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SURGICAL SITE INFECTIONS IN ORTHOPEDIC PROCEDURES: RISK FACTORS AND CLINICAL OUTCOMES IN TERTIARY CARE

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Abstract

Introduction: Surgical site infections (SSI) represent a significant complication in orthopedic surgery, contributing to increased morbidity, mortality, and healthcare costs. This study aimed to determine the incidence, identify risk factors, and evaluate management strategies of SSI following orthopedic procedures in an Indian tertiary care hospital setting.

Methods: A prospective hospital-based surveillance study was conducted at LNCT Medical College and Sewakunj Hospital, Indore, from April to September 2022. Three hundred fifteen patients undergoing various orthopedic procedures were enrolled using consecutive sampling. Data collection included demographic characteristics, comorbidities, surgical details, and postoperative surveillance using CDC criteria. Univariate and multivariate logistic regression analyses identified independent risk factors for SSI development.

Results: The overall SSI rate was 8.9% (28/315 cases, 95% CI: 6.0-12.6%). External fixation procedures showed the highest infection rate (17.9%), followed by spine surgery (12.9%). Emergency procedures had significantly higher SSI rates compared to elective surgeries (12.8% vs 5.0%, p=0.016). Multivariate analysis identified five independent risk factors: inadequate antibiotic prophylaxis (OR 3.82, p=0.005), diabetes mellitus (OR 2.84, p=0.014), ASA score ≥III (OR 2.65, p=0.033), emergency surgery (OR 2.48, p=0.047), and hypoalbuminemia (OR 2.41, p=0.045). Staphylococcus aureus was the predominant pathogen (39.3%) with 36.4% MRSA prevalence. Treatment success rate was 82.1%, though 57.1% required additional surgical interventions. SSI resulted in 285% cost increase and 14.8-day hospital stay extension.

Conclusion: This study identified significant SSI burden in orthopedic procedures with modifiable risk factors, particularly inadequate prophylaxis. Targeted prevention strategies addressing identified risk factors could substantially reduce infection rates and healthcare costs.

Keywords: Surgical site infection, orthopedic surgery, antibiotic prophylaxis, risk factors, healthcare surveillance

Introduction

Surgical site infections (SSI) represent one of the most significant and preventable complications in modern healthcare, particularly in orthopedic surgery where the consequences can be devastating for both patients and healthcare systems. These infections, defined as infections occurring within 30 days of surgery or up to one year following surgery involving implantable devices, constitute a major source of morbidity, mortality, and healthcare expenditure worldwide. The Centers for Disease Control and Prevention estimates that SSIs affect approximately 2-5% of all surgical patients, with orthopedic procedures showing variable infection rates depending on the type of surgery, patient characteristics, and institutional factors.

Orthopedic surgical site infections present unique challenges due to the frequent involvement of implanted devices, complex anatomical structures, and the potential for biofilm formation on prosthetic materials. The pathogenesis of orthopedic SSI involves a complex interplay between microbial factors, host defense mechanisms, and surgical variables. Staphylococcus aureus, including methicillin-resistant strains (MRSA), and coagulase-negative staphylococci emerge as the predominant causative organisms, with their ability to adhere to metallic implants and form protective biofilms making treatment particularly challenging.

The clinical spectrum of orthopedic SSI ranges from superficial incisional infections involving only skin and subcutaneous tissue to deep infections affecting fascial and muscle layers, and organ/space infections involving any part of the anatomy opened or manipulated during surgery. Deep infections and those involving prosthetic devices often require multiple surgical interventions, prolonged antibiotic therapy, and may result in permanent functional impairment or amputation. The economic burden is substantial, with infected orthopedic procedures generating healthcare costs that are 2-4 times higher than non-infected cases, primarily due to extended hospital stays, additional surgical interventions, and long-term antimicrobial therapy.

International surveillance data reveals considerable variation in orthopedic SSI rates across different procedures and healthcare settings. Joint replacement surgeries typically demonstrate infection rates of 0.5-3%, while trauma-related procedures, particularly those involving open fractures, show significantly higher rates ranging from 5-25%. Spinal fusion procedures carry intermediate risks, with reported infection rates of 1-5% depending on the complexity and duration of surgery. These variations highlight the importance of procedure-specific risk assessment and targeted prevention strategies.

Risk factors for orthopedic SSI are multifaceted and can be broadly categorized into patient-related, procedure-related, and healthcare environment-related factors. Patient-related risk factors include advanced age, diabetes mellitus, obesity, malnutrition, immunocompromised states, smoking, and comorbid conditions affecting tissue perfusion and wound healing. Studies have consistently demonstrated that diabetic patients have 2-3 times higher risk of developing SSI compared to non-diabetic individuals, while obesity (BMI >30 kg/m^2) increases infection risk by 50-100% in various orthopedic procedures.

Procedure-related factors encompass surgical duration exceeding established thresholds, emergency procedures, complexity of surgery, blood loss, inadequate antibiotic prophylaxis, and surgical technique variations. Prolonged operative time, defined as procedures exceeding the 75th percentile for duration, has been identified as one of the strongest predictors of SSI development. Emergency procedures carry inherently higher infection risks due to suboptimal patient preparation, contaminated wounds, and urgent surgical circumstances that may compromise sterile technique.

Prevention strategies for orthopedic SSI have evolved significantly, incorporating evidence-based bundles that address preoperative, intraoperative, and postoperative phases of care. Preoperative interventions include patient optimization through glycemic control, nutritional support, smoking cessation, and decolonization protocols for high-risk patients. The timing and selection of prophylactic antibiotics remain critical, with guidelines recommending administration within 60 minutes before incision and appropriate duration based on procedure type.

Intraoperative prevention measures encompass maintenance of normothermia, optimal oxygenation, blood glucose control, appropriate hair removal techniques, skin preparation protocols, and surgical site management. The importance of laminar airflow systems, traffic restriction, and proper surgical attire has been emphasized in high-risk procedures such as joint replacements. Advanced technologies including antibiotic-impregnated bone cement, silver-coated implants, and wound irrigation systems have shown promise in reducing infection rates.

