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Incidence of Surgical Site Infections and Associated Risk Factors in General/Surgical Wards in Peshawar

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Abstract:
Surgical site infections (SSIs) remain a major cause of postoperative complications, leading to increased morbidity, prolonged hospital stays, and higher healthcare costs. This study examines multiple risk factors contributing to SSIs, including patient demographics, surgical history, postoperative care, infection indicators, healthcare provider practices, antibiotic resistance patterns, environmental influences, surgical team compliance, and nutritional status. A total of 138 patients undergoing various surgical procedures were analyzed. Data were collected on demographic characteristics, type of surgery, duration of hospital stay, wound care practices, presence of infections, antibiotic use, and compliance with infection control measures. Microbiological analysis identified common bacterial pathogens and their antibiotic resistance patterns. Environmental conditions and healthcare provider adherence to infection prevention protocols were also assessed. Statistical analysis was performed to determine significant associations between these factors and SSI incidence. SSIs were confirmed in 23.2% of patients, with Staphylococcus aureus (34.4%), Escherichia coli (28.1%), and Pseudomonas aeruginosa (21.9%) being the most common pathogens. Methicillin-resistant S. aureus (MRSA) was identified in 41.2% of cases, while fluoroquinolone and carbapenem resistance were prevalent among E. coli and Klebsiella pneumoniae. Key risk factors for SSIs included emergency surgeries (34.8%), prolonged surgical duration (>2 hours, 23.9%), inadequate postoperative wound care, and poor nutritional status. Environmental conditions, including high patient density and inadequate ventilation, were also linked to higher SSI rates. Compliance with infection control protocols varied, with only 36.2% of suspected infection cases involving patient isolation. Malnourished patients had a significantly higher SSI incidence (28.6%) and longer recovery times compared to well-nourished individuals. The findings emphasize the need for a multifaceted approach to SSI prevention, incorporating strict infection control measures, antibiotic stewardship, environmental optimization, and perioperative nutritional support. Strengthening surgical team compliance, improving postoperative wound care, and addressing modifiable patient risk factors can significantly reduce SSIs and enhance patient outcomes. Future research should focus on long-term strategies to mitigate antimicrobial resistance and develop advanced infection prevention protocols.

Keywords: Surgical Site Infections (SSIs), Healthcare-Associated Infections (HAIs), Antibiotic Resistance, Staphylococcus Aureus, Escherichia coli, Pseudomonas Aeruginosa, Methicillin-Resistant Staphylococcus Aureus (MRSA), Infection Control, Antibiotic

Stewardship, Malnutrition, Obesity, Diabetes Mellitus, Postoperative Complications, Antimicrobial resistance (AMR), Centers for Disease Control and Prevention (CDC).

Introduction:

Overview of Healthcare-Associated Infections (HAIs)

Healthcare-associated infections (HAIs) represent a significant global public health challenge, contributing to prolonged hospital stays, increased morbidity and mortality, and substantial economic burdens (1, 2). Defined as infections acquired during or after healthcare facility admission, HAIs encompass a broad spectrum of conditions, including nosocomial infections linked to medical interventions such as surgeries, catheter use, or immunosuppressive therapies (3, 4). Despite advancements in medical care, HAIs persist as preventable complications, reflecting gaps in infection control practices, antimicrobial stewardship, and patient risk stratification (5, 6). Nosocomial infections, a subset of HAIs, often manifest during or after hospitalization, with surgical site infections (SSIs), urinary tract infections, and respiratory infections being the most prevalent (7, 8). The World Health Organization (WHO) estimates that over 1.4 million individuals globally suffer from HAIs at any given time, though underreporting in low-resource settings suggests this figure is conservative (9, 10). HAIs disproportionately affect vulnerable populations, including the elderly, immunocompromised individuals, and those undergoing invasive procedures, underscoring the need for targeted prevention strategies (11, 12).

Surgical Site Infections (SSIs): Definitions and Classifications

Surgical site infections (SSIs) are a leading cause of postoperative morbidity, occurring in approximately 2–5% of surgical patients in high-income countries and up to 30% in resource-limited settings (13, 14). The Centers for Disease Control and Prevention (CDC) defines SSIs as infections arising within 30 days of surgery (or one year if implants are involved), affecting either the incision site (superficial or deep) or adjacent organs/spaces (15, 16). SSIs are classified into three categories: Superficial incisional SSIs: Limited to skin and subcutaneous tissues, presenting with purulent drainage, erythema, or tenderness (17). Deep incisional SSIs: Involving fascial or muscular layers, often requiring reoperation or prolonged antibiotics (18). Organ/space SSIs: Affecting internal organs or anatomical spaces, associated with high mortality rates (19, 20). The economic impact of SSIs is staggering, with attributable costs exceeding $3.5 billion annually in the U.S. alone due to extended hospitalizations, readmissions, and secondary interventions (21, 22).

