International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

Original Researcher Article *DOI: 10.61336/im/26-2-12*

Comparative Analysis of Surgical Site Infections (SSI) in Emergency vs. Elective Abdominal Surgeries: A Hospital-Based Prospective Study

Lokesh M. Reddy[1], Kanagala Rajesh[2]

[1]*Maramreddy Lokesh Reddy, Associate professor, Department of General Surgery, Katuri Medical College & Hospital (KMCH), Guntur District, Andhra Pradesh, India.*

[2]*Associate professor, Department of General Surgery, Katuri Medical College & Hospital, Guntur, Andhra Pradesh, India.*

Correspondence:
Kanagala Rajesh
Associate professor, Department of General Surgery, Katuri Medical College & Hospital, Guntur, Andhra Pradesh, India.
Email:
drkanagala@gmail.com

Received: February 12, 2026
Revised: February26, 2026
Accepted: March 09, 2026
Published: March 30, 2026

Abstract
Background: Surgical site infections (SSIs) remain among the most common healthcare-associated infections, contributing significantly to postoperative morbidity, prolonged hospitalization, and increased healthcare costs. Emergency abdominal surgeries carry higher infection risks compared to elective procedures due to multiple patient and procedural factors. **Objective**: To compare the incidence, risk factors, bacteriological profile, and outcomes of surgical site infections between emergency and elective abdominal surgeries at Katuri Medical College & Hospital, Andhra Pradesh. ***Methods***: A prospective observational study was conducted over 18 months (September 2024 - February 2026) involving 300 patients undergoing abdominal surgery (150 emergency, 150 elective). Patients were followed for 30 days postoperatively for SSI development according to CDC criteria. Clinical data, wound classification, bacteriological culture, antibiotic sensitivity, and outcomes were analyzed. Statistical analysis included chi-square tests and multivariate logistic regression. ***Results***: The overall SSI rate was 15.7% (47/300): 24.0% (36/150) in emergency surgeries versus 7.3% (11/150) in elective surgeries ($p<0.001$). SSI rates correlated strongly with wound classification: clean 4.2%, clean-contaminated 11.8%, contaminated 32.6%, and dirty/infected 51.4% ($p<0.001$). Independent risk factors included emergency surgery (OR: 3.84, 95% CI: 1.82-8.11, $p<0.001$), diabetes mellitus (OR: 3.26, 95% CI: 1.54-6.89, $p=0.002$), operative time >2 hours (OR: 2.91, 95% CI: 1.38-6.14, $p=0.005$), and contaminated/dirty wounds (OR: 7.52, 95% CI: 3.21-17.61, $p<0.001$). Gram-negative organisms predominated (61.7%), with Escherichia coli (25.5%), Klebsiella pneumoniae (17.0%), and Pseudomonas aeruginosa (12.8%) being most common. ESBL production was detected in 54.2% of Gram-negative isolates, and MRSA in 40.9% of Staphylococcus aureus. Mean hospital stay was significantly longer in SSI cases (14.8 ± 6.2 vs 7.4 ± 3.1 days, $p<0.001$). ***Conclusions***: Emergency abdominal surgeries have significantly higher SSI rates compared to elective procedures, primarily due to wound contamination, compromised patient optimization, and urgency of intervention. Diabetes, prolonged operative time, and wound classification are critical determinants. High antimicrobial resistance necessitates culture-guided therapy. Enhanced infection control measures, preoperative optimization when feasible, and adherence to surgical bundles can reduce SSI burden.

Keywords: Surgical site infection, emergency surgery, elective surgery, abdominal surgery, wound classification, antibiotic resistance, risk factors, Andhra Pradesh.

INTRODUCTION
Surgical site infections (SSIs) represent one of the most preventable yet persistent complications in surgical practice, accounting for approximately 20% of all healthcare-associated infections globally[1]. Despite advances in surgical techniques, antimicrobial prophylaxis, and infection control practices, SSIs continue to impose substantial burden on patients and healthcare systems through increased morbidity, prolonged hospitalization, readmissions, and healthcare costs[2].

The incidence of SSIs varies considerably depending on surgical specialty, procedure type, and patient characteristics. Abdominal surgeries, particularly those involving gastrointestinal tract manipulation, carry inherently higher infection risks due to potential bacterial contamination from endogenous flora[3]. The distinction between emergency and elective abdominal surgeries is particularly relevant, as these represent fundamentally different clinical scenarios with distinct risk profiles.