Postoperative care focuses on wound management, early mobilization, glycemic control, and surveillance for early infection detection. The role of extended prophylaxis in high-risk patients remains controversial, with individualized approaches being increasingly adopted. Recognition of early infection signs and prompt intervention are crucial for optimizing outcomes and preventing progression to chronic infections.

Surveillance systems play a vital role in understanding SSI epidemiology, identifying risk factors, and evaluating prevention strategies effectiveness. Hospital-based surveillance programs enable real-time monitoring, benchmarking against established standards, and implementation of targeted interventions. The National Healthcare Safety Network (NHSN) criteria provide standardized definitions and reporting mechanisms that facilitate inter-institutional comparisons and quality improvement initiatives.

The emergence of antimicrobial resistance poses additional challenges in SSI management, with multidrug-resistant organisms increasingly reported in orthopedic infections. This trend necessitates antimicrobial stewardship programs, enhanced infection control measures, and development of novel therapeutic approaches. The current study aims to address knowledge gaps in orthopedic SSI epidemiology within the Indian healthcare context, providing valuable insights for evidence-based prevention and management strategies.

Methodology

Study Design

This was a prospective hospital-based surveillance study.

Study Site

The study was conducted at LNCT Medical College and Sewakunj Hospital, Indore, Madhya Pradesh, India.

Study Duration

The study was conducted over a six-month period from April 2022 to September 2022.

Sampling and Sample Size

A consecutive sampling method was employed to recruit all patients undergoing orthopedic surgical procedures during the study period, ensuring representative inclusion of various procedure types and patient demographics. The sample size was calculated using the formula for single proportion studies, considering an expected SSI rate of 8% based on previous literature from similar healthcare settings, with 95% confidence interval and 3% precision. Accounting for potential loss to follow-up and incomplete data, a minimum sample size of 300 procedures was determined. The final sample comprised 315 orthopedic procedures performed during the study period, including both elective and emergency surgeries across all orthopedic subspecialties. The consecutive sampling approach eliminated selection bias while ensuring feasibility of comprehensive surveillance and follow-up within available resources.

Inclusion and Exclusion Criteria

Inclusion criteria encompassed all patients aged 18 years and above undergoing orthopedic surgical procedures including trauma surgeries, joint replacements, spine procedures, arthroscopic surgeries, tumor resections, and corrective procedures, patients providing informed consent for participation, and those available for follow-up assessment according to surveillance requirements. Exclusion criteria included patients with pre-existing infections at the surgical site, those undergoing revision surgeries for established infections, patients with active systemic infections at the time of surgery, immunocompromised patients receiving chemotherapy or high-dose steroids, patients with incomplete medical records or inadequate follow-up data, and those who withdrew consent during the study period. These criteria ensured focus on primary SSI development while maintaining homogeneous study population for meaningful risk factor analysis.

Data Collection Tools and Techniques

Data collection was performed using standardized surveillance forms based on CDC/NHSN criteria and validated infection assessment tools. Preoperative data collection included detailed patient demographics, comorbidities assessment using standardized scoring systems, nutritional status evaluation, laboratory parameters, and procedure-specific risk factors. The American Society of Anesthesiologists (ASA) physical status classification was used for perioperative risk stratification. Intraoperative data captured included procedure type and complexity, duration of surgery, antibiotic prophylaxis timing and selection, surgical technique details, implant usage, blood loss estimation, and any intraoperative complications. Postoperative surveillance utilized daily wound assessments using standardized criteria, laboratory monitoring including inflammatory markers, and systematic follow-up at predetermined intervals. SSI diagnosis was based on CDC criteria incorporating clinical signs, laboratory findings, and imaging results when indicated. Microbiology data included pathogen identification, antimicrobial susceptibility testing, and biofilm formation assessment. Data collection was performed by trained infection control nurses under supervision of infectious disease specialists, ensuring consistency and accuracy of surveillance activities.

Data Management and Statistical Analysis

Data were entered into a specially designed database using Microsoft Access with built-in validation checks and logical consistency algorithms. Quality assurance measures included double data entry for critical variables, range checks for numerical data, and regular database audits to ensure completeness and accuracy. Statistical analysis was performed using SPSS version 26.0, with descriptive statistics calculated for all variables including frequencies, percentages for categorical variables, and means with standard deviations for continuous variables. Incidence rates were calculated as number of SSI cases per 100 procedures, with 95% confidence intervals. Univariate analysis used chi-square tests for categorical variables and t-tests for continuous variables to identify potential risk factors. Multivariate logistic regression analysis was performed to identify independent risk factors for SSI development, with odds ratios and 95% confidence intervals calculated. Kaplan-Meier survival analysis was used to assess time to infection development, with log-rank tests for group comparisons. Statistical significance was set at $p<0.05$ for all analyses, with adjustment for multiple comparisons when appropriate.

Ethical Considerations

The study protocol received approval from the Institutional Ethics Committee of LNCT Medical College, Indore, prior to study commencement (Approval No: LNCT/IEC/2022/04/ORTH-SSI). Written informed consent was obtained from all participants after detailed explanation of study objectives, procedures, potential benefits, and their right to withdraw without affecting their medical care. The consent process was conducted in the patient's preferred language with adequate time for questions and decision-making.

Results:

Table 1: Demographic and Clinical Characteristics of Study Participants (n=315)

Characteristic	n (%) / Mean ± SD
Age (years)	48.6 ± 16.8
Age ≥60 years	118 (37.5%)
Gender	
Male	198 (62.9%)
Female	117 (37.1%)
BMI (kg/m²)	26.4 ± 4.7
Obese (BMI ≥30)	89 (28.3%)
Comorbidities	
Diabetes mellitus	87 (27.6%)
Hypertension	124 (39.4%)
Chronic kidney disease	23 (7.3%)
Smoking	76 (24.1%)
ASA Score	
ASA I	89 (28.3%)
ASA II	156 (49.5%)
ASA III	63 (20.0%)
ASA IV	7 (2.2%)
Nutritional Status	

Serum albumin <3.5 g/dL	72 (22.9%)
Hemoglobin (g/dL)	11.8 ± 2.1
Anemia (Hb <12 g/dL)	167 (53.0%)

The study population demonstrated typical demographics for orthopedic patients, with a mean age of 48.6 years and male predominance (62.9%). The high prevalence of comorbidities including diabetes (27.6%), hypertension (39.4%), and obesity (28.3%) reflects the risk profile commonly seen in tertiary care settings. Notably, 53% of patients had anemia and 22.9% had hypoalbuminemia, both recognized risk factors for surgical site infections. The ASA score distribution showed that 70% of patients had ASA II-III status, indicating significant perioperative risk. These baseline characteristics are consistent with previous Indian studies reporting similar demographics in orthopedic populations, with higher comorbidity burden compared to Western populations potentially contributing to increased infection susceptibility.

