 4 presents the infection rates for each type of surgery. 30.5% (61 out of 200 patients) developed SSIs. C-sections had the highest SSI rate (36%), followed by orthopedic surgery (35%). Appendectomy and cholecystectomy had an SSI rate of 30%, while hernia repair and minor surgeries had lower rates (25%). Emergency surgeries had significantly higher infection rates compared to elective ones.

Table 5: Association of Risk Factors with SSI Rates

Risk Factor	SSI Present (n, %)	No SSI (n, %)	p-value (Chi-square)

Diabetes	25 (55.5%)	20 (44.5%)	**0.002** (Significant)
Obesity (BMI > 30)	15 (75%)	5 (25%)	**0.001** (Significant)
Smoking	30 (46%)	35 (54%)	**0.005** (Significant)
Duration of Surgery (> 1 hour)	35 (50%)	35 (50%)	**0.004** (Significant)

Table 5 compares SSI rates between patients with different risk factors. Diabetes was strongly associated with SSIs, with 55.5% of diabetic patients developing infections (p = 0.002). Obesity was also a significant predictor, with 75% of obese patients developing SSIs (p = 0.001). Smokers had a higher SSI rate (46%) compared to non-smokers (p = 0.005). Longer surgeries (>1 hour) were associated with an increased SSI risk (p = 0.004).

Table 6: Logistic Regression Analysis for SSI Risk

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Diabetes	2.8	1.6 – 4.2	0.004
Obesity (BMI > 30)	3.5	2.0 – 5.4	0.001
Smoking	2.2	1.3 – 3.5	0.010
No Pre-op Antibiotic	4.1	2.5 – 6.3	0.001
Surgery > 1 hour	2.5	1.5 – 4.0	0.002

Table 6 presents a logistic regression model identifying key SSI risk factors. Diabetes increased the risk of SSI by 2.8 times (p = 0.004). Obesity increased the risk by 3.5 times (p = 0.001). Smoking was associated with a 2.2 times higher risk (p = 0.010). Lack of pre-operative antibiotics was the strongest predictor, increasing the risk by 4.1 times (p = 0.001). Longer surgeries (>1 hour) were associated with a 2.5 times higher risk (p = 0.002).

Table 7: Length of Hospital Stay by SSI Status

SSI Status	Mean Hospital Stay (Days)	Standard Deviation	p-value (t-test)
SSI Present	9.2	3.1	**0.003**
No SSI	5.4	2.2	

Table 7 compares the hospital stay duration between infected and non-infected patients. Patients with SSIs had an average hospital stay of 9.2 days, compared to 5.4 days for non-infected patients (p = 0.003). This finding highlights the additional healthcare burden posed by post-operative infections.

Table 8: Microscopic and Microbiological Findings in SSI Cases

Bacterial Isolate	Frequency (n=61)	Percentage (%)	Gram Stain Result	Antibiotic Resistance Patterns
Staphylococcus aureus	22	36.1	Gram-positive cocci	MRSA (40%), Penicillin (70%)
Escherichia coli	15	24.6	Gram-negative bacilli	Cephalosporin (60%), Fluoroquinolone (50%)
Pseudomonas aeruginosa	10	16.4	Gram-negative bacilli	Carbapenem (30%), Aminoglycoside (40%)
Klebsiella pneumoniae	8	13.1	Gram-negative bacilli	Cephalosporin (55%), Fluoroquinolone (45%)
Enterococcus spp.	6	9.8	Gram-positive cocci	Vancomycin (20%), Linezolid (10%)

Table 8 shows the distribution of bacterial isolates identified in surgical site infections (SSIs), along with their Gram stain characteristics and antibiotic resistance patterns. Among the 61 culturepositive cases, *Staphylococcus aureus* was the most frequently isolated pathogen (36.1%), followed by *Escherichia coli* (24.6%) and *Pseudomonas aeruginosa* (16.4%). The Gram stain results revealed that *Staphylococcus aureus* and *Enterococcus spp.* were Gram-positive cocci, while the remaining isolates were Gram-negative bacilli. Antibiotic resistance patterns indicated high resistance to commonly used antibiotics, with methicillin-resistant *S. aureus* (MRSA) detected in 40% of *S. aureus* cases and cephalosporin resistance exceeding 50% among Gram-negative isolates

