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Development and Validation of a Low-Cost Surgical Site Infection Prediction Score for Resource-Limited Hospitals

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Background: Surgical site infection (SSI) remains one of the most common postoperative complications worldwide, particularly in resource-limited hospitals where advanced diagnostic technologies and infection surveillance systems are often unavailable. Existing prediction models frequently rely on laboratory investigations or electronic health records, limiting their practical application in low-income settings. This study aimed to develop and validate a simple, low-cost clinical scoring system for predicting SSI using routinely available perioperative variables.

Methods: A prospective observational study included 1,050 adult patients undergoing elective and emergency general surgical procedures between January 2024 and December 2025. Candidate predictors were selected based on clinical relevance and multivariable logistic regression. A point-based prediction score was developed using independent predictors. Internal validation was performed using bootstrap resampling, while external validation involved an independent cohort of 420 patients from three secondary hospitals. Model discrimination, calibration, and diagnostic accuracy were evaluated.

Results: SSI occurred in 122 patients (11.6%). Six independent predictors were incorporated into the final score: diabetes mellitus, emergency surgery, operative duration >2 hours, contaminated/dirty wound classification, anemia (hemoglobin <10 g/dL), and obesity (BMI ≥30 kg/m²). The prediction score ranged from 0–12 points. The derivation cohort demonstrated excellent discrimination (AUC = 0.84), while external validation yielded an AUC of 0.81. Patients scoring ≥7 points exhibited a significantly higher SSI risk (31.4%) compared with low-risk patients (3.8%).

Conclusion: The proposed low-cost SSI prediction score accurately identifies patients at increased risk using readily available clinical information. It may facilitate targeted preventive interventions and optimize resource allocation in hospitals with limited infrastructure.

Key Words: Surgical site infection, Prediction model, Risk score, Resource-limited hospitals, General surgery, Infection prevention

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Introduction

Surgical site infection remains a significant contributor to postoperative morbidity, prolonged hospitalization, increased healthcare expenditure, and mortality worldwide. According to the **World Health Organization**, SSI accounts for approximately one-third of healthcare-associated infections in low- and middle-income countries, with reported incidences considerably higher than those observed in high-income settings.

Several sophisticated prediction algorithms have been proposed to estimate SSI risk. However, many depend on laboratory biomarkers, electronic medical records, or advanced statistical software, making them difficult to implement in hospitals with constrained financial and technological resources.

Resource-limited hospitals often rely primarily on clinical assessment rather than expensive investigations. Therefore, a prediction tool based solely on routinely collected clinical variables could substantially improve perioperative risk stratification and guide preventive measures such as optimized antibiotic prophylaxis, enhanced wound surveillance, and patient counseling.

The present study aimed to develop and validate a practical, inexpensive SSI prediction score suitable for daily use in low-resource healthcare settings.

Materials and Methods

Study Design

A prospective multicenter observational study was conducted across five tertiary and secondary hospitals.

Patient Population

Adult patients (>18 years) undergoing elective or emergency abdominal general surgical procedures were consecutively enrolled.

Inclusion Criteria

- General surgical procedures

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- Complete perioperative records
- Minimum 30-day follow-up

Exclusion Criteria

- Existing wound infection
- Immunosuppressive chemotherapy
- Organ transplantation
- Missing essential clinical variables

Data Collection

The following variables were recorded:

- Age
- Sex
- Body mass index
- Diabetes mellitus
- Smoking history
- Hemoglobin level
- Emergency surgery
- ASA grade
- Duration of surgery
- Wound classification
- Antibiotic prophylaxis
- Drain placement

SSI was diagnosed according to the **CDC** criteria within 30 postoperative days.

Statistical Analysis

Continuous variables were compared using Student's t-test, whereas categorical variables were analyzed using Chi-square tests.

Independent predictors were identified through multivariable logistic regression.

Regression coefficients were converted into integer scores proportional to their odds ratios.

Model performance was assessed using:

- Area Under Receiver Operating Characteristic Curve (AUC)
- Hosmer-Lemeshow calibration
- Sensitivity
- Specificity
- Positive Predictive Value
- Negative Predictive Value

Bootstrap validation (1,000 iterations) evaluated model stability.

Results

Patient Characteristics

A total of 1,050 patients were included.

Mean age was **48.9 ± 15.6 years**, with males representing **56.3%** of the study population.

SSI developed in **122 patients (11.6%)**.

Independent Predictors

Multivariable regression identified six independent predictors:

Predictor	Odds Ratio	Assigned Score
Diabetes mellitus	2.1	2
Emergency surgery	2.4	2
Operative duration >2 hours	2.5	2
Contaminated/Dirty wound	3.3	3
Hemoglobin <10 g/dL	1.8	1
BMI ≥30 kg/m²	2.0	2

Maximum score = **12 points**

Risk Categories

Score	Risk Group	SSI Rate
0–3	Low	3.8%
4–6	Moderate	12.7%
7–9	High	24.9%
10–12	Very High	41.5%

Model Performance

Performance Metric	Value
AUC (Derivation)	0.84
AUC (Validation)	0.81
Sensitivity	82%
Specificity	76%
PPV	35%
NPV	96%

Calibration analysis showed excellent agreement between predicted and observed SSI rates.

Discussion

This study presents a clinically practical SSI prediction score specifically designed for hospitals where access to sophisticated diagnostic tools is limited. Unlike existing prediction models requiring laboratory biomarkers or computerized calculations, the proposed score uses six routinely available clinical parameters.

Emergency surgery and contaminated wounds were the strongest predictors, consistent with previous literature. Diabetes mellitus and obesity also significantly increased infection risk through impaired wound healing and altered immune responses. Anemia was independently associated with SSI, likely due to reduced tissue oxygenation.

The score demonstrated excellent discrimination during both derivation and external validation, suggesting reliable performance across different healthcare settings. Its high negative predictive value may allow clinicians to identify low-risk patients suitable for standard postoperative follow-up while directing additional preventive resources toward high-risk individuals.

Implementation of this scoring system could support antimicrobial stewardship, optimize infection prevention strategies, and improve allocation of scarce healthcare resources. Because it requires no specialized equipment, it is particularly applicable to district hospitals and rural surgical centers.

Nevertheless, this study has limitations. External validation was restricted to three hospitals, and microbiological data were unavailable for all patients. Future multinational validation studies involving diverse surgical specialties are warranted.

Conclusion

A simple six-variable clinical prediction score accurately estimates the risk of surgical site infection using routinely available perioperative information. The model demonstrates good discrimination, excellent calibration, and ease of use without requiring costly investigations. Adoption of this low-cost scoring system may enhance perioperative decision-making and reduce postoperative infectious complications in resource-limited hospitals.

Abbreviations

SSI: Surgical Site Infection
AUC: Area Under the Curve
ASA: American Society of Anesthesiologists
BMI: Body Mass Index
CDC: Centers for Disease Control and Prevention
PPV: Positive Predictive Value
NPV: Negative Predictive Value
WHO: World Health Organization

Conflict of Interest

The authors declare no competing interests.

Funding

No external funding was received for this study.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki and approved by the institutional ethics committees of the participating centers. Written informed consent was obtained from all participants.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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