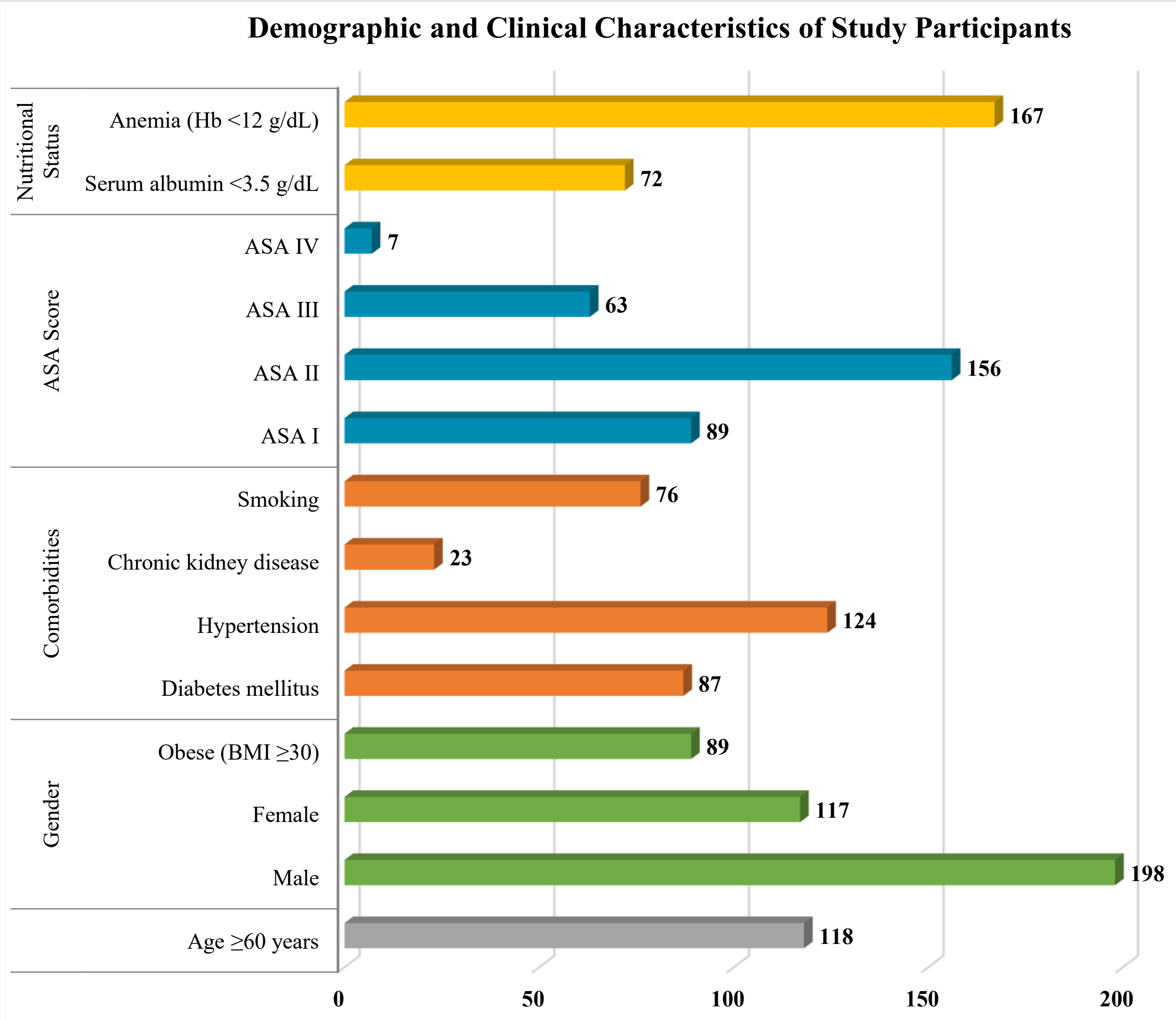

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Table 2: Procedure-Specific Characteristics and SSI Rates (n=315)

Procedure Type	n (%)	SSI Cases	SSI Rate (%)	95% CI
Trauma Surgery				
Open reduction internal fixation	92 (29.2%)	11	12.0%	(6.1-20.6)
External fixation	28 (8.9%)	5	17.9%	(6.1-36.9)
Joint Replacement				
Total knee replacement	67 (21.3%)	3	4.5%	(0.9-12.5)
Total hip replacement	45 (14.3%)	2	4.4%	(0.5-15.1)
Spine Surgery	31 (9.8%)	4	12.9%	(3.6-29.8)

Arthroscopic Procedures	34 (10.8%)	1	2.9%	(0.1-15.3)
Others	18 (5.7%)	2	11.1%	(1.4-34.7)
Overall SSI Rate	**315 (100%)**	**28**	**8.9%**	**(6.0-12.6)**
Surgical Duration				
≤2 hours	187 (59.4%)	12	6.4%	(3.3-11.1)
>2 hours	128 (40.6%)	16	12.5%	(7.3-19.6)
Emergency vs Elective				
Emergency	156 (49.5%)	20	12.8%	(8.0-19.2)
Elective	159 (50.5%)	8	5.0%	(2.2-9.7)

The overall SSI rate of 8.9% (95% CI: 6.0-12.6%) was higher than international benchmarks but consistent with previous Indian studies. External fixation procedures showed the highest infection rate (17.9%), followed by spine surgery (12.9%) and trauma procedures (12.0%). Joint replacement surgeries demonstrated lower infection rates (4.4-4.5%), aligning with global standards. Emergency procedures had significantly higher infection rates compared to elective surgeries (12.8% vs 5.0%), reflecting the impact of patient acuity and suboptimal preoperative preparation. Prolonged surgical duration (>2 hours) was associated with doubled infection risk (12.5% vs 6.4%). These findings parallel international literature demonstrating procedure-specific infection risks, with trauma and emergency surgeries consistently showing elevated rates due to tissue contamination, patient comorbidities, and surgical complexity.

