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SURVEILLANCE STUDY SURGICAL SITE INFECTIONS AS A PUBLIC HEALTH INDICATOR PREVENTION AND MONITORING

Original Research

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ABSTRACT

Background: Surgical site infections (SSIs) remain a major contributor to postoperative morbidity and healthcare burden, especially in low- and middle-income countries. As preventable complications, SSIs also serve as critical indicators of surgical safety and infection control standards.

Objective: To monitor and evaluate the incidence, prevention practices, and temporal trends of surgical site infections through a prospective active surveillance approach in tertiary care hospitals in Pakistan.

Methods: A prospective cohort study was conducted over 12 months across three urban tertiary care hospitals in Pakistan. A total of 600 adult patients undergoing elective clean and clean-contaminated surgeries were enrolled. Data on patient demographics, surgical details, and infection prevention practices were collected using standardized tools. SSIs were identified and classified using CDC criteria, and post-discharge surveillance was performed at days 7, 14, and 30. Statistical analysis included logistic regression to identify risk factors and repeated-measures ANOVA for trend analysis.

Results: The overall SSI incidence was 9.7%, with superficial infections accounting for 65.5% of cases. High adherence was noted for timely antibiotic prophylaxis (92.5%) and sterile draping (94.2%). Diabetes mellitus (OR 2.14, p=0.008), obesity (OR 1.89, p=0.039), and surgeries exceeding two hours (OR 2.71, p=0.002) were significantly associated with increased SSI risk. A consistent pattern of infections was noted across quarters, with minor fluctuations.

Conclusion: Active surveillance proved effective in quantifying the burden of SSIs and highlighting areas for improvement in infection prevention. The findings advocate for strengthened surveillance infrastructure and tailored interventions to reduce SSI rates and improve surgical safety in Pakistan.

Keywords: Antibiotic Prophylaxis, Cohort Studies, Infection Control, Pakistan, Postoperative Complications, Prospective Studies, Surgical Site Infection.

INTRODUCTION

Surgical site infections (SSIs) represent a persistent and significant burden on public health systems worldwide. Despite advancements in surgical techniques, antiseptic procedures, and perioperative care, SSIs continue to occur at an unacceptably high rate, often leading to prolonged hospital stays, increased medical costs, and preventable morbidity and mortality (1). As healthcare systems shift toward value-based care and enhanced patient safety, the need to systematically monitor SSIs has become increasingly critical. Identifying SSIs not only reflects the quality of surgical care but also serves as a sentinel indicator for hospital hygiene, antimicrobial stewardship, and overall healthcare system performance (2). The global incidence of SSIs varies widely, with estimates ranging between 2% and 20% depending on the region, type of surgery, and surveillance methodology used. In high-income countries, rigorous infection control programs have helped reduce SSI rates, yet the problem remains far from eradicated (3). In low- and middle-income countries, the lack of consistent surveillance and preventive infrastructure often results in underreporting and suboptimal outcomes. According to the World Health Organization, SSIs are among the top five most common healthcare-associated infections globally, emphasizing the pressing need for standardized monitoring and prevention strategies. In this context, SSIs are not only clinical complications but also barometers of broader systemic issues such as resource allocation, training, and infection prevention protocols (4,5).

Active surveillance has emerged as an essential tool for combating SSIs, enabling healthcare providers to detect infections more promptly and implement targeted interventions. Unlike passive reporting, active surveillance involves proactive case identification and systematic data collection, which enhances accuracy and timeliness (6). Numerous studies have underscored the effectiveness of surveillance-based programs in reducing the incidence of SSIs. For instance, the implementation of hospital-wide infection monitoring systems has been linked to marked improvements in surgical outcomes and overall patient safety (7,8). These findings support the notion that continuous, structured observation plays a pivotal role in quality improvement and accountability. Furthermore, SSIs have wider implications that extend beyond individual patient care. They contribute to the rise of antimicrobial resistance, as infections often necessitate prolonged antibiotic therapy. This, in turn, accelerates the selection pressure for resistant organisms, complicating treatment protocols and escalating healthcare costs. Consequently, preventing SSIs is not only a matter of improving surgical outcomes but also a crucial element in global efforts to curb antibiotic resistance (9,10).