Emergency abdominal surgeries are performed under urgent or life-threatening circumstances—such as perforated viscus, intestinal obstruction, acute appendicitis, trauma, or ischemic bowel—that preclude comprehensive preoperative optimization. Patients presenting for emergency surgery often have systemic illness, dehydration, electrolyte imbalances, anemia, and compromised immune function. The surgical conditions themselves frequently involve peritoneal contamination, established infection, or tissue necrosis, resulting in contaminated or dirty surgical fields[4]. Additionally, the urgency of intervention limits opportunities for thorough bowel preparation, meticulous skin antisepsis, and optimal timing of antibiotic prophylaxis.

In contrast, elective abdominal surgeries allow for systematic preoperative assessment, correction of modifiable risk factors (anemia, hyperglycemia, malnutrition), mechanical bowel preparation when indicated, appropriate antibiotic prophylaxis timing, and controlled surgical environments. These procedures typically involve clean or clean-contaminated wounds with minimal bacterial burden[5].

Multiple international and Indian studies have documented 2-5 fold higher SSI rates in emergency compared to elective abdominal surgeries[6][7][8]. A systematic review identified emergency procedures as independent risk factors for SSI development (OR: 2.5-4.2), along with other factors including diabetes mellitus, obesity, prolonged operative duration, increased wound classification, smoking, and perioperative blood transfusion[9].

The bacteriological profile of SSIs reflects the surgical site anatomy and degree of contamination. Abdominal SSIs typically involve mixed aerobic and anaerobic flora from gastrointestinal or genitourinary sources. Escherichia coli, Klebsiella species, Pseudomonas aeruginosa, Enterococcus species, Staphylococcus aureus, and anaerobes like Bacteroides fragilis are commonly isolated[10]. The emergence of multidrug-resistant organisms—particularly extended-spectrum beta-lactamase (ESBL) producing Enterobacteriaceae and methicillin-resistant Staphylococcus aureus (MRSA)—has complicated empirical therapy and contributed to treatment failures[11].

In India, SSI rates remain higher than international benchmarks, ranging from 8-25% for abdominal surgeries compared to 2-5% in developed countries[12]. This disparity reflects differences in healthcare infrastructure, infection control practices, antibiotic stewardship, patient comorbidity burden, and healthcare-seeking behavior. Rural populations, which constitute the majority in states like Andhra Pradesh, face additional challenges including delayed presentation, limited access to tertiary care, malnutrition, and inadequate primary health interventions.

Andhra Pradesh, with a population of approximately 49 million and significant rural predominance (62-65%), faces a substantial surgical disease burden. Katuri Medical College & Hospital (KMCH), located in Guntur district, serves as a tertiary referral center for rural and semi-urban populations from multiple districts. Understanding local SSI epidemiology, risk factors, and microbial resistance patterns is essential for developing evidence-based prevention strategies and empirical treatment protocols tailored to this population.

The Centers for Disease Control and Prevention (CDC) classifies SSIs into superficial incisional (involving skin and subcutaneous tissue), deep incisional (involving fascia and muscle), and organ/space infections (involving organs or spaces accessed during surgery)[13]. The CDC also employs a surgical wound classification system based on contamination degree: Class I (clean), Class II (clean-contaminated), Class III (contaminated), and Class IV (dirty/infected). This classification correlates strongly with SSI risk and serves as a critical preoperative risk stratification tool[14].

This prospective study was designed to comprehensively compare SSI incidence, risk factor profiles, bacteriological characteristics, antimicrobial resistance patterns, and clinical outcomes between emergency and elective abdominal surgeries at KMCH. The specific objectives were to: (1) determine and compare SSI rates between emergency and elective abdominal surgeries, (2) evaluate the association between wound classification and SSI development, (3) identify independent risk factors for SSI in both surgery types, (4) characterize the bacteriological profile and antimicrobial susceptibility patterns, and (5) assess the impact of SSI on hospital stay duration and patient outcomes.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational cohort study was conducted in the Department of General Surgery, Katuri Medical College & Hospital (KMCH), Gannavaram, Guntur district, Andhra Pradesh, over 18 months from September 2024 to February 2026. KMCH is a 1000-bedded tertiary care teaching hospital providing comprehensive surgical services to predominantly rural and semi-urban populations from Guntur, Krishna, Prakasam, and surrounding districts.

Study Population and Sample Size

The study included 300 consecutive patients undergoing abdominal surgery, stratified into two equal cohorts: 150 emergency surgeries and 150 elective surgeries. Sample size was calculated to detect a minimum 10% difference in SSI rates between groups (assuming 20% in emergency vs 10% in elective), with 80% power and 5% significance level, yielding 140 patients per group. Accounting for 7% potential loss to follow-up, 150 patients per group were enrolled.