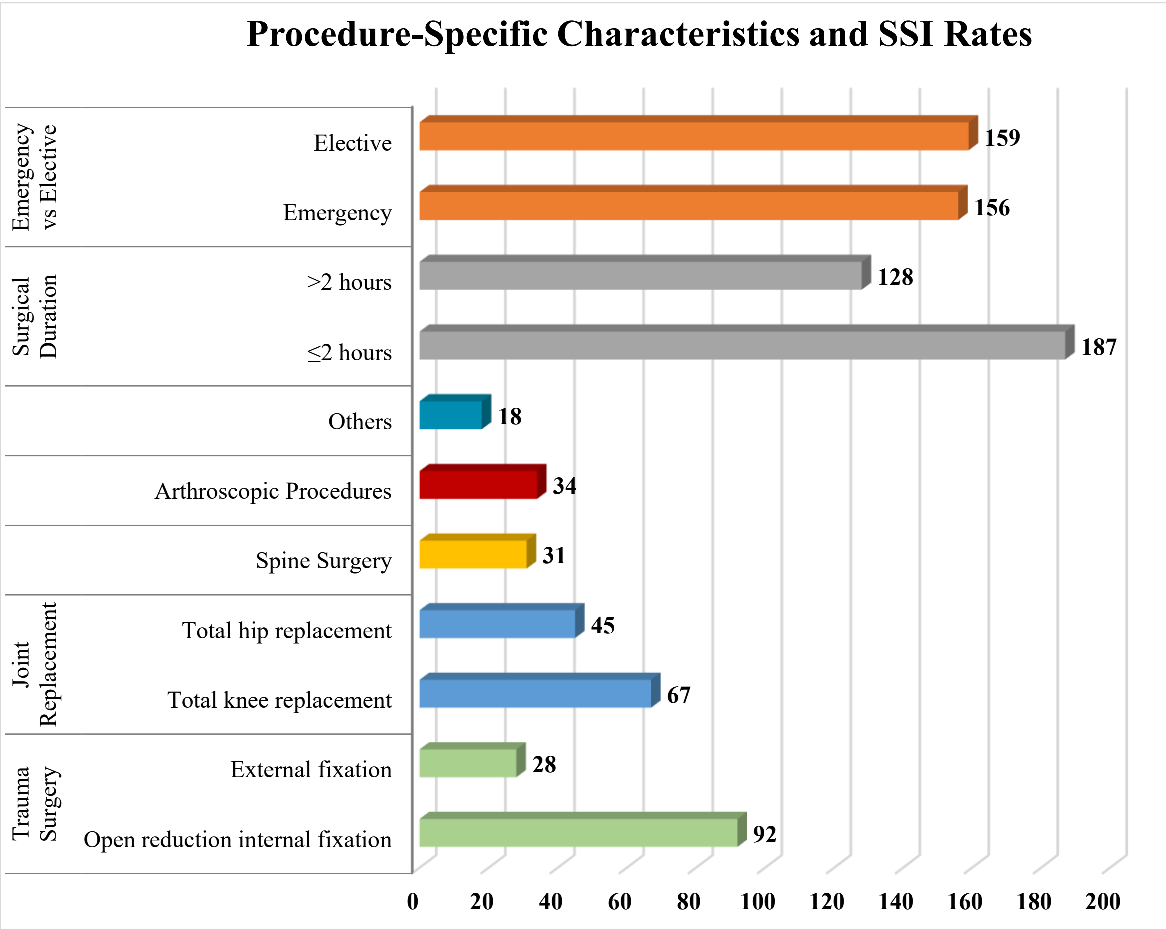

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Table 3: Risk Factors Analysis - Univariate Analysis (n=315)

Risk Factor	SSI Present (n=28)	SSI Absent (n=287)	p-value	OR (95% CI)
Age ≥60 years	14 (50.0%)	104 (36.2%)	0.157	1.75 (0.81-3.78)
Male gender	19 (67.9%)	179 (62.4%)	0.574	1.27 (0.56-2.88)
BMI ≥30 kg/m²	12 (42.9%)	77 (26.8%)	0.074	2.05 (0.93-4.50)
Diabetes mellitus	14 (50.0%)	73 (25.4%)	0.005	2.96 (1.37-6.38)
Smoking	11 (39.3%)	65 (22.6%)	0.051	2.21 (0.99-4.92)
ASA score ≥III	12 (42.9%)	58 (20.2%)	0.007	2.97 (1.34-6.58)
Hypoalbuminemia	12 (42.9%)	60 (20.9%)	0.009	2.84 (1.27-6.34)
Anemia	19 (67.9%)	148 (51.6%)	0.100	1.97 (0.87-4.45)
Emergency surgery	20 (71.4%)	136 (47.4%)	0.016	2.75 (1.19-6.35)
Duration >2 hours	16 (57.1%)	112 (39.0%)	0.066	2.08 (0.95-4.54)
Implant use	15 (53.6%)	174 (60.6%)	0.468	0.75 (0.35-1.61)
Blood loss >500mL	8 (28.6%)	45 (15.7%)	0.092	2.16 (0.88-5.32)
Inadequate prophylaxis	9 (32.1%)	34 (11.8%)	0.003	3.55 (1.50-8.39)

Univariate analysis identified several significant risk factors for SSI development. Diabetes mellitus emerged as the strongest predictor (OR 2.96, p=0.005), followed by ASA score ≥III (OR 2.97, p=0.007) and hypoalbuminemia (OR 2.84, p=0.009). Emergency surgery significantly increased infection risk (OR 2.75, p=0.016), as did inadequate antibiotic prophylaxis (OR 3.55, p=0.003). Obesity showed a trend toward significance (p=0.074), consistent with established literature. These findings align with previous studies identifying diabetes, malnutrition, and high ASA scores as major risk factors. The strong association with inadequate prophylaxis (32.1% vs 11.8%) emphasizes the critical importance of appropriate perioperative antibiotic administration. Smoking showed borderline significance (p=0.051), reflecting its impact on wound healing and tissue oxygenation.