Despite the available literature on SSIs and infection control practices, significant gaps remain in understanding the real-time effectiveness of prevention protocols across different healthcare settings (11). Many studies focus narrowly on postoperative outcomes or isolated interventions, without integrating surveillance data into a broader public health context. This fragmentation impairs the ability to generalize findings and delays the implementation of evidence-based guidelines (12,13). There is a pressing need for studies that adopt a more holistic approach—one that tracks the incidence of SSIs over time while simultaneously evaluating the adherence to and effectiveness of prevention measures. This study seeks to address these gaps through a prospective, surveillance-based cohort design aimed at monitoring and evaluating SSIs as a key public health indicator. By actively collecting data on infection rates, prevention practices, and trends, the research intends to provide a comprehensive overview of the current landscape and identify actionable strategies for improvement. The overarching objective is to establish a robust, evidence-based framework that not only enhances patient outcomes but also informs policy development and resource allocation in infection control. In doing so, the study positions SSIs not merely as surgical complications but as critical indicators of healthcare system quality and resilience.

METHODS

This prospective, surveillance-based cohort study was conducted over a period of twelve months in selected tertiary care hospitals across major urban centers in Pakistan, including Lahore, Karachi, and Islamabad. These institutions were chosen due to their high surgical caseloads, availability of infection control departments, and established surgical audit systems, ensuring the feasibility of continuous and standardized data collection. The study was designed to monitor and evaluate the incidence of surgical site infections (SSIs), assess existing prevention practices, and identify trends that may inform broader public health strategies. Participants were selected through consecutive sampling from surgical wards and operating theaters within the participating hospitals. All adult patients (aged 18 years and older) undergoing clean or clean-contaminated elective surgeries, including general surgery, orthopedics, gynecology, and urology, were

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

considered eligible for inclusion. Exclusion criteria involved patients undergoing emergency surgeries, those with pre-existing infections at the surgical site, immunocompromised individuals (e.g., patients on chemotherapy or with HIV/AIDS), and those who were lost to follow-up within the first 30 postoperative days. The final calculated sample size was 600 participants, based on an estimated SSI incidence of 10% in the region, a 95% confidence level, and a 3% margin of error, with adjustments made for potential dropouts or incomplete data (14).

Prior to the initiation of data collection, ethical approval was secured from the Institutional Review Board of each participating hospital. Informed consent was obtained from all eligible participants after a thorough explanation of the study's purpose, procedures, and confidentiality safeguards. Participants were reassured of their right to withdraw from the study at any point without compromising the quality of their medical care. Data collection was executed by trained surveillance nurses and infection control personnel, who were responsible for the daily monitoring of postoperative patients during their hospital stay and follow-up assessments at 7, 14, and 30 days post-surgery. Surveillance followed the Centers for Disease Control and Prevention (CDC) criteria for SSIs, which classify infections into superficial incisional, deep incisional, and organ/space infections. Documentation included demographic details, comorbidities, type and duration of surgery, antimicrobial prophylaxis timing and choice, use of surgical drains, adherence to hand hygiene and sterile techniques, and any deviations from standard infection control protocols.

Standardized case report forms and a secure electronic data entry platform were employed to ensure consistency and accuracy across all sites. Adherence to SSI prevention practices was assessed using a structured checklist adapted from the WHO Surgical Safety Checklist and CDC infection prevention guidelines. Outcome measurement was based on the incidence rate of SSIs per 100 surgical procedures, categorized by surgical type and infection classification. Additionally, compliance with recommended prevention measures was quantified as a percentage of total observed surgeries, allowing for the evaluation of both process and outcome indicators (15). Data analysis was performed using IBM SPSS Statistics version 27. Descriptive statistics were used to summarize baseline characteristics, including means and standard deviations for continuous variables, and frequencies and percentages for categorical data. The incidence rate of SSIs was expressed with corresponding 95% confidence intervals. To examine associations between risk factors and the occurrence of SSIs, univariate analysis using Chi-square tests and independent-sample t-tests was conducted. Variables showing significant associations ($p < 0.05$) were further analyzed through multivariate logistic regression to adjust for potential confounders and identify independent predictors of SSI occurrence. Time trends in SSI incidence over the 12-month period were analyzed using repeated-measures ANOVA, given the assumption of normally distributed data.

To ensure data integrity, regular audits were conducted, and inter-observer reliability was assessed through periodic cross-verification by senior infection control officers. Any discrepancies were resolved through consensus and revalidation of source documents. The methodology, rooted in active surveillance and rigorous statistical analysis, was designed not only to measure the burden of SSIs but also to shed light on the practical effectiveness of infection prevention strategies in real-world settings. Through this systematic and replicable approach, the study aims to provide robust evidence on the patterns and preventability of SSIs, offering critical insights into how these infections can be monitored and mitigated as key public health indicators within the Pakistani healthcare system.