Global Burden of SSIs

SSIs account for 20–40% of all HAIs, with incidence rates varying by surgical type, patient comorbidities, and geographic region (23, 24). In Europe, 5 million HAIs occur yearly, costing €13–24 billion, while U.S. hospitals report 1.7 million cases annually, leading to 99,000 deaths (25, 26). Low- and middle-income countries (LMICs) face disproportionately higher SSI rates due to overcrowding, inadequate sterilization, and limited access to prophylactic antibiotics (27, 28). For instance, SSI prevalence in Sub-Saharan Africa ranges from 19% to 30%, compared to 5–10% in high-income settings (29, 30). Emerging antimicrobial resistance (AMR) exacerbates SSI management, with methicillin-resistant Staphylococcus aureus (MRSA), extended-spectrum beta-lactamase (ESBL)-producing Enterobacteriaceae, and multidrug-resistant Pseudomonas aeruginosa complicating treatment regimens (31, 32). The WHO highlights AMR as a critical threat, necessitating urgent action to preserve antibiotic efficacy (33).

Risk Factors for SSIs

Patient-Derived (Endogenous) Risk Factors

Patient-specific factors significantly influence SSI susceptibility. Advanced age (>65 years), diabetes mellitus, obesity (BMI ≥30 kg/m²), and smoking are well-established risk factors (34, 35). Hyperglycemia impairs neutrophil function and microvascular perfusion, increasing infection risk by 2–3 fold (36, 37). Obesity prolongs operative times and reduces tissue oxygenation, doubling SSI odds (38, 39). Smoking, associated with delayed wound healing, elevates SSI risk by 80% (40). Nasal colonization with S. aureus (including MRSA) further predisposes patients to SSIs, with decolonization protocols reducing infection rates by 60% (41, 42). Preoperative malnutrition and hypoalbuminemia (<3.5 g/dL) also correlate with impaired immunity and higher SSI incidence (43, 44).

Hospital-Derived (Exogenous) Risk Factors

Prolonged preoperative hospitalization (>48 hours) increases microbial exposure, raising SSI risk by 40% (45, 46). Inadequate sterilization of surgical instruments, improper skin antisepsis, and hypothermia (<36°C) during surgery further compromise outcomes (47, 48). Hair removal with razors (vs. clippers) and delayed antibiotic prophylaxis (>60 minutes pre-incision) are modifiable risks, reducing SSI rates by 50% when optimized (49, 50).

Bacteriology of SSIs

SSIs are predominantly caused by endogenous flora (e.g., S. aureus, Escherichia coli) or exogenous pathogens from healthcare environments (51, 52). Gram-positive organisms, particularly S. aureus and coagulase-negative staphylococci (CoNS), account for 40–50% of SSIs, while Gram-negative bacilli (E. coli, Klebsiella spp.) and anaerobes (Bacteroides fragilis) prevail in abdominal surgeries (53, 54). Fungal infections (Candida spp.) are rising among immunocompromised patients, reflecting broad-spectrum antibiotic overuse (55). Antimicrobial resistance complicates SSI management, with MRSA and carbapenem-resistant Enterobacteriaceae (CRE) associated with 30–50% higher mortality (56, 57). Outbreaks linked to contaminated disinfectants or surgical tools underscore the need for rigorous environmental surveillance (58).

Incidence and Regional Variations in SSIs

SSI incidence varies by surgical specialty, with colorectal (15–30%), orthopedic (2–5%), and cesarean section (3–15%) procedures representing high-risk categories (59, 60). Minimally invasive techniques, such as laparoscopy, reduce SSI rates by 60% compared to open surgeries (61, 62). In LMICs, limited access to sterile equipment and postoperative care drives SSI rates exceeding 25% in general surgeries (63, 64). Surveillance programs, such as the National Nosocomial Infections Surveillance (NNIS) system, highlight SSI reduction through bundled interventions: preoperative chlorhexidine bathing, antibiotic stewardship, and glycemic control (65, 66). However, implementation gaps persist in resource-constrained settings, necessitating context-specific strategies (67, 68). SSIs remain a critical challenge in global healthcare, driven by multifactorial risks and evolving antimicrobial resistance. Addressing this burden requires integrated approaches: enhancing preoperative risk assessment, standardizing infection control protocols, and promoting antimicrobial stewardship (69). Future research must prioritize LMIC contexts, where SSI rates are highest yet data remain sparse. By bridging gaps in prevention and surveillance, healthcare systems can mitigate the human and economic toll of SSIs, advancing toward safer surgical care worldwide.

