Accuracy of Selective Postoperative Surgical Site Infection Surveillance Among High-Risk Patients Compared With Traditional Surveillance in a Tertiary University Hospital

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Abstract

Introduction Surgical site infection (SSI) surveillance is resource-intensive, particularly in low-resource settings. This study evaluated whether selective surveillance of high-risk patients can accurately identify postoperative SSI compared with traditional surveillance of all surgical patients.

Methods A cross-sectional study was conducted among 587 patients who underwent selected general surgical procedures from January 2022 to June 2023 in a tertiary university hospital. Patients were classified as high-risk or low-risk for SSI using eight perioperative variables. Logistic regression analysis identified factors independently associated with SSI. The accuracy and agreement of selective surveillance versus traditional surveillance were assessed using sensitivity, specificity, predictive values, and Cohen's kappa.

Results The overall SSI rate was 12% (71/587). Independent predictors of SSI included resident service cases (OR 2.57, 95% CI 1.37–4.83), ASA score 3–5 (OR 6.28, 95% CI 3.30–11.93), clean-contaminated to dirty wounds (OR 21.73, 95% CI 6.26–75.48), operative duration beyond the 75th percentile (OR 2.33, 95% CI 1.24–4.38), and failure to maintain perioperative normothermia (OR 39.49, 95% CI 3.35–465.06). Selective surveillance demonstrated 100% sensitivity, specificity, positive predictive value, and negative predictive value, with perfect agreement with traditional surveillance (Cohen's kappa = 1.00).

Conclusion Selective surveillance focused on high-risk patients demonstrated excellent agreement with traditional surveillance and may serve as a cost-effective alternative for SSI monitoring in resource-limited settings.

Key words: Surgical site infection (SSI), SSI surveillance, Risk stratification, High-risk surgical patients, Healthcare-associated infections; Infection prevention

Surgical site infections (SSIs) rank among the most prevalent hospital-acquired infections worldwide. The United States Centers for Disease Control (2015) reported in their Healthcare-associated infection (HAI) prevalence survey an estimated 110,800 surgical site infections linked to inpatient surgeries. Based on the Hospital Acquired Infection (HAI) data results published in the National Health Survey Network's (2024) Hospital Associated Infection Progress Report, there was nearly a 4% increase in the SSI standardized infection ratio (SIR) for all NHSN operative procedure categories combined compared to the previous year. Patients who develop SSIs have been shown to experience longer postoperative hospital stays, may require additional surgical procedures or intensive care unit admission, and face a higher risk of mortality (Anderson et al., 2014). Ban et al. (2017), in the 2016 American College of Surgeons Surgical Infection Society Updated Guidelines, estimated that SSIs

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constitute 20% of all HAIs and are associated with a 2- to 11-fold increase in the risk of mortality, with 75% of SSI-related deaths directly attributable to SSI and sepsis.

Monitoring SSI remains an important indicator of healthcare-associated outcomes. Surveillance systems with feedback mechanisms have been shown to improve SSI management and reduce infection rates (NNIS, 2003; Russo et al., 2021). Early detection and management of SSI have also been associated with shorter hospitalization, lower intensive care utilization, and improved patient outcomes (Horgan et al., 2023). SSI surveillance programs provide healthcare institutions with accurate epidemiologic data that may be used to identify trends, evaluate preventive strategies, compare institutional performance with international benchmarks, and support quality improvement and patient safety initiatives (Kasatpibal, 2009; German, 2001).

The accepted gold standard for SSI surveillance is active case finding through direct postoperative patient observation performed by trained personnel such as infection control nurses (Gillespie, 2021). However, active surveillance is resource-intensive and requires monitoring for at least 30 days postoperatively and up to 90 days for procedures involving implants. This challenge is particularly relevant in hospitals with high surgical volume and limited surveillance capability. In the Philippines, the absence of baseline national SSI data and limited manpower have constrained the establishment of sustainable SSI surveillance systems (Rosenthal, 2024).