Inclusion Criteria
- Patients aged 18 years and above
- Undergoing abdominal surgery (emergency or elective)
- Willing to provide informed consent
- Available for 30-day postoperative follow-up

Exclusion Criteria
- Patients with pre-existing infection at surgical site
- Immunocompromised patients (HIV, malignancy on active chemotherapy, organ transplant recipients on immunosuppression)
- Patients on long-term corticosteroid therapy (>10 mg prednisolone equivalent daily for >3 months)
- Re-operations at the same site within study period
- Laparoscopic procedures (to maintain homogeneity—only open surgeries included)
- Incomplete medical records or lost to follow-up

Definitions
Emergency Surgery: Surgical intervention required within 24 hours of hospital presentation due to urgent or life-threatening conditions (perforated viscus, intestinal obstruction, acute appendicitis, trauma, ischemic bowel, intra-abdominal hemorrhage, strangulated hernia).
Elective Surgery: Planned surgical procedure scheduled in advance, allowing preoperative optimization and preparation (hernia repair, cholelithiasis, benign tumors, inflammatory bowel disease, elective bowel resection).
Surgical Site Infection (SSI): Infection occurring within 30 days after surgery, classified according to CDC/NHSN criteria[15]:
- Superficial incisional SSI: Involves skin and subcutaneous tissue with purulent drainage, positive culture, pain/tenderness, localized swelling, erythema, or heat
- Deep incisional SSI: Involves fascia and muscle layers with purulent drainage from deep incision, spontaneous wound dehiscence with fever ($>$38°C), or abscess formation
- Organ/space SSI: Involves organs or spaces accessed during surgery (intra-abdominal abscess, peritonitis, anastomotic leak with infection)

Wound Classification (CDC System):
- Class I - Clean: Non-traumatic, uninfected operative wound; no inflammation; respiratory, alimentary, genital, or urinary tracts not entered
- Class II - Clean-Contaminated: Operative wound entering respiratory, alimentary, genital, or urinary tracts under controlled conditions without unusual contamination
- Class III - Contaminated: Open, fresh traumatic wounds; gross spillage from gastrointestinal tract; major break in sterile technique; acute non-purulent inflammation
- Class IV - Dirty/Infected: Old traumatic wounds with devitalized tissue; existing clinical infection or perforated viscus

Clinical Assessment and Data Collection
Comprehensive preoperative assessment included detailed history (age, gender, occupation, residence, smoking, alcohol consumption, duration and type of symptoms), comorbidities (diabetes mellitus, hypertension, chronic kidney disease, obesity), nutritional status (serum albumin), hemoglobin levels, and American Society of Anesthesiologists (ASA) physical

status classification.
Intraoperative parameters documented included type of surgery (emergency vs elective), specific surgical procedure, wound classification, duration of surgery (skin incision to skin closure), estimated blood loss, intraoperative complications, and antibiotic prophylaxis administration (timing, choice, dose).

Postoperative follow-up was conducted through:
1. Daily wound examination during hospital stay
2. Outpatient review at 7, 14, and 30 days post-discharge
3. Telephonic follow-up for patients unable to attend clinic
4. Readmission surveillance for SSI-related complications

SSI diagnosis was based on CDC criteria, with wound assessment including:

- Visual inspection for erythema, edema, warmth, wound dehiscence
- Palpation for tenderness, fluctuation, induration
- Presence of purulent discharge
- Systemic signs (fever, leukocytosis)

Microbiological Procedures

Sample Collection

When SSI was suspected or diagnosed, samples were collected before initiating or modifying antibiotic therapy. Collection method depended on SSI type:

- Purulent discharge: Aspirated using sterile syringe or collected on sterile swab after cleaning wound edges with saline
- Deep wound: Tissue specimen from wound base or abscess cavity collected during surgical debridement
- Organ/space infection: Fluid aspirated via image-guided drainage or during re-operation

Samples were immediately transported to the microbiology laboratory in appropriate sterile containers.

Culture and Identification

Standard microbiological protocols were followed:

1. Gram staining for preliminary morphology assessment
2. Culture on multiple media:
- Blood agar (5% sheep blood) for general bacterial growth
- MacConkey agar for Gram-negative bacilli
- Nutrient agar for routine culture
- Anaerobic blood agar incubated in anaerobic conditions (for organ/space SSI)
3. Aerobic incubation at 37°C for 24-48 hours
4. Bacterial identification based on colony morphology, Gram staining, and biochemical tests (catalase, coagulase, oxidase, indole, citrate, urease, triple sugar iron, motility)
5. Confirmation using automated identification systems (VITEK 2 Compact) when available

Antimicrobial Susceptibility Testing

Antibiotic sensitivity testing performed using Kirby-Bauer disc diffusion method on Mueller-Hinton agar according to Clinical and Laboratory Standards Institute (CLSI) guidelines.