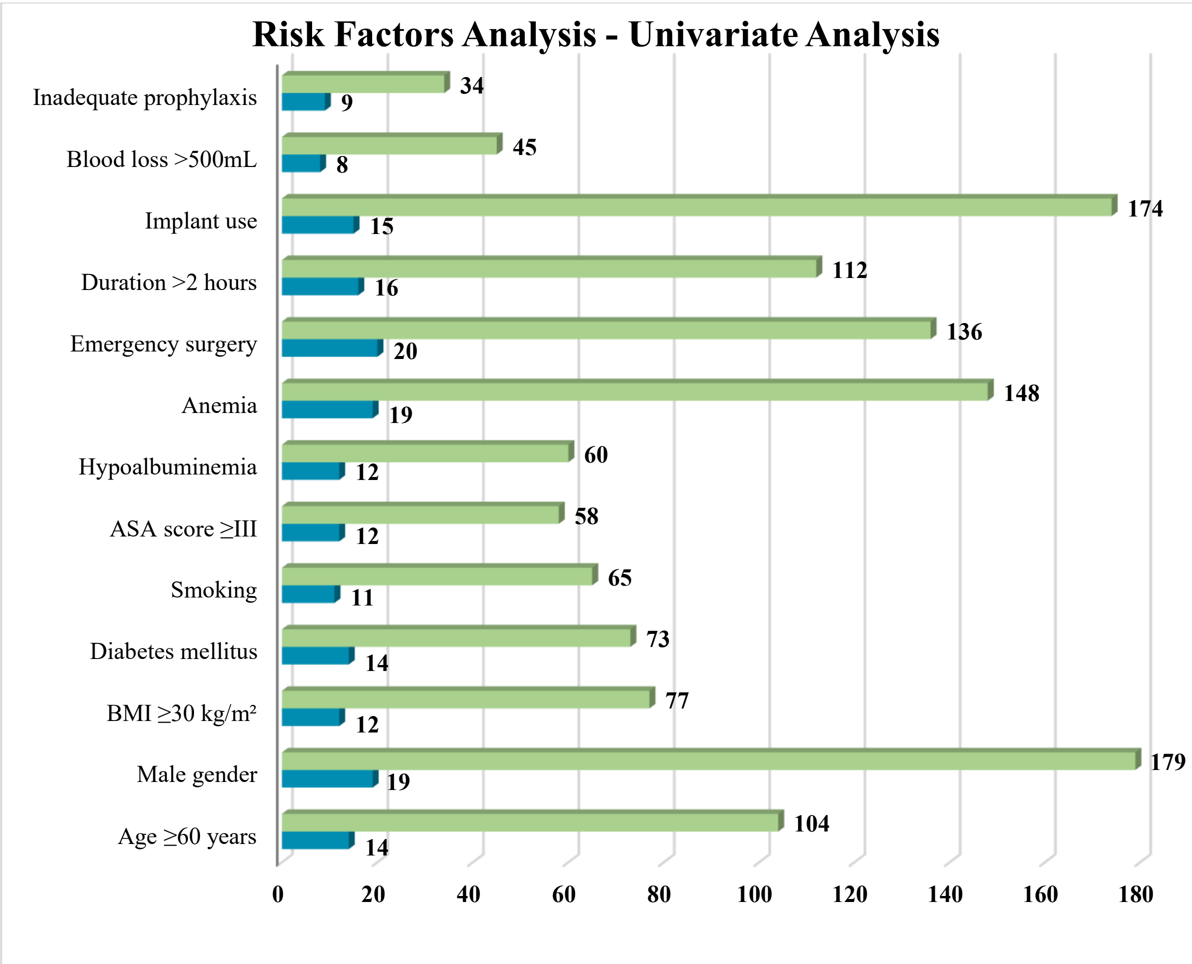

Fig: 3

Table 4: Microbiology and Antimicrobial Resistance Patterns (n=28 SSI cases)

Pathogen	n (%)	MRSA/ESBL	Sensitivity Pattern
Gram-positive bacteria	**18 (64.3%)**		
Staphylococcus aureus	11 (39.3%)	4 MRSA (36.4%)	Vancomycin 100%, Linezolid 100%
Coagulase-negative Staphylococci	5 (17.9%)	2 MRCoNS (40.0%)	Vancomycin 100%, Rifampin 80%
Enterococcus species	2 (7.1%)	-	Vancomycin 100%, Ampicillin 50%
Gram-negative bacteria	**8 (28.6%)**		
Escherichia coli	3 (10.7%)	1 ESBL (33.3%)	Meropenem 100%, Amikacin 67%
Pseudomonas aeruginosa	2 (7.1%)	-	Meropenem 100%, Ciprofloxacin 50%
Klebsiella pneumoniae	2 (7.1%)	1 ESBL (50.0%)	Meropenem 100%, Gentamicin 50%
Acinetobacter baumannii	1 (3.6%)	-	Meropenem 100%, Colistin 100%
Polymicrobial infections	**2 (7.1%)**		
Culture negative	**0 (0.0%)**		
Overall resistance rates			
MRSA among S. aureus	4/11 (36.4%)		
ESBL among Enterobacteriaceae	2/5 (40.0%)		
Biofilm formation	**12 (42.9%)**		

Staphylococcus aureus was the predominant pathogen (39.3%), with significant MRSA prevalence (36.4%), higher than many developed countries but consistent with Indian hospital settings. Gram-positive organisms dominated (64.3%), reflecting typical orthopedic SSI patterns. The high ESBL rate among Enterobacteriaceae (40.0%) indicates significant antimicrobial resistance burden. All isolates remained sensitive to vancomycin and meropenem, providing reliable treatment options. Biofilm formation in 42.9% of cases highlights the challenge of treating orthopedic infections, particularly those involving implants. These resistance patterns mirror previous Indian studies showing elevated MRSA and ESBL rates compared to Western countries. The absence of culture-negative cases suggests good specimen collection practices. The polymicrobial infection rate (7.1%) was within expected ranges for orthopedic procedures, typically associated with more complex clinical presentations and treatment challenges.