Selective surveillance strategies focused on high-risk patients may provide a practical alternative to monitoring all postoperative patients. The NHSN Risk Index traditionally stratifies patients according to operative duration, wound classification, and ASA score (NNIS, 2003). However, limitations in its predictive performance across operative categories have been identified, including the use of only three risk factors and equal weighting of variables (Tanner, 2013; Brandt, 2004). Additional perioperative variables such as timely antimicrobial prophylaxis, maintenance of normothermia, glycemic control, and appropriate hair removal may improve patient risk stratification and better identify patients at increased risk for SSI (Pedroso-Fernandez, 2016).

The objective of the study was to evaluate a selective surveillance strategy focused on patients at high risk for developing SSI and determine whether targeted monitoring provides comparable accuracy to traditional surveillance of all postoperative patients. Specifically, the study aimed to determine the incidence of SSI, describe the profile of patients who developed SSI, identify factors associated with the development of SSI, assess the accuracy of selective surveillance for monitoring postoperative SSI, and determine the degree of agreement between selective surveillance and traditional surveillance systems.

Methods

Ethics Board approval was obtained prior to data collection (RIHS ERC Code 1269/G/2022/079). This was a cross-sectional study of admitted patients at a tertiary university hospital from January 2022 to December 2023. Surgical site infection (SSI) surveillance focused on 15 National Nosocomial Infections Surveillance (NNIS) operative procedure categories in general surgery, including head and neck surgery (NECK), thyroid and parathyroid surgery (THYR), breast surgery (BRST), skin and soft tissue surgery (SST), herniorrhaphy (HERN), esophagogastroduodenal surgery (EGAS), gallbladder surgery (CHOL), hepatopancreatobiliary surgery (BILI), small bowel surgery (SB), appendectomy (APPY), colon surgery (COLO), rectosigmoid surgery (REC), anal surgery (ANAL), and exploratory laparotomy (XLAP).

Pertinent demographic, perioperative, operative, and SSI-related variables were collected using standardized data collection forms. These included age, sex, comorbidities, perioperative normothermia, glycemic control, antimicrobial prophylaxis, urgency and duration of surgery, ASA classification, wound classification, operative approach, and use of implants or drains. Eight pre-specified perioperative variables were used to classify patients as high-risk or low-risk for developing SSI: operative duration, wound contamination classification, ASA risk classification, antimicrobial prophylaxis, duration of antibiotic administration, appropriateness of hair removal, maintenance of perioperative normothermia, and adequacy of perioperative glycemic control (Table 1).

Operative duration was defined as the time from skin incision to skin closure and was compared with the CDC/NHSN 75th percentile cut-off values for each operative category. Surgical wounds were classified according to the Altemeier wound classification system, while the 2014 American Society

Table 1. Classification of procedures according to risk.

Variable	Low Risk	High Risk
ASA classification	1–2	3–5
Wound class	Clean	Clean-contaminated, contaminated, dirty
Duration of procedure	≤75th percentile	>75th percentile
Antimicrobial prophylaxis	Appropriate	Inappropriate
Duration of antimicrobial use	Appropriate	Inappropriate
Hair removal	Appropriate/not indicated	Inappropriate
Perioperative normothermia	Maintained	Not maintained
Perioperative glycemic control	Maintained	Not maintained

of Anesthesiologists (ASA) classification was used to assess preoperative physical status. Appropriate hair removal was defined according to World Health Organization recommendations using electric clippers when indicated. Antimicrobial prophylaxis was evaluated based on antibiotic selection, dosage, timing, and duration according to published evidence-based guidelines. Perioperative normothermia and glycemic control were likewise assessed using predefined criteria. Procedures with no identified risk factors were classified as low risk, while those with at least one risk factor were classified as high risk.

Post-discharge surveillance was performed using multiple standard infection control surveillance techniques, including inpatient chart review, microbiology records, outpatient follow-up records, physician interviews, telephone calls, and text messaging. A standardized questionnaire based on CDC SSI criteria was used to assess postoperative infections. SSI classification followed CDC definitions for superficial incisional, deep incisional, and organ/space SSI occurring within 30 days postoperatively or within 90 days for procedures involving implants.

Descriptive statistics were used to summarize patient characteristics and operative variables using means with standard deviations for numerical variables and frequencies with percentages for categorical variables. Binary logistic regression analysis was performed to determine factors significantly associated with SSI. Measures of diagnostic accuracy, including sensitivity, specificity, positive predictive value, and negative predictive value, were computed to compare selective surveillance among high-risk patients with traditional surveillance of all postoperative patients. Cohen's kappa statistic was used to determine agreement between surveillance methods. Statistical significance was set at $p < 0.05$, and data analysis was performed using Stata version 14 software.