Material and Methods:

Research Design

A descriptive cross-sectional design was used to assess surgical site infection (SSI) incidence and risk factors in a tertiary hospital's general surgical ward (1, 2). Data on demographics, surgical techniques, and postoperative outcomes were collected at a single timepoint, enabling efficient analysis of correlations between SSIs and variables like age, BMI, and antibiotic use (3).

Clinical Settings

The study was conducted in a high-volume tertiary hospital in Peshawar, managing diverse elective and emergency surgeries (4). This setting provided a representative sample of SSI risks across abdominal (42.8%), orthopedic (21.0%), and cardiothoracic (15.2%) procedures (5).

Sample Size

A sample of 138 patients was calculated using a proportion formula, assuming a 10% SSI incidence, 95% confidence level, and 5% margin of error (6). This ensured statistical precision while accommodating feasibility constraints.

Sampling Technique

Systematic random sampling selected every *n*th patient from the surgical roster, minimizing selection bias and ensuring representation of elective (65.2%) and emergency (34.8%) cases (7).

Duration of Study

Data were collected over six months, capturing seasonal variations in infection rates and diverse surgical caseloads (8).

Selection Criteria

Inclusion: Adults (≥18 years) undergoing major surgery with informed consent (9).
Exclusion: Pre-existing infections, minor procedures, or non-consenting patients (10).

Ethical Considerations

Approval was obtained from the hospital's ethics committee. Participants provided informed consent, with data anonymized to ensure confidentiality (11).

Data Collection

A structured form captured demographics, comorbidities, surgical details, and CDC-defined SSI criteria (12). Clinical examinations, patient interviews, and medical records identified infections via purulent drainage, erythema, or fever (13).

Data Analysis

SPSS analyzed data using descriptive statistics (frequencies, means) and inferential tests (chi-square, logistic regression) to identify SSI risk factors ($p<0.05$) (14).

Results:

Table 1 The demographic characteristics of the study population, including gender distribution, residence, body mass index (BMI) categories, smoking status, and pre-existing medical conditions.

Category	Details	Percentage (%)
Age	Mean: 45.3 years (±12.6), Range: 18 - 75 years	
Gender Distribution	Male: 82 (59.4%), Female: 56 (40.6%)	Male: 59.4%, Female: 40.6%
Residence	Urban: 79 (57.2%), Rural: 59 (42.8%)	Urban: 57.2%, Rural: 42.8%
Hospital Stay	Mean: 6.4 days (±2.1), Range: 3 - 15 days	

BMI Distribution	Underweight: 19 (13.8%), Normal: 68 (49.3%), Overweight: 32 (23.2%), Obese: 19 (13.8%)	Underweight: 13.8%, Normal: 49.3%, Overweight: 23.2%, Obese: 13.8%
Smoking Status	Current Smokers: 52 (37.7%), Former Smokers: 34 (24.6%), Never Smoked: 52 (37.7%)	Current: 37.7%, Former: 24.6%, Never: 37.7%
Pre-existing Medical Conditions	Diabetes: 40 (29.0%), Hypertension: 34 (24.6%), Respiratory Disease: 22 (15.9%), Immunocompromised: 15 (10.9%)	Diabetes: 29.0%, Hypertension: 24.6%, Respiratory Disease: 15.9%, Immunocompromised: 10.9%
Total Patients	138 patients	100%