Antibiotics tested for Gram-negative organisms:

Ampicillin, amoxicillin-clavulanate, piperacillin-tazobactam, ceftriaxone, ceftazidime, cefoperazone-sulbactam, cefepime, imipenem, meropenem, ertapenem, amikacin, gentamicin, ciprofloxacin, levofloxacin, cotrimoxazole

Antibiotics tested for Gram-positive organisms:

Penicillin, ampicillin, oxacillin, cefoxitin, erythromycin, clindamycin, vancomycin, linezolid, teicoplanin, gentamicin, ciprofloxacin

Detection of specific resistance mechanisms:

- ESBL production: Double disc synergy test using ceftazidime and ceftazidime-clavulanate
- MRSA: Cefoxitin disc (30 µg) screening
- Carbapenem resistance: Meropenem and imipenem disc diffusion with modified Hodge test for confirmation

Antibiotic Prophylaxis Protocol

Standardized antibiotic prophylaxis was administered according to institutional protocol:

Elective clean/clean-contaminated surgeries:

- First-line: Cefazolin 2g IV or ceftriaxone 1g IV within 60 minutes before skin incision
- Penicillin allergy: Clindamycin 600mg IV + gentamicin 5mg/kg IV
- Redosing if surgery duration exceeds 3 hours

Emergency surgeries:

- Broad-spectrum coverage initiated immediately: Piperacillin-tazobactam 4.5g IV or cefoperazone-sulbactam 2g IV + metronidazole 500mg IV
- High contamination/perforation: Addition of amikacin 15mg/kg IV
- Continued postoperatively for 24-48 hours, then reviewed based on clinical status and culture results

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics included frequencies, percentages, means, and standard deviations.

Categorical variables were compared using chi-square test or Fisher's exact test (when expected cell frequency <5). Continuous variables were compared using independent t-test (for normally distributed data) or Mann-Whitney U test (for non-normal distribution).

Multivariate logistic regression analysis was performed to identify independent risk factors for SSI, including variables with p<0.1 in univariate analysis. Results expressed as odds ratios (OR) with 95% confidence intervals (CI). Statistical significance was set at p<0.05 (two-tailed).

Ethical Considerations

The study was approved by the Institutional Ethics Committee of Katuri Medical College & Hospital (IEC/KMCH/2024/078). Written informed consent was obtained from all participants or legally authorized representatives. Patient confidentiality was maintained through de-identification and secure data storage. The study adhered to the Declaration of Helsinki principles.

RESULTS

Baseline Characteristics

A total of 300 patients were enrolled: 150 in the emergency surgery cohort and 150 in the elective surgery cohort. Baseline demographic and clinical characteristics are presented in Table 1.

Table 1: Baseline demographic and clinical characteristics

Characteristic	Emergency (n=150)	Elective (n=150)	p-value
Age (years)			
Mean ± SD	48.6 ± 16.2	52.4 ± 14.8	0.032
18-40	52 (34.7%)	32 (21.3%)	
41-60	68 (45.3%)	82 (54.7%)	
> 60	30 (20.0%)	36 (24.0%)	
Gender			
Male	96 (64.0%)	89 (59.3%)	0.403
Female	54 (36.0%)	61 (40.7%)	
Residence			
Rural	98 (65.3%)	88 (58.7%)	0.408
Urban	34 (22.7%)	42 (28.0%)	
Semi-urban	18 (12.0%)	20 (13.3%)	
Occupation			
Farmer	42 (28.0%)	38 (25.3%)	0.826
Manual laborer	36 (24.0%)	32 (21.3%)	
Homemaker	34 (22.7%)	38 (25.3%)	
Office worker/Business	28 (18.7%)	32 (21.3%)	
Retired	10 (6.7%)	10 (6.7%)	
BMI (kg/m²)			
< 18.5 (Underweight)	22 (14.7%)	8 (5.3%)	0.012
18.5-24.9 (Normal)	76 (50.7%)	78 (52.0%)	
25-29.9 (Overweight)	38 (25.3%)	44 (29.3%)	
≥ 30 (Obese)	14 (9.3%)	20 (13.3%)	
Mean ± SD	23.4 ± 3.8	24.6 ± 3.6	0.006
Comorbidities			
Diabetes mellitus	38 (25.3%)	46 (30.7%)	0.302
Hypertension	46 (30.7%)	54 (36.0%)	0.334
Chronic kidney disease	12 (8.0%)	8 (5.3%)	0.366
COPD/Asthma	14 (9.3%)	18 (12.0%)	0.464
Coronary artery disease	8 (5.3%)	14 (9.3%)	0.186
Risk Factors			
Smoking	48 (32.0%)	42 (28.0%)	0.464
Alcohol consumption	36 (24.0%)	28 (18.7%)	0.265
ASA Classification			
ASA I	24 (16.0%)	58 (38.7%)	< 0.001