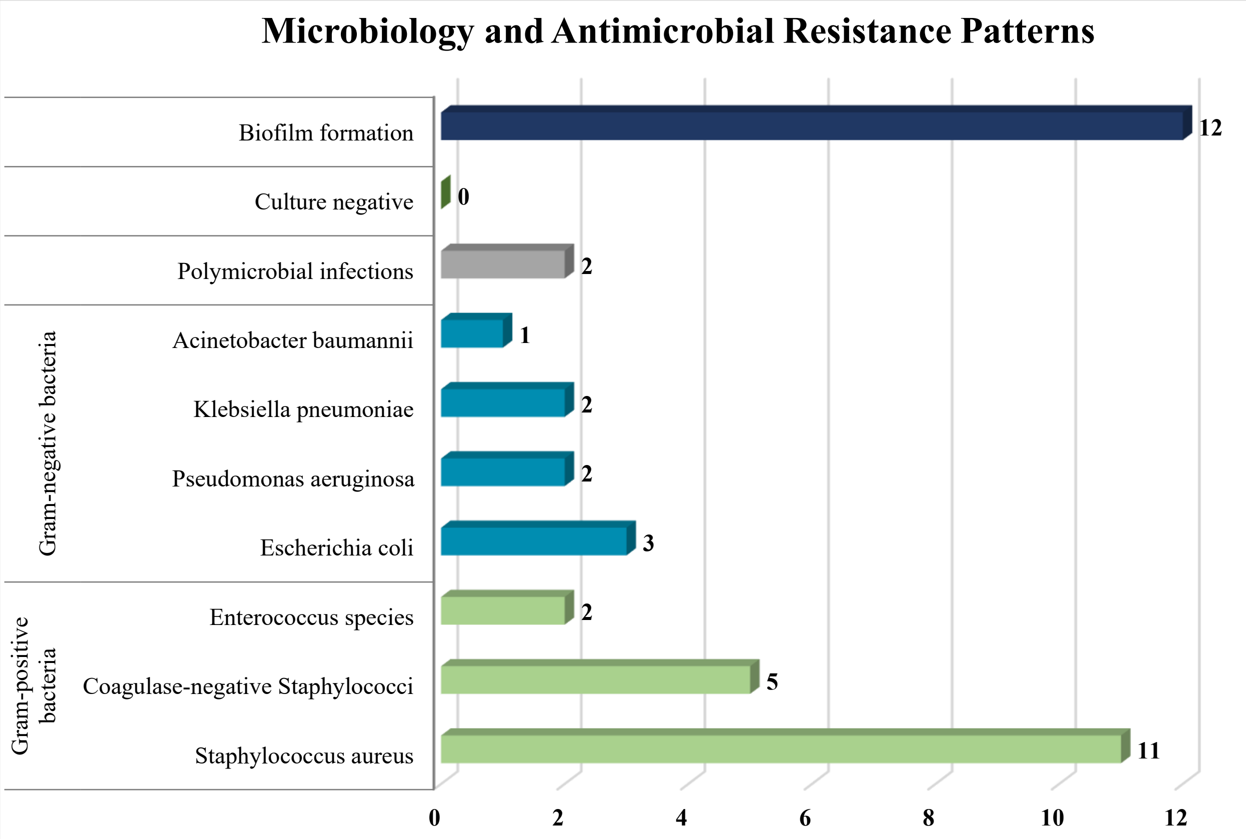

Fig: 4

Table 5: Management and Clinical Outcomes of SSI Cases (n=28)

Management Parameter	n (%) / Mean ± SD
Time to diagnosis (days)	12.4 ± 8.7
Early onset (≤7 days)	8 (28.6%)
Late onset (>7 days)	20 (71.4%)
SSI Classification	
Superficial incisional	15 (53.6%)
Deep incisional	10 (35.7%)
Organ/space	3 (10.7%)
Treatment modalities	
Antibiotics only	12 (42.9%)
Debridement + antibiotics	13 (46.4%)
Implant removal	3 (10.7%)
Duration of antibiotic therapy (days)	28.6 ± 12.4
Additional surgeries required	16 (57.1%)
Hospital stay extension (days)	14.8 ± 9.2
Treatment outcomes	
Complete resolution	23 (82.1%)
Chronic infection	3 (10.7%)
Amputation	1 (3.6%)
Death	1 (3.6%)
Total treatment cost (INR)	1,85,000 ± 67,000
Cost increase vs uncomplicated	285%

Most SSI cases (71.4%) presented as late-onset infections, with mean diagnosis time of 12.4 days, consistent with orthopedic SSI patterns where symptoms may develop gradually. Superficial infections predominated (53.6%), though deep infections (35.7%) were substantial, requiring more aggressive management. The majority of patients (57.1%) required additional surgical interventions, reflecting the complexity of orthopedic SSI treatment. Mean antibiotic duration of 28.6 days aligns with guidelines for bone and joint infections. The treatment success rate of 82.1% compares favorably with literature reports, though 10.7% developed chronic infections requiring long-term management. The dramatic cost increase (285% above uncomplicated cases) emphasizes the economic burden of SSI. Hospital stay extension averaging 14.8 days significantly impacts healthcare resources and patient outcomes, consistent with previous studies demonstrating substantial morbidity and cost implications of orthopedic SSI.