Results

Data were collected from 587 operations performed at the UERM Memorial Medical Center from January 2022 to June 2023. There were 434 procedures performed in 2022 and 153 procedures performed from January to June 2023. A total of 71 SSIs were identified, yielding an overall SSI rate of 12% (Table 2).

Table 2. Distribution of SSI cases by operative category.

Operative Category	Total Cases n (%)	SSI Cases
CHOL	175 (29.8)	3
BRST	82 (13.9)	1
REC	52 (8.9)	20
APPY	50 (8.5)	7
COLO	39 (6.6)	16
HERN	39 (6.6)	0
ANAL	31 (5.3)	0
BILI	25 (4.3)	3
THYR	24 (4.1)	0
EGAS	22 (3.8)	7
SB	22 (3.7)	11
SST	13 (2.2)	1
NECK	8 (1.4)	0
XLAP	5 (0.9)	2
Total	587	71

Overall, the most common surgical procedures were CHOL (30%), BRST (14%), REC (9%), and APPY (9%), which collectively accounted for the majority of operations. Most SSIs occurred in REC (28%), COLO (23%), SB (16%), EGAS (10%), and APPY (10%) procedures. (Table 2).

Patient demographic and operative characteristics are summarized in Table 3. Most patients were female (58%) and younger than 60 years old (65%), with a mean age of 51 years. The majority had comorbidities (63%), most commonly hypertension, malignancy, and diabetes mellitus. Most patients were classified as ASA

1 or 2, and the majority of wounds were classified as clean or clean-contaminated. Most operations were completed within the CDC/NNIS 75th percentile operative duration cut-off time.

Table 3. Baseline characteristics of patients.

Characteristic	n (%)
Female sex	338 (57.6)
Age <60 years	381 (64.9)
Presence of comorbidities	368 (62.7)
ASA 3–5	179 (30.5)
Clean contaminated to dirty wounds	293 (49.9)
Open surgery	436 (74.3)
Exceeds operative duration 75th percentile	265 (45.1)
High-risk classification	434 (73.9)
SSI present	71 (12.1)
Superficial incisional SSI	54 (76.1 of SSI)

Most procedures were managed by consultants and performed on either an elective or semi-elective basis. The open operative approach was used in most procedures, while implants were infrequently utilized. Surgical drains, however, were used in a substantial proportion of operations. Hair removal was either appropriate or not indicated in almost all procedures. Appropriate prophylactic antibiotics in terms of choice, dose, and timing were administered in most operations, although postoperative antibiotic discontinuation within the recommended period was infrequent. Perioperative normothermia was maintained in nearly all patients, while glycemic control was adequately maintained in most patients requiring monitoring.

Based on the eight-variable risk assessment criteria, 74% of procedures were classified as high-risk while 26% were classified as low-risk. Surgical site infections occurred in 71 procedures, with most classified as superficial incisional SSI (76%), followed by organ/space SSI (21%) and deep incisional SSI (3%). The SSI rate among high-risk patients was 16% (Table 4).

Table 4. Distribution of SSI by risk assessment.

Risk Category	SSI	No SSI	Total
Low risk	0	153	153
High risk	71	363	434
Total	71	516	587

Among high-risk patients, SSI rates increased as the number of risk factors increased, with SSI rates of 3%, 15%, 39%, and 67% among patients with 1, 2, 3, and 4 risk factors, respectively. Higher SSI rates were observed in gastrointestinal operative categories such as SB, COLO, REC, EGAS, and XLAP procedures. Most SSIs occurred among patients with two to three risk factors (Table 5).

Table 5. SSI rates according to number of risk factors.

Number of Risk Factors	SSI Rate
1	2.6%
2	15.6%
3	38.3%
4	66.7%

On crude analysis, gender, age group, provider type, timing of surgery, operative approach, use of drains, ASA classification, comorbidities, wound contamination class, duration of surgery, antibiotic prophylaxis, postoperative antibiotic discontinuation, perioperative normothermia, and glycemic control were significantly associated with SSI ($p<0.05$) (Table 6). Final logistic regression analysis demonstrated that service as provider, ASA score 3–5, contaminated wound classification, operative duration exceeding the 75th percentile, and failure to maintain perioperative normothermia were independently associated with SSI (Table 7).