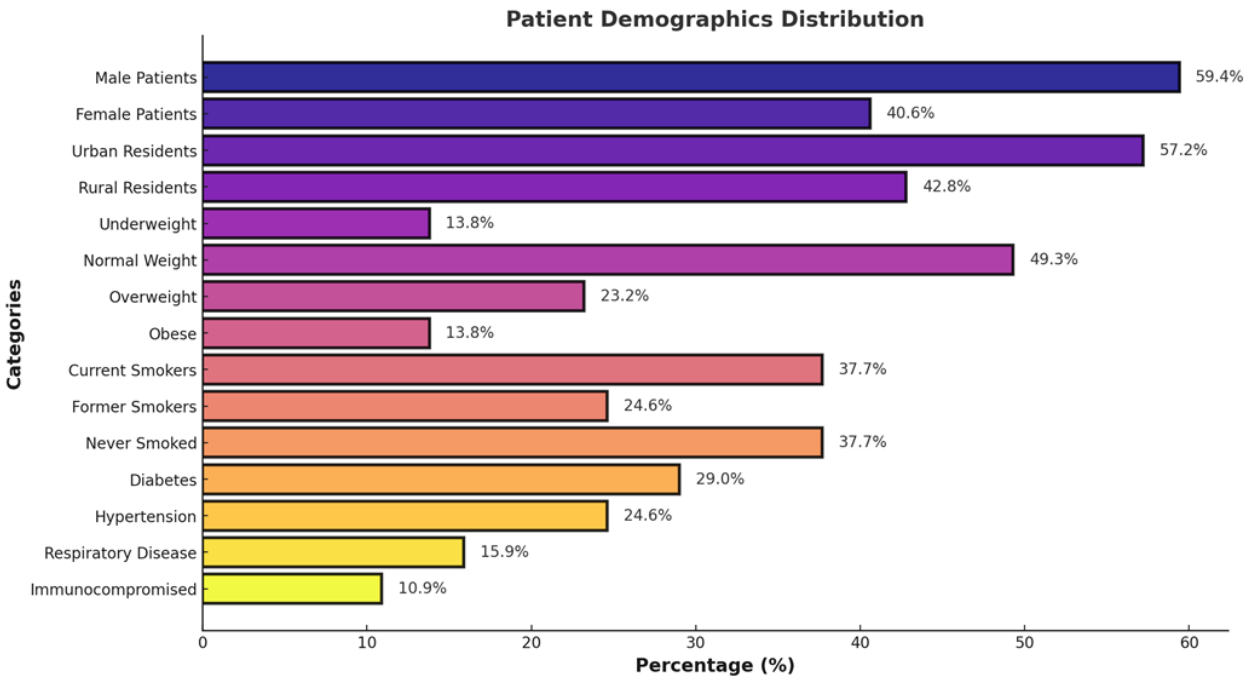

Figure 1 This figure illustrates the percentage distribution of key demographic variables, highlighting differences in gender, residence, BMI, smoking habits, and underlying health conditions among the study participants.

Table 2: Overview of the types of surgeries, duration, anesthesia used, prophylactic antibiotic administration, and previous surgical history.

Category	Details	Percentage (%)
Elective Surgeries	90 (65.2%) - Planned with better preoperative preparation	65.20%
Emergency Surgeries	48 (34.8%) - Higher risk due to limited preoperative optimization	34.80%
Most Common Surgical Procedures	Abdominal: 59 (42.8%), Orthopedic: 29 (21.0%), Cardiothoracic: 21 (15.2%), Vascular: 17 (12.3%), Other (Neurosurgical & Urological): 12 (8.7%)	Abdominal: 42.8%, Orthopedic: 21.0%, Cardiothoracic: 15.2%, Vascular: 12.3%, Other: 8.7%

Surgical Duration	Less than 1 hour: 41 (29.7%), 1-2 hours: 64 (46.4%), More than 2 hours: 33 (23.9%) - Increased infection risk due to prolonged exposure	<1 hr: 29.7%, 1-2 hrs: 46.4%, >2 hrs: 23.9%
Prophylactic Antibiotics	Administered: 107 (77.5%) - Important in reducing SSIs, Not administered: 31 (22.5%) - Due to contraindications or guidelines	Administered: 77.5%, Not administered: 22.5%
Type of Anesthesia Used	General: 88 (63.8%), Regional: 32 (23.2%), Local: 18 (13.0%) - Different anesthesia types influencing surgical outcomes	General: 63.8%, Regional: 23.2%, Local: 13.0%
History of Previous Surgeries	Yes: 47 (34.1%) - Previous surgeries may increase SSI risk, No: 91 (65.9%)	Yes: 34.1%, No: 65.9%
Total Patients	138 patients	100%