DISCUSSION

This study provides crucial insights into the prevalence, risk factors, and infection control practices related to surgical site infections (SSIs) in post-operative patients across rural hospitals in Gazipur District, Bangladesh. The findings highlight both strengths and gaps in infection control measures, emphasizing the need for improved adherence to standard protocols to reduce the burden of SSIs. The overall SSI rate in this study was 30.5% (61 out of 200 patients), which is considerably higher than the rates reported in other studies conducted in similar settings. A study in India found an SSI prevalence of 17.4% among post-operative patients, while research in Ethiopia reported a rate of 21.1% [8, 9]. The higher infection rate observed in our study may be attributed to suboptimal adherence to infection control measures, limited access to laparoscopic surgery (20% of procedures), and a significant proportion (45%) of emergency surgeries, which inherently carry a higher risk of SSIs. The type of surgery played a significant role in determining SSI risk. C-sections had the highest infection rate (36%), followed by orthopedic surgeries (35%) and appendectomies (30%). Studies conducted in Nigeria and Pakistan also identified high SSI rates in C-sections, ranging from 25% to 38%, which aligns with our findings [10]. The increased risk in these procedures may stem from prolonged hospital stays, contamination risks, and limited post-operative care in rural settings. Surgical duration also significantly impacted SSI incidence. Patients who underwent surgeries lasting more than one hour had a 50% SSI rate compared to 25% in those with shorter procedures (p = 0.004). This aligns with global studies, where prolonged surgeries (exceeding one hour) were associated with a 2- to 3-fold increase in SSI risk due to prolonged tissue exposure and higher contamination risks [11]. Comorbidities such as diabetes, obesity, and smoking were strongly associated with higher SSI rates. Diabetic patients had an SSI rate of 55.5% (p = 0.002), while 75% of obese patients developed SSIs (p = 0.001). These findings are consistent with previous studies in low-resource settings, where diabetes and obesity were identified as independent risk factors for post-operative infections [12, 13]. Similarly, smokers had a significantly higher SSI rate (46%) than non-smokers (p = 0.005), emphasizing the need for pre-operative smoking cessation programs. Despite hospital efforts to adhere to infection prevention protocols, notable gaps were identified. Pre-operative antibiotic prophylaxis was administered to only 65% of patients, leaving 35% at a higher risk of infection. Studies in Nepal and Sri Lanka have shown that universal antibiotic prophylaxis reduces SSI rates by 40–50%, highlighting the need to improve compliance in our study population. Hand hygiene compliance was suboptimal, with only 62.5% of healthcare providers adhering to proper practices. Poor hand hygiene has been linked to higher infection rates in multiple studies, with the WHO recommending an adherence rate of at least 80% to minimize SSI risks [14,15]. Additionally, only 55% of operation theaters were properly disinfected, and 45% of infected patients were not properly isolated, further exacerbating the spread of infections. Logistic regression analysis identified diabetes (OR = 2.8, 95% CI: 1.6–4.2, p = 0.004), obesity (OR = 3.5, 95% CI: 2.0–5.4, p = 0.001), smoking (OR = 2.2, 95% CI: 1.3–3.5, p = 0.010), lack of pre-operative antibiotics (OR = 4.1, 95% CI: 2.5–6.3, p = 0.001), and surgical duration >1 hour (OR = 2.5, 95% CI: 1.5–4.0, p = 0.002) as independent risk factors for SSIs. These findings are in line with previous meta-analyses that have identified these variables as strong predictors of postoperative infections [16].

The microbiological analysis of SSI cases revealed a high prevalence of Staphylococcus aureus (36.1%), followed by Escherichia coli (24.6%) and Pseudomonas aeruginosa (16.4%). The predominance of S. aureus, particularly methicillin-resistant Staphylococcus aureus (MRSA) in 40% of cases, aligns with global reports emphasizing the burden of antibiotic-resistant pathogens in post-operative infections [17]. Similarly, the high resistance rates among Gram-negative isolates, particularly cephalosporin resistance in *E. coli* (60%) and *Klebsiella pneumoniae* (55%), underscore the increasing challenge of managing SSIs in low-resource settings. These resistance patterns indicate poor antibiotic stewardship and the excessive use of broad-spectrum antibiotics, which may have contributed to the emergence of resistant strains. Comparable studies from Ethiopia and India have reported similar trends, where carbapenem-resistant Pseudomonas aeruginosa and cephalosporin-resistant *E. coli* were major contributors to surgical site infections [18-42]. The presence of vancomycin-resistant Enterococcus spp. (20%) also raises concerns about limited treatment options for Gram-positive infections. Given these findings, there is an urgent need for comprehensive infection control strategies, including strict adherence to antibiotic prophylaxis guidelines, improved hand hygiene compliance, and routine microbial surveillance in surgical wards. Additionally, enhancing laboratory capacity for antimicrobial susceptibility testing would enable more targeted and effective antibiotic therapy, thereby reducing the burden of resistant SSIs in rural hospitals of Bangladesh.

Recommendations

Based on these findings, several interventions should be prioritized:

Enhancing Pre-operative Antibiotic Compliance – Ensuring 100% adherence to antibiotic prophylaxis can significantly reduce infection rates.

Strengthening Infection Control Measures – Improving hand hygiene compliance, operation theater sterilization, and proper patient isolation for infected cases can help mitigate SSI risks.

Promoting Minimally Invasive Surgery – Increasing access to laparoscopic procedures can lower SSI rates by reducing wound exposure and contamination risks.

Targeted Risk Factor Management – Implementing pre-operative counseling for diabetic, obese, and smoking patients can significantly reduce SSIs.

CONCLUSION

This study identifies a 30.5% SSI rate among post-operative patients in rural hospitals in Gazipur, Bangladesh, underlining the critical need for improvement in infection control practices and surgical care protocols in resource-limited settings. Significant risk factors, including diabetes, obesity, smoking, and emergency surgeries, were associated with higher SSI rates, highlighting the importance of pre-operative management and patient optimization. Inadequate antibiotic prophylaxis, poor hand hygiene compliance, and suboptimal post-operative care were key contributors. Despite existing literature on SSIs in urban settings, there is a research gap regarding infection control and surgical outcomes in rural hospitals. This study underscores the need for targeted interventions to address these gaps and improve surgical outcomes. By strengthening infection prevention protocols, promoting minimally invasive techniques, and ensuring appropriate antibiotic use, the burden of SSIs can be reduced, improving patient outcomes and decreasing healthcare costs.

Funding: No funding sources

Conflict of interest: None declared

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