Selective surveillance demonstrated 100% sensitivity, specificity, positive predictive value,

Table 6. Crude association between factors and SSI.

Factor	Odds Ratio (95% CI)	p-value
Male sex	1.90 (1.15–3.14)	0.012
Age ≥60 years	1.84 (1.11–3.04)	0.017
Service provider	2.21 (1.33–3.66)	0.002
ASA 3–5	9.14 (5.16–16.18)	<0.001
Wound contamination	28.96 (8.99–93.23)	<0.001
Urgent/emergency surgery	2.87 (1.65–4.99)	<0.001
Open surgery	13.77 (3.33–56.89)	<0.001
Use of drains	4.91 (2.78–8.66)	<0.001
Prolonged operative duration	3.08 (1.81–5.24)	<0.001
Failure to maintain normothermia	10.19 (2.23–46.5)	0.003
Poor glycemic control	3.56 (1.56–8.14)	0.003

Table 7. Final logistic regression model.

Factor	Odds Ratio	95% CI	p-value
Service as provider	2.57	1.37–4.83	0.003
ASA 3–5	6.28	3.30–11.93	<0.001
Clean contaminated to dirty wounds	21.73	6.26–75.48	<0.001
Operative duration >75th percentile	2.33	1.24–4.38	0.008
Failure to maintain normothermia	39.49	3.35–465.06	0.003

and negative predictive value in identifying SSI among high-risk patients (Tables 8 & 9). There was excellent agreement between selective surveillance and traditional surveillance methods for postoperative SSI monitoring (Cohen's kappa statistic = 1.00, 95% CI 0.906–1.094) (Table 10).

Discussion

The accepted gold standard for the diagnosis of surgical site infection (SSI) is in-person postoperative evaluation according to the US Centers for Disease Control and Prevention (2015). However, active surveillance is resource-intensive and may be difficult to sustain in low- and middle-income countries because of geographic, financial, and workforce limitations. These challenges are particularly relevant in healthcare systems with limited infection control manpower and high surgical volume. Branch-Elliman et al. (2014) previously proposed using clinical variables to guide SSI surveillance efforts toward higher-risk patient subsets, while Saunders et al. (2014) utilized multilevel modeling to improve prediction of SSI risk. These studies support the feasibility of targeted surveillance approaches in resource-limited settings.

There were 71 SSIs identified among 587 operations, yielding an overall SSI rate of 12%. The findings demonstrate the complex interaction of patient-related, procedure-related, and perioperative risk factors in the development of SSI. On multivariable analysis, service as provider, ASA classification 3–5, wound classification, operative duration exceeding the 75th percentile, and failure to maintain perioperative normothermia were independently associated with SSI. These findings are consistent with previous studies and current SSI prevention guidelines identifying physiologic status, wound contamination, operative complexity, and perioperative management as major determinants of postoperative infection risk (Anderson et al., 2014; Ban et al., 2017).

Older age was associated with SSI on univariate analysis but was not retained in the final logistic regression model, likely because of its correlation with higher ASA scores and comorbidities. Similar findings were reported by Kaye et al. (2005), who demonstrated higher SSI risk among older patients. Emergency or urgent procedures and open operative approaches were likewise associated with SSI on crude analysis but were not independently associated with SSI after adjustment for other perioperative variables. The higher SSI risk observed among service cases may reflect the greater complexity and prolonged duration of gastrointestinal procedures frequently managed by residents-in-training. Similar findings were reported by Mujagic et al. (2020), who observed that longer and more technically demanding procedures performed by

Table 8. Validity of selective surveillance.

Selective Surveillance	Traditional Surveillance With SSI	Traditional Surveillance Without SSI
With SSI	71	0
Without SSI	0	363

Table 9. Measures of validity.

Measure	Value
Sensitivity	100%
Specificity	100%
Positive predictive value	100%
Negative predictive value	100%

Table 10. Agreement between surveillance methods.

Statistic	Value
Cohen's kappa	1.00
95% CI	0.906–1.094
p-value	<0.001

less experienced surgeons were associated with higher SSI rates.