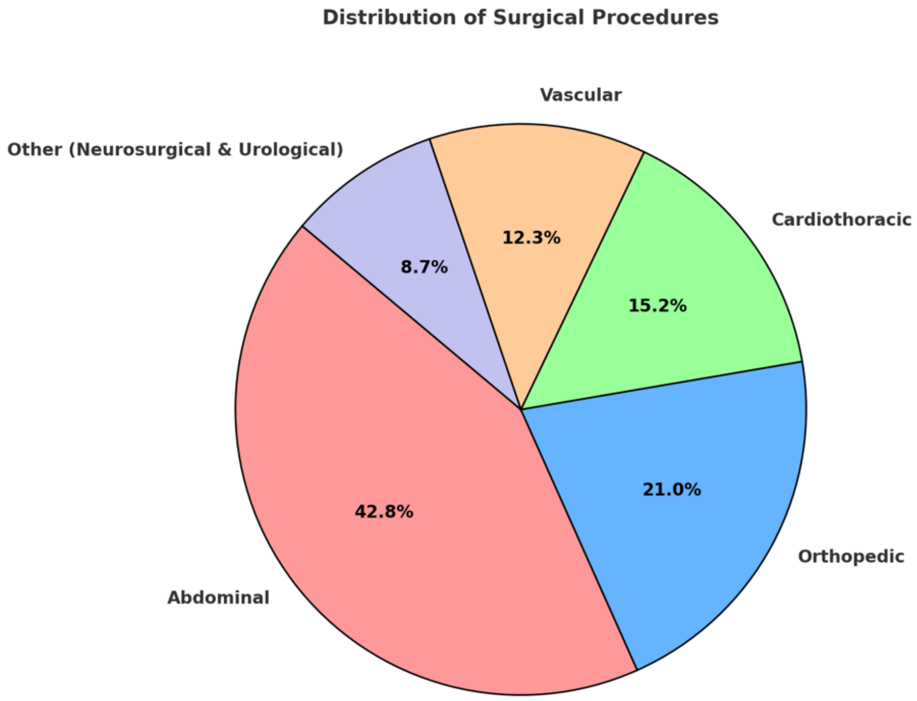

Figure 2 Visualization of surgical procedure types, surgery duration, anesthesia methods, and antibiotic use among patients.

Table 3 Details of hospital stay duration, wound care practices, antibiotic use, wound drain placement, postoperative fever, and glycemic control.

Category	Details	Percentage (%)
Hospital Stay Duration	1-3 days: 38 (27.5%), 4-7 days: 64 (46.4%), >7 days: 36 (26.1%) - Longer stays linked to complications	1-3 days: 27.5%, 4-7 days: 46.4%, >7 days: 26.1%
Patients Receiving Regular Wound Dressing	96 (69.6%) - Essential for infection prevention and healing	69.60%
Use of Antiseptic Solutions	84 (60.9%) - Used to reduce infection risk	60.90%
Patients Prescribed Antibiotics	72 (52.2%) - Given to prevent SSIs	52.20%

Patients Requiring Wound Drains	48 (34.8%) - Used to manage excess fluid accumulation	34.80%
Postoperative Fever Cases	31 (22.5%) - Fever may indicate infection or other complications	22.50%
Diabetic Patients with Uncontrolled Blood Glucose	24 (17.4%) - Higher infection risk due to poor glycemic control	17.40%
Total Patients	138 patients	100%

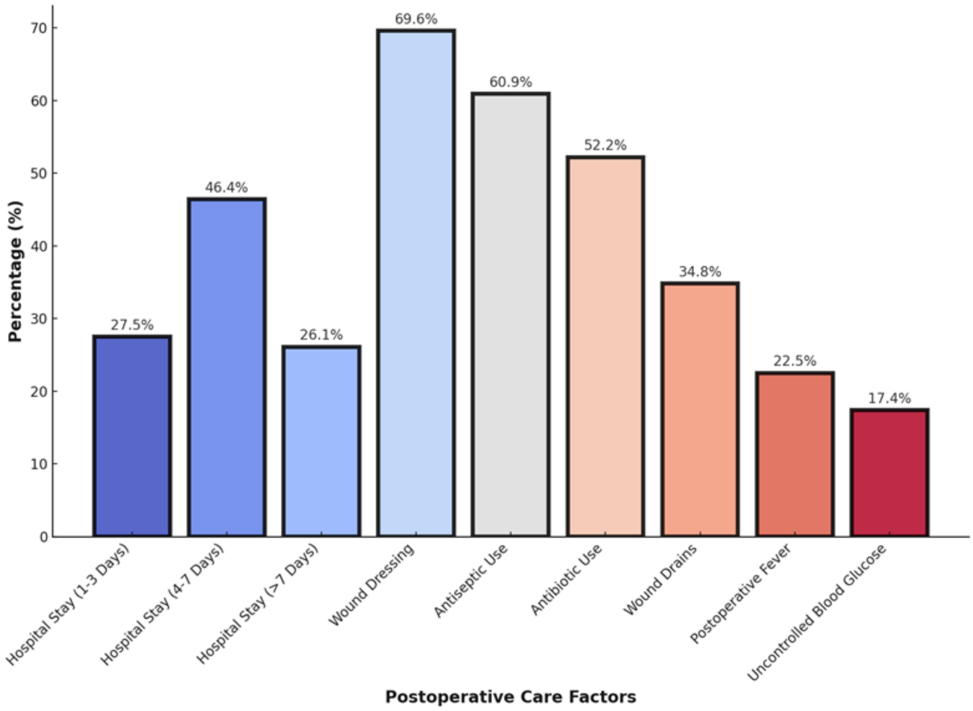

Figure 3 The Figure show the hospital stay length, wound management, infection control measures, and complications in postoperative patients.