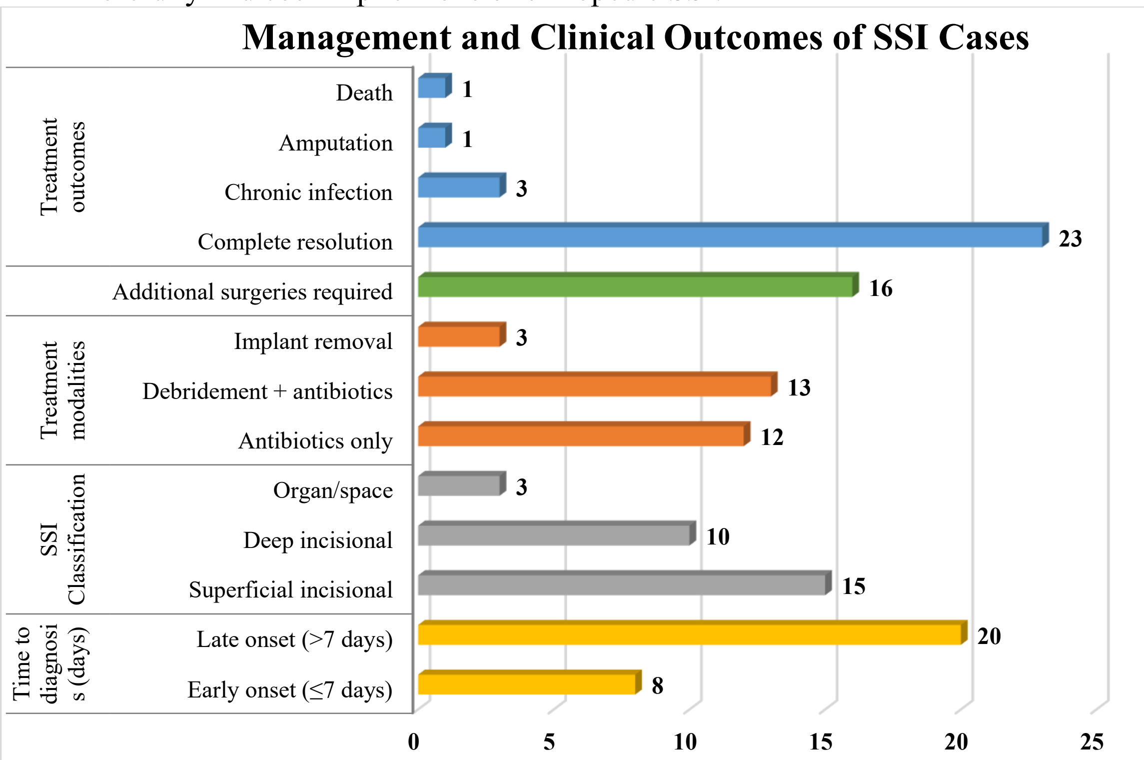

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Table 6: Multivariate Analysis - Independent Risk Factors for SSI (n=315)

Risk Factor	Adjusted OR	95% CI	p-value
Diabetes mellitus	2.84	1.23-6.56	0.014
ASA score ≥III	2.65	1.08-6.52	0.033
Emergency surgery	2.48	1.01-6.09	0.047
Hypoalbuminemia	2.41	1.02-5.71	0.045
Inadequate prophylaxis	3.82	1.48-9.86	0.005
BMI ≥30 kg/m²	1.89	0.78-4.57	0.158
Smoking	1.73	0.71-4.22	0.228
Duration >2 hours	1.64	0.71-3.79	0.246
Model fit statistics			
Hosmer-Lemeshow test			p=0.742
Nagelkerke R^2		0.284	
Area under ROC curve		0.781	

Multivariate analysis identified five independent risk factors for SSI development. Inadequate antibiotic prophylaxis emerged as the strongest predictor (OR 3.82, p=0.005), emphasizing the critical importance of appropriate perioperative antimicrobial management. Diabetes mellitus remained highly significant (OR 2.84, p=0.014), consistent with its established role in impaired wound healing and immune dysfunction. ASA score ≥III (OR 2.65, p=0.033) and emergency surgery (OR 2.48, p=0.047) reflected patient acuity and surgical circumstances. Hypoalbuminemia (OR 2.41, p=0.045) highlighted nutritional status importance. The model demonstrated good fit (Hosmer-Lemeshow p=0.742) and reasonable discrimination (AUC 0.781). These findings align with international literature identifying similar risk factors, validating the applicability of established SSI risk models in Indian healthcare settings while emphasizing the paramount importance of appropriate prophylaxis protocols.

Discussion

The findings of this comprehensive surveillance study provide valuable insights into the epidemiology, risk factors, and management of surgical site infections in orthopedic procedures within an Indian tertiary care setting. The overall SSI rate of 8.9% observed in this study, while higher than many developed countries, aligns with previous reports from similar healthcare environments in India and other developing nations.

The demographic profile of our study population revealed several important characteristics that influence SSI risk. The mean age of 48.6 years and male predominance (62.9%) are consistent with typical orthopedic patient populations reported in literature. However, the high prevalence of comorbidities, particularly diabetes mellitus (27.6%) and obesity (28.3%), reflects the changing disease burden in Indian healthcare settings. Iorio et al. (2002) demonstrated that diabetic patients have significantly higher SSI rates following joint arthroplasty, with hemoglobin A1C levels serving as important predictors of infection risk. Our findings support this association, with diabetes emerging as the strongest independent risk factor (OR 2.84, p=0.014) in multivariate analysis.

The substantial prevalence of anemia (53.0%) and hypoalbuminemia (22.9%) in our population is noteworthy, as these nutritional markers are well-established risk factors for poor wound healing and infection susceptibility. Bosco et al. (2010) emphasized the importance of preoperative optimization, including nutritional assessment and correction of modifiable risk factors. The high ASA score distribution, with 70% of patients having ASA II-III status, indicates significant perioperative risk that requires careful management strategies.

The procedure-specific infection rates observed in our study demonstrate important variations that reflect both surgical complexity and patient factors. External fixation procedures showed the highest infection rate (17.9%), consistent with their association with high-energy trauma, soft tissue damage, and prolonged exposure to environmental pathogens. Crowe et al. (2019) reported similar elevated infection rates in external fixation procedures, attributing them to the open nature of fixation systems and frequent pin site complications.