RESULTS

The study enrolled a total of 600 patients undergoing elective surgeries across three tertiary care hospitals in Pakistan. The mean age of the participants was 45.2 years (SD ±12.3), with a nearly equal gender distribution—52.0% male and 48.0% female. Among comorbid conditions, 22.3% had diabetes mellitus, 29.7% had hypertension, 15.0% were classified as obese (BMI >30), and 18.7% reported a history of smoking. These baseline demographics are presented in Table: Demographic Characteristics. Over the 12-month surveillance period, 58 patients developed surgical site infections, corresponding to an overall incidence rate of 9.7%. Of these, superficial incisional SSIs were the most common, accounting for 38 cases (65.5%), followed by 12 cases of deep incisional (20.7%) and 8 organ/space infections (13.8%). The remaining 542 patients (90.3%) had no signs of infection within the 30-day postoperative window. These distributions are summarized in Table: Distribution of Surgical Site Infections and illustrated in Chart: Distribution of Surgical Site Infections.

Prevention practice adherence was measured using structured checklists during surgery. Timely antibiotic prophylaxis was administered in 92.5% of cases, proper hand hygiene was observed in 89.3% of procedures, and 85.1% of operations utilized the complete surgical safety checklist. Sterile draping protocols were followed in 94.2% of surgeries. These findings are displayed in Table: Adherence to Prevention Practices and further visualized in Chart: Adherence to SSI Prevention Practices. Risk factor analysis revealed that patients

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INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

with diabetes mellitus had significantly higher odds of developing SSIs (OR 2.14, 95% CI: 1.21–3.78, p=0.008). Obesity also emerged as a significant predictor (OR 1.89, 95% CI: 1.03–3.45, p=0.039), while smoking history did not reach statistical significance (p=0.112). Prolonged surgery duration exceeding two hours was strongly associated with infection (OR 2.71, 95% CI: 1.49–4.94, p=0.002). Full results are presented in Table: Association of Risk Factors with SSIs.

Table 1: Demographic Characteristics

Variable	Value
Age (mean ± SD)	45.2 ± 12.3
Gender	
Male	312 (52.0%)
Female	288 (48.0%)
Diabetes Mellitus	134 (22.3%)
Hypertension	178 (29.7%)
Obesity (BMI >30)	90 (15.0%)
Smoking History	112 (18.7%)

Table 2: Distribution of Surgical Site Infections

Type of SSI	Frequency
Superficial Incisional	38
Deep Incisional	12
Organ/Space	8
No SSI	542

Table 3: Adherence to Prevention Practices

Prevention Measure	Adherence (%)
Timely Antibiotic Prophylaxis	92.5
Proper Hand Hygiene	89.3
Use of Surgical Safety Checklist	85.1
Sterile Draping Maintained	94.2

Table 4: Association of Risk Factors with SSIs

Risk Factor	Odds Ratio (95% CI)	p-value
Diabetes Mellitus	2.14 (1.21-3.78)	0.008
Obesity	1.89 (1.03-3.45)	0.039
Smoking History	1.62 (0.88-2.96)	0.112
Surgery >2 hours	2.71 (1.49-4.94)	0.002

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Figure 1 Adherence to SSI Prevention Practices