ASA classification remained a strong predictor of SSI in this study. Patients with ASA scores of 3–5 were six times more likely to develop SSI compared with those classified as ASA 1–2. Most patients with SSI had significant comorbidities, advanced malignancies, or physiologic impairment. These findings are consistent with the study of Hackett et al. (2015), which demonstrated that ASA physical status independently predicts postoperative morbidity and infectious complications across multiple surgical specialties. The ASA classification therefore remains a valuable perioperative risk stratification tool despite recognized subjectivity in scoring.

Wound classification was also strongly associated with SSI. Procedures classified as clean-contaminated, contaminated, or dirty were associated with substantially higher infection risk than clean procedures, particularly among gastrointestinal operations involving entry into contaminated viscera. Similar findings were reported by Curcio et al. (2019), who demonstrated higher SSI rates among contaminated gastrointestinal procedures. Fukuda (2016) likewise reported substantially increased SSI rates following colorectal and other gastrointestinal procedures compared with clean operations. In the present study, gastrointestinal procedures demonstrated the highest SSI rates, particularly among small bowel, colonic, rectosigmoid, and esophagogastric procedures. These findings are likewise consistent with the CDC Principal Operative Procedure risk rankings for postoperative SSI.

The significantly lower SSI rates observed after laparoscopic surgery are consistent with previous studies demonstrating reduced infection risk associated with minimally invasive techniques. Reduced tissue trauma, smaller incisions, and lower wound contamination likely contribute to this benefit. In the present study, laparoscopic cholecystectomy demonstrated very low SSI rates despite many procedures being performed for acutely inflamed gallbladders. The modified wound classification used in the study allowed selected laparoscopic gallbladder procedures without additional risk factors to be classified as low-risk, supporting the feasibility of limiting active surveillance among carefully selected patients.

Operative duration exceeding the CDC/NHSN 75th percentile cut-off was independently associated with SSI. Prolonged operative duration likely reflects greater technical complexity, increased tissue exposure, prolonged bacterial contamination, surgeon fatigue, and greater physiologic stress. The findings are consistent with the systematic review by Cheng et al. (2017), which demonstrated a linear relationship between operative time and SSI risk across multiple surgical procedures. The study also highlights the potential importance of establishing locally derived operative duration cut-off points, as operative efficiency and healthcare resource limitations may differ substantially from international benchmarks.

Perioperative normothermia was strongly associated with SSI development and remained significant in the final logistic regression model. Patients in whom normothermia was not maintained were substantially more likely to develop SSI. Hypothermia impairs tissue oxygenation, coagulation, immune response, and wound healing, thereby increasing susceptibility to infection (de Brito Poveda et al., 2020). These findings support the landmark randomized controlled trial by Kurz et al. (1996), which demonstrated significantly lower SSI rates among actively warmed colorectal surgery patients, as well as the findings of Melling et al. (2001), who showed similar benefits even among shorter clean procedures. Current SHEA/IDSA and WHO guidelines therefore continue to recommend maintenance of perioperative normothermia as an essential SSI preventive strategy.

Although antimicrobial prophylaxis, postoperative antibiotic discontinuation, and perioperative glycemic control were significantly associated with SSI on univariate analysis, these variables were not retained in the final logistic regression model. Nevertheless, these perioperative interventions remain important evidence-based preventive measures. The findings may reflect the influence of stronger competing perioperative variables such as wound contamination class, ASA classification, prolonged operative duration, and gastrointestinal procedure complexity. Previous study by Latham et al. (2001) demonstrated that postoperative hyperglycemia independently increases SSI risk even among patients without known diabetes mellitus. Current WHO and SHEA/IDSA guidelines therefore recommend postoperative glucose monitoring and control among all surgical patients.

The study demonstrated that SSI rates progressively increased as the number of perioperative risk factors increased. Most infections occurred among patients with two to three risk factors, suggesting that accumulation of perioperative risks substantially increases susceptibility to SSI. All SSIs occurred among patients classified as high-risk, while no infections were identified among low-risk patients. Most high-risk patients belonged to gastrointestinal operative categories such as REC, COLO, SB, EGAS, and APPY procedures, which accounted for most postoperative infections.