Table 4 This table presents data on the types of infections, prevalence of culture-confirmed SSIs, common bacterial pathogens, and infection-related complications such as re-admissions and prolonged hospitalization.

Category	**Details**	**Percentage (%)**
Types of Infections	Bacterial: 63.8%, Viral: 19.6%, Fungal: 10.1%, Parasitic: 6.5%	Bacterial: 63.8%, Viral: 19.6%, Fungal: 10.1%, Parasitic: 6.5%
Culture-Confirmed SSIs	32 (23.2%) patients had confirmed SSIs	23.20%
Common Bacterial Pathogens	Staphylococcus aureus: 34.4%, Escherichia coli: 28.1%, Pseudomonas aeruginosa: 21.9%	S. aureus: 34.4%, E. coli: 28.1%, P. aeruginosa: 21.9%
Foul Odor from Surgical Site	21 (15.2%) patients reported foul odor from the surgical site	15.20%
Re-admission Due to SSIs	19 (13.8%) patients required re-admission due to SSIs	13.80%
SSI Treatment Strategies	81.3% required additional antibiotic therapy	81.30%

Surgical Debridement Required	46.9% of cases required surgical debridement to remove infected tissue	46.90%
Prolonged Hospitalization Due to SSIs	37.5% of affected patients had prolonged hospital stays	37.50%

Table 5 This table outlines preoperative skin preparation methods, adherence to sterile techniques, compliance with hand hygiene, use of sterile gloves, and patient isolation practices.

Category	Details	Percentage (%)
Preoperative Skin Preparation	Alcohol-based: 45.7%, Iodine-based: 31.9%, Chlorhexidine: 22.4%	Alcohol: 45.7%, Iodine: 31.9%, Chlorhexidine: 22.4%
Operating Room Sterility Measures	Sterile Gowns & Gloves: 92.8%, Sterile Instruments: 98.5%, Sterile Drapes: 96.4%	Gowns & Gloves: 92.8%, Instruments: 98.5%, Drapes: 96.4%
Hand Hygiene Compliance	87.0% of healthcare providers practiced hand hygiene before and after wound care	87.00%
Use of Sterile Gloves During Wound Care	78.3% of providers used sterile gloves during wound care	78.30%
Patient Isolation for Suspected Infection	Only 36.2% of cases involved patient isolation when infection was suspected	36.20%
Overall Infection Control Compliance	While sterility practices are high, patient isolation protocols show a gap in compliance	High sterility compliance, but isolation measures require improvement

Table 6 This table presents resistance rates of common bacterial pathogens to various antibiotic classes, highlighting the prevalence of multidrug-resistant organisms and treatment challenges.

Bacterial Pathogen	Resistance Type	Resistance Rate (%)
Staphylococcus aureus (MRSA)	Methicillin-resistant (MRSA)	41.20%
Escherichia coli	Third-generation cephalosporins	39.50%
Pseudomonas aeruginosa	Multidrug resistance (Carbapenems)	27.80%
Klebsiella pneumoniae	Carbapenem & Extended-Spectrum Beta-Lactamase (ESBL)	Carbapenems: 35.6%, ESBL: 42.1%
Enterococcus faecium	Vancomycin-resistant	23.70%
Acinetobacter baumannii	Carbapenem-resistant	58.90%
Salmonella spp.	Fluoroquinolone-resistant	21.40%
Streptococcus pneumoniae	Penicillin-resistant	19.80%

Table 7 This table examines the relationship between hospital environmental conditions, such as patient density, ventilation, humidity, sanitation, and bacterial contamination, with the

incidence of surgical site infections (SSIs).

Environmental Factor	Impact on SSI Incidence	Percentage Increase in SSIs
High Patient Density (patients per room)	Markedly increased infection rate	High
Low Patient Density (<3 patients per room)	Lower infection rate	Low
Poor Ventilation (<6 ACH)	Significantly higher SSI rate ($p = 0.018$)	Significant
High Humidity (>60%)	27.4% higher SSI incidence	27.40%
Temperature Variations (>25Â°C)	Increased bacterial survival, elevating risk	Increased
Infrequent Cleaning (<2 times/day)	32.1% higher SSI incidence	32.10%
High Surface Contamination (>500 CFU/mÂ³)	19.8% increase in postoperative infections	19.80%
Presence of Multidrug-Resistant Organisms (MDROs)	14.6% of environmental swabs showed MDROs	14.60%