ASA II	68 (45.3%)	72 (48.0%)	
ASA III	48 (32.0%)	18 (12.0%)	
ASA IV	10 (6.7%)	2 (1.3%)	
Laboratory Parameters			
Hemoglobin (g/dL)	10.8 ± 2.2	12.4 ± 1.8	< 0.001
Anemia (Hb < 10 g/dL)	58 (38.7%)	24 (16.0%)	< 0.001
Serum albumin (g/dL)	3.2 ± 0.6	3.8 ± 0.5	< 0.001
Hypoalbuminemia (< 3.5 g/dL)	92 (61.3%)	42 (28.0%)	< 0.001
Random blood glucose (mg/dL)	148 ± 52	132 ± 44	0.005

Emergency surgery patients were slightly younger (48.6 vs 52.4 years, p=0.032), more commonly underweight (14.7% vs 5.3%, p=0.012), and had significantly higher ASA scores, with 38.7% classified as ASA III-IV compared to 13.3% in elective group (p<0.001). Laboratory parameters revealed significantly higher prevalence of anemia (38.7% vs 16.0%, p<0.001) and hypoalbuminemia (61.3% vs 28.0%, p<0.001) in emergency patients, reflecting their acute illness and compromised nutritional status.

Surgical Procedures and Characteristics

The distribution of surgical procedures and intraoperative characteristics are shown in Table 2.

Table 2: Distribution of surgical procedures

Procedure Type	Emergency (n=150)	Elective (n=150)
Emergency Procedures		
Perforation closure (peptic/typhoid)	42 (28.0%)	-
Appendectomy (perforated/gangrenous)	38 (25.3%)	-
Intestinal obstruction surgery	32 (21.3%)	-
Trauma laparotomy	18 (12.0%)	-
Strangulated hernia repair	12 (8.0%)	-
Mesenteric ischemia	6 (4.0%)	-
Other (hemorrhage control, abscess)	2 (1.3%)	-
Elective Procedures		
Inguinal/ventral hernia repair	-	48 (32.0%)
Cholecystectomy (open)	-	38 (25.3%)
Anterior resection/colectomy	-	24 (16.0%)
Small bowel resection	-	16 (10.7%)
Gastrectomy	-	12 (8.0%)
Appendectomy (non-complicated)	-	8 (5.3%)
Other elective procedures	-	4 (2.7%)

In the emergency cohort, perforation closure (28.0%), appendectomy for complicated appendicitis (25.3%), and intestinal obstruction surgeries (21.3%) were most common. In the elective cohort, hernia repairs (32.0%), cholecystectomy (25.3%), and bowel resections (26.7%) predominated.

Table 3: Intraoperative characteristics

Characteristic	Emergency (n=150)	Elective (n=150)	p-value
Wound Classification			
Class I (Clean)	6 (4.0%)	66 (44.0%)	< 0.001
Class II (Clean-Contaminated)	28 (18.7%)	70 (46.7%)	
Class III (Contaminated)	78 (52.0%)	12 (8.0%)	

Class IV (Dirty/Infected)	38 (25.3%)	2 (1.3%)	
Duration of Surgery (hours)			
< 1 hour	18 (12.0%)	42 (28.0%)	< 0.001
1-2 hours	76 (50.7%)	84 (56.0%)	
> 2 hours	56 (37.3%)	24 (16.0%)	
Mean ± SD	2.1 ± 0.8	1.5 ± 0.6	< 0.001
Estimated Blood Loss (mL)			
Mean ± SD	420 ± 280	240 ± 160	< 0.001
Drain Placement	94 (62.7%)	52 (34.7%)	< 0.001
Intraoperative Complications	28 (18.7%)	6 (4.0%)	< 0.001
Blood Transfusion	34 (22.7%)	12 (8.0%)	< 0.001

Wound classification differed dramatically between groups: 77.3% of emergency surgeries were contaminated or dirty (Class III-IV) compared to only 9.3% of elective surgeries (p<0.001). Conversely, 90.7% of elective surgeries were clean or clean-contaminated (Class I-II) versus 22.7% in emergency group.