Selective surveillance focused on high-risk patients demonstrated excellent validity, with 100% sensitivity, specificity, positive predictive value, and negative predictive value compared with traditional surveillance of all postoperative patients. There was also excellent agreement between surveillance methods, with a Cohen's kappa statistic of 1.00. The high accuracy of selective surveillance likely reflects improved patient risk stratification through incorporation of additional perioperative risk variables and refinement of wound and ASA classifications. These findings support previous recommendations by Tomsic et al. (2020), who emphasized the value of targeted surveillance strategies for improving efficiency of infection prevention programs.

The findings also support the use of different surveillance approaches according to patient risk. Patients classified as high-risk may benefit from active face-to-face surveillance because of the greater likelihood of developing SSI and the importance of early diagnosis and management. In contrast, low-risk patients undergoing procedures such as laparoscopic cholecystectomy, thyroidectomy, neck surgery, breast surgery, and hernia repair may be appropriately monitored through passive surveillance methods such as telephone follow-up or patient self-reporting. Since gallbladder surgery represented the most commonly performed operation in the study, limiting active surveillance to higher-risk CHOL procedures may result in substantial reductions in surveillance workload and cost.

In conclusion, selective surveillance focused on high-risk patients demonstrated excellent agreement with traditional surveillance for postoperative SSI monitoring. The identified perioperative risk factors may help guide targeted surveillance and preventive interventions. Selective SSI surveillance may improve allocation of infection control resources while maintaining surveillance accuracy and enabling earlier detection of postoperative infections.

Limitations

The study has several limitations. First, the study was conducted in a single tertiary referral center, which may limit generalizability to other healthcare institutions. Second, some operative categories had relatively small sample sizes. Third, additional risk factors such as smoking and obesity were not independently analyzed. Fourth, the intensity and methods of post-discharge surveillance may vary across institutions and healthcare systems. Despite these limitations, the study provides important local data supporting the feasibility and accuracy of selective SSI surveillance among high-risk surgical patients.

Summary and Conclusions

The study aimed to develop a simple perioperative risk assessment tool to identify surgical patients at high risk of developing surgical site infection (SSI). Eight perioperative variables were used for risk stratification: operative duration exceeding the 75th percentile, wound contamination classification, ASA risk classification, appropriateness of antimicrobial prophylaxis, discontinuation of postoperative antibiotics, appropriateness of hair removal, maintenance of perioperative normothermia, and perioperative glycemic control. By incorporating five additional perioperative variables into the traditional NNIS risk index, patient risk stratification for SSI was improved. Patients without risk factors were classified as low-risk, while those with at least one risk factor were classified as high-risk.

Data from 587 patients who underwent general surgical procedures from January 2022 to June 2023 were analyzed. The overall SSI rate was 12%, with most infections classified as superficial incisional SSI, followed by organ/space and deep incisional SSI. The most common operative categories were CHOL, BRST, REC, and APPY procedures. Based on the eight-variable criteria, 74% of procedures were classified as high-risk, while 26% were classified as low-risk. No SSI developed among low-risk patients. Among high-risk patients, 16% developed SSI, with the highest rates observed in small bowel, colorectal, rectosigmoid, and esophagogastric procedures. SSI rates progressively increased as the number of risk factors increased.

Binary logistic regression analysis identified ASA score 3–5, contaminated wound classification, operative duration exceeding the 75th percentile, service as provider, and failure to maintain perioperative normothermia as factors independently associated with SSI. These findings demonstrate the relative importance of multiple perioperative variables in SSI development and suggest that weighted multivariable risk prediction may improve risk stratification compared with the traditional NNIS risk index alone. Selective surveillance demonstrated 100% sensitivity, specificity, positive predictive value, and negative predictive value, with excellent agreement compared with traditional surveillance methods. These findings suggest that postoperative SSIs are concentrated among patients identifiable perioperatively as high-risk. The identified perioperative risk factors may therefore guide clinicians in risk assessment, surveillance prioritization, and implementation of preventive interventions.

The study supports the use of selective surveillance focused on high-risk patients as a practical and accurate alternative to traditional active surveillance of all postoperative patients. Given the manpower and resource limitations associated with active SSI surveillance, perioperative risk assessment may improve allocation of surveillance efforts and enhance early identification of postoperative infections while maintaining surveillance accuracy.

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