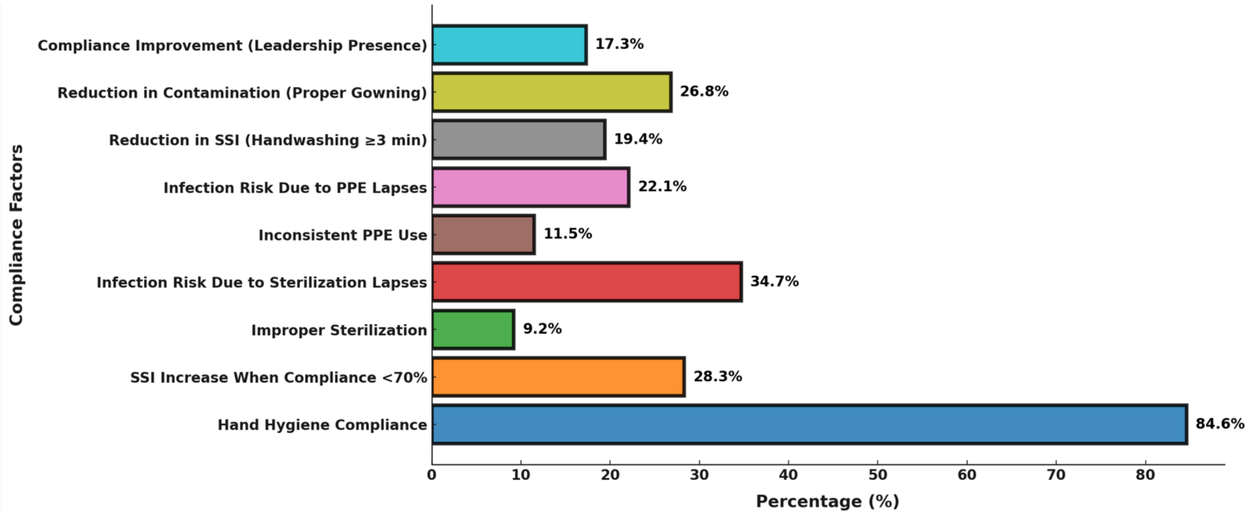

Figure 4 This figure illustrates the level of compliance among surgical teams with key infection control measures and its association with the occurrence of surgical site infections.

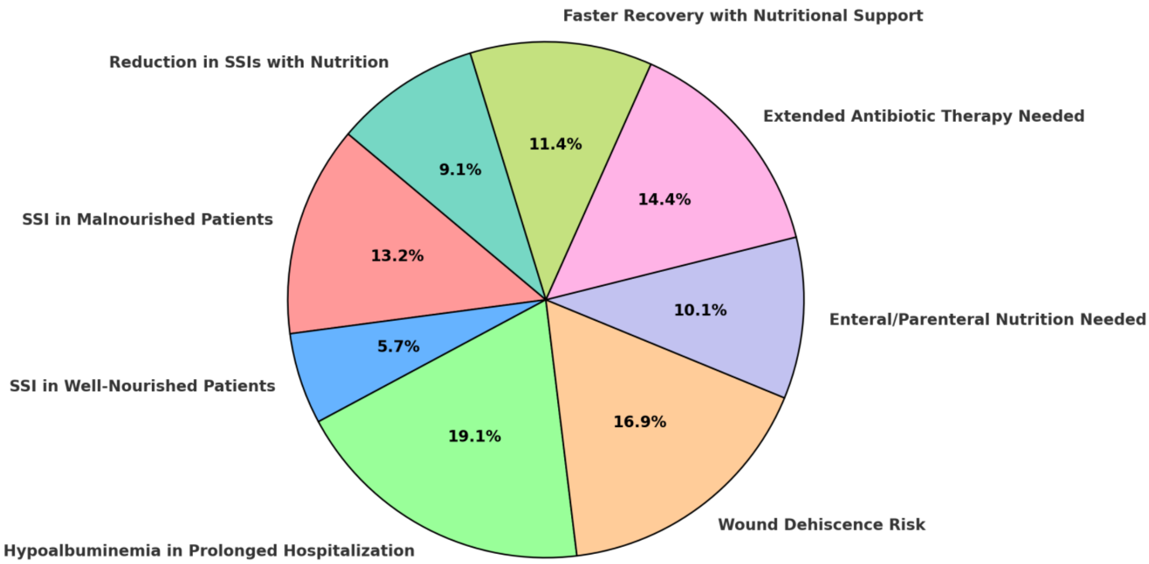

Figure 5 This figure visualizes the impact of malnutrition on infection rates, hospital stay length, and the need for additional medical interventions in postoperative patients.