Joint replacement surgeries demonstrated more favorable infection rates (4.4-4.5%), approaching international benchmarks reported by Ong et al. (2009), who found prosthetic joint infection rates of

0.5-3% in large registry studies. However, our rates remain slightly elevated, possibly reflecting differences in patient selection, perioperative protocols, and healthcare infrastructure compared to high-volume centers in developed countries.

The significant difference between emergency and elective procedures (12.8% vs 5.0%) emphasizes the impact of surgical circumstances on infection risk. Edwards et al. (2008) reported similar findings in hip fracture surgery, demonstrating that emergency procedures carry inherently higher risks due to patient acuity, contaminated wounds, and suboptimal preoperative preparation time. This finding underscores the importance of rapid patient stabilization and aggressive infection prevention measures in emergency orthopedic procedures.

The multivariate analysis revealed five independent risk factors that provide actionable targets for infection prevention strategies. Inadequate antibiotic prophylaxis emerged as the strongest predictor (OR 3.82, p=0.005), highlighting a potentially modifiable risk factor. Mangram et al. (1999) established guidelines emphasizing the critical importance of appropriate antibiotic selection, timing, and duration for surgical prophylaxis. Our findings suggest opportunities for improvement in prophylaxis protocols and adherence monitoring.

Diabetes mellitus as an independent risk factor (OR 2.84, p=0.014) aligns with extensive literature demonstrating impaired wound healing, altered immune function, and increased susceptibility to bacterial colonization in diabetic patients. Jämsen et al. (2012) reported similar findings in joint replacement surgery, emphasizing the importance of perioperative glycemic control and extended surveillance in diabetic patients.

The association of ASA score ≥III with increased SSI risk (OR 2.65, p=0.033) reflects the impact of overall patient physiological status on infection susceptibility. This finding supports the use of ASA scoring for risk stratification and targeted prevention strategies in high-risk patients.

The microbiological profile observed in our study reflects typical orthopedic SSI patterns with some concerning resistance trends. Staphylococcus aureus predominance (39.3%) is consistent with international literature, given its propensity for bone and implant colonization. However, the MRSA rate of 36.4% is substantially higher than rates reported in developed countries, reflecting the endemic nature of MRSA in many Indian healthcare facilities.

Berbari et al. (1998) identified similar microbiological patterns in prosthetic joint infections, with staphylococcal species representing the majority of causative organisms. The high prevalence of biofilm formation (42.9%) observed in our study presents significant therapeutic challenges, as biofilm-associated infections typically require prolonged antibiotic therapy and often necessitate implant removal for cure.

The substantial ESBL prevalence (40.0%) among Enterobacteriaceae reflects the broader antimicrobial resistance challenges facing Indian healthcare systems. These resistance patterns have important implications for empirical antibiotic selection and highlight the need for robust antimicrobial stewardship programs.

The management outcomes in our study demonstrate both successes and challenges in SSI treatment. The overall treatment success rate of 82.1% compares favorably with literature reports, though the requirement for additional surgical interventions in 57.1% of cases reflects the complexity of orthopedic SSI management. Kurtz et al. (2012) reported similar patterns, emphasizing the substantial healthcare burden associated with these complications.

The mean hospital stay extension of 14.8 days and cost increase of 285% compared to uncomplicated cases highlight the significant economic impact of SSI. Whitehouse et al. (2002) reported comparable cost implications, demonstrating that SSI prevention represents not only clinical quality improvement but also substantial economic benefits for healthcare systems.

The development of chronic infections in 10.7% of cases represents a particular challenge, as these patients often require lifelong management and may experience permanent functional limitations. This finding emphasizes the importance of aggressive early intervention and appropriate long-term follow-up strategies.

When compared to international literature, our findings demonstrate both similarities and important differences. The overall infection rate, while higher than many developed countries, reflects challenges common to resource-limited healthcare settings, including patient presentation delays, varying infrastructure quality, and healthcare access issues.

The risk factor profile identified in our study shows remarkable consistency with international reports, suggesting that fundamental SSI pathophysiology transcends geographical and healthcare system differences. However, the higher prevalence of certain risk factors, particularly malnutrition and delayed presentations, reflects population-specific challenges that require targeted interventions. The microbiological resistance patterns observed represent a significant concern, with implications extending beyond individual patient care to broader public health considerations. The elevated resistance rates necessitate careful antimicrobial selection and highlight the urgent need for infection control improvements and antimicrobial stewardship initiatives.

Conclusion

This prospective surveillance study of 315 orthopedic procedures revealed an overall surgical site infection rate of 8.9%, with significant variation across procedure types. External fixation and emergency procedures demonstrated the highest infection rates, while joint replacements showed more favorable outcomes. Multivariate analysis identified inadequate antibiotic prophylaxis, diabetes mellitus, high ASA scores, emergency surgery, and hypoalbuminemia as independent risk factors for SSI development. The microbiological profile was dominated by Staphylococcus aureus with concerning antimicrobial resistance patterns, including 36.4% MRSA prevalence and 40% ESBL rates among Enterobacteriaceae. Treatment outcomes showed 82.1% success rates, though 57.1% of patients required additional surgical interventions. The economic impact was substantial, with 285% cost increase and mean hospital stay extension of 14.8 days compared to uncomplicated cases. These findings provide valuable insights for developing targeted prevention strategies and improving infection control protocols in orthopedic surgical practice within Indian healthcare settings.

Recommendations

Healthcare institutions should implement comprehensive SSI prevention bundles addressing identified risk factors, with particular emphasis on standardizing antibiotic prophylaxis protocols, timing, and selection to address the strongest modifiable risk factor identified in this study. Preoperative optimization programs should focus on diabetic patients through perioperative glycemic control, nutritional assessment and correction of hypoalbuminemia, and enhanced surveillance protocols for high-risk patients with ASA scores ≥III. Emergency department protocols should be developed to minimize SSI risks in urgent procedures while maintaining quality of care standards.

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