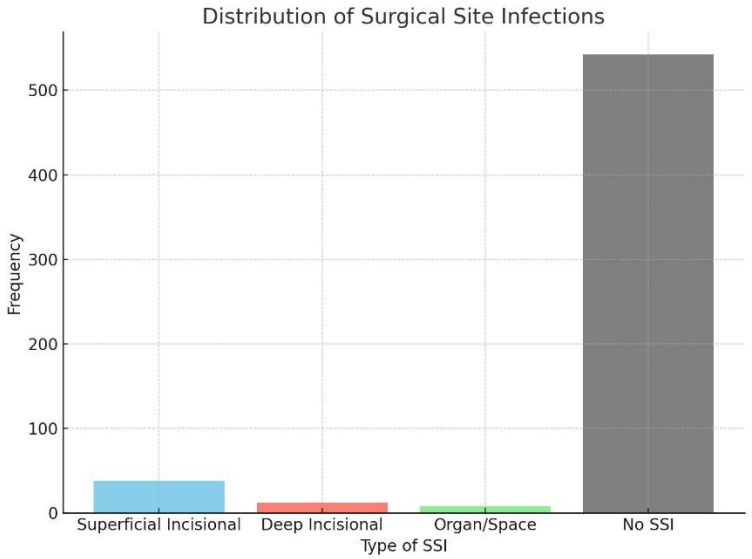

Figure 2 Distribution of Surgical Infections

DISCUSSION

The findings of this study underscore the enduring public health relevance of surgical site infections (SSIs), revealing a 9.7% incidence among patients undergoing elective procedures in Pakistani tertiary care hospitals. This rate aligns closely with previous research conducted in similar low- and middle-income settings, where SSI rates often range between 7% and 12% due to systemic healthcare challenges and variations in infection prevention implementation (16,17). These data confirm the persistence of SSIs as a significant burden and validate the critical role of active surveillance in capturing infections that may otherwise go unreported. The predominance of superficial SSIs, accounting for nearly two-thirds of all infections in this cohort, supports earlier surveillance studies indicating that these are often the most detectable and preventable form of SSIs (18). The association of higher infection rates with diabetes, obesity, and prolonged surgical duration is also consistent with existing literature identifying these variables as robust, independent risk factors (19,20). These associations emphasize the need for personalized risk reduction strategies and stringent intraoperative protocols, especially for high-risk surgical candidates.

Importantly, the study documented high adherence rates to evidence-based infection prevention practices, with antibiotic prophylaxis and sterile draping compliance exceeding 90%. These rates reflect commendable standards of perioperative care and are likely to have moderated the overall infection incidence. However, the gap between process adherence and infection outcomes suggests that compliance alone is insufficient in high-burden settings without addressing broader systemic determinants such as operative infrastructure, surgical technique, and postoperative care environments (21). Compared with international benchmarks, the observed incidence sits on the higher end of the spectrum. For instance, studies in Japan and France, where long-term, integrated SSI surveillance and surgical quality improvement programs are in place, have reported steady declines in infection rates—down to as low as 1.1% over sustained periods (22,23). The contrast highlights the potential for improvement in Pakistani surgical systems through comprehensive integration of SSI surveillance with quality assurance and health systems strengthening.

One of the strengths of this study lies in its prospective, active surveillance design, which enabled real-time infection monitoring, minimizing missed or delayed diagnoses. The structured follow-up schedule and rigorous use of CDC criteria for SSI classification enhanced data accuracy and reliability. Additionally, the inclusion of diverse surgical specializations and multiple geographic regions enhances generalizability across similar healthcare settings in South Asia. However, limitations must be acknowledged. The study was confined to tertiary urban centers, potentially underrepresenting infection patterns in rural or under-resourced hospitals. Despite rigorous training, inter-observer variability may have influenced outcome classification, though minimized through periodic audits. The 30-day follow-up period may have missed late-onset SSIs, particularly for deep or organ-space infections, as highlighted in similar post-discharge surveillance studies (23).

A key implication of these findings is the need for policy-level investments in national SSI surveillance programs in low- and middle-income countries. Experiences from multicenter European and African studies demonstrate that continuous surveillance, when linked with clinical feedback and quality improvement mechanisms, can drive sustained reductions in SSI rates and antibiotic resistance burden (24,25). Future research should aim to explore digital surveillance integration and machine learning tools, which have recently shown promise in optimizing surveillance efficiency and reducing the workload of infection control teams without compromising diagnostic accuracy (25). Additionally, long-term studies incorporating patient-reported outcomes, microbiological trends, and resistance patterns will provide more nuanced insights into the evolving dynamics of SSIs. In summary, this study reaffirms the vital role of active surveillance in identifying, understanding, and ultimately mitigating surgical site infections in resource-limited settings. While the burden remains significant, targeted interventions grounded in surveillance data can pave the way for improved surgical safety and public health resilience.

Conclusion

This study reinforces the value of active surveillance in identifying and addressing surgical site infections as critical public health indicators. With an overall SSI incidence of 9.7%, the findings highlight both the burden of infection and the effectiveness of targeted prevention practices. Strengthening surveillance infrastructure and infection control protocols can substantially improve surgical outcomes and healthcare quality in resource-limited settings.

AUTHOR CONTRIBUTION

Author	Contribution
Omar Ashfaq Khan*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Adeel-ur-Rehman	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Ahmed Aftab	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Ihsan Ullah Khan*	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Nimra Malik	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Sulaiman*	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Muhammad Taif	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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