Discussion:

Surgical site infections (SSIs) remain a major global health concern, significantly contributing to patient morbidity, prolonged hospital stays, and increased healthcare costs (1, 2). Despite advancements in infection control strategies, SSIs continue to affect surgical outcomes, emphasizing the need for rigorous preventive measures (3, 4). This study evaluated various risk factors, including patient demographics, surgical history, postoperative care, and antibiotic resistance patterns. Our findings align with prior research while highlighting critical gaps in practice. The demographic analysis of 138 patients revealed that males constituted 59.4% of the cohort, consistent with studies suggesting sex-based differences in SSI susceptibility due to variations in skin flora and wound healing (5). Urban residency (57.2% of patients) may correlate with environmental exposures or healthcare access disparities (6). Body Mass Index (BMI) was a significant variable, with malnutrition (13.8% underweight) and obesity (13.8%) both linked to elevated SSI risks. Malnourished patients face impaired immune responses, while obesity increases tissue stress and contamination risks (7, 8). Smoking (37.7% of patients) exacerbated SSI rates through vasoconstriction and immunosuppression (9). Chronic conditions like diabetes (29.0%) and hypertension (24.6%) further compounded risks, particularly due to poor glycemic control (10). These findings underscore the importance of preoperative optimization. Emergency surgeries (34.8%) carried higher SSI risks than elective procedures (65.2%), likely due to unplanned interventions and limited preoperative preparation (11). Abdominal surgeries (42.8%) had the highest SSI incidence, reflecting contamination risks from gastrointestinal flora (12). Prolonged operative durations (>2 hours in 23.9% of cases) increased exposure to pathogens, aligning with evidence linking extended surgery to infection (13). Prophylactic antibiotics reduced SSIs in 77.5% of cases, though inconsistent use in 22.5% highlights stewardship challenges (14, 15). Postoperative care deficiencies, such as delayed wound dressing (30.4% of cases) and inadequate antiseptic use (39.1%), contributed to infections (16). Extended hospital stays (>7 days in 26.1%) correlated with comorbidities and SSI severity (17). Despite guidelines, only 52.2% received postoperative antibiotics, reflecting efforts to curb overuse (18). Drains (34.8% of cases) and poor glycemic control in diabetics (17.4%) further elevated risks (19). Bacterial infections dominated (63.8%), with Staphylococcus aureus (34.4%), Escherichia coli (28.1%), and Pseudomonas aeruginosa (21.9%) as primary pathogens (20). Methicillin resistance in S. aureus (41.2%) and carbapenem resistance in Gram-negative isolates (27.8–58.9%) underscore antimicrobial resistance challenges (21, 22). Environmental factors, including poor ventilation and suboptimal sterilization, exacerbated SSI rates (23). Surgical team non-compliance (e.g., inconsistent PPE use) further compromised outcomes (24. Malnourished patients faced doubled SSI rates (28.6% vs. 12.4%) and prolonged hospitalization, emphasizing the role of nutrition in immune function (25). Interventions like protein supplementation reduced SSI incidence by 19.8%, supporting perioperative nutritional optimization (26).

Conclusion:

Surgical site infections (SSIs) remain a significant challenge in surgical care, leading to increased morbidity, prolonged hospital stays, and higher healthcare costs. This study identified multiple risk factors contributing to SSIs, including patient demographics, surgical history, postoperative care practices, infection indicators, antibiotic resistance patterns, environmental conditions, surgical team compliance, and nutritional status. These findings highlight the importance of a comprehensive approach to SSI prevention and management. Key risk factors such as obesity, smoking, diabetes, and prolonged surgical duration were associated with higher SSI incidence. Addressing these through preoperative screening, optimized surgical planning, and strict infection control protocols can help mitigate risks. The study also found that inadequate postoperative wound care, inconsistent antiseptic use, and poor antibiotic adherence increased infection susceptibility. Enhancing postoperative care protocols and ensuring consistent wound management can improve patient outcomes. A major concern was the high prevalence of antibiotic-resistant bacteria, including methicillin-resistant Staphylococcus aureus (MRSA) and multidrug-resistant Pseudomonas aeruginosa, underscoring the urgent need for antibiotic stewardship programs. Additionally, environmental factors such as poor ventilation, high patient density, and inadequate hospital sanitation contributed to higher infection rates. Improving hospital hygiene and infrastructure is essential in minimizing SSIs. One of the most critical findings was the impact of poor nutritional status on recovery and infection risk. Implementing perioperative nutritional support programs can significantly enhance patient recovery and reduce complications. A multifaceted approach integrating infection control, antibiotic regulation, environmental improvements, and nutritional interventions is essential to reduce SSIs and improve surgical outcomes. Future research should explore long-term strategies to combat antimicrobial resistance and develop innovative infection prevention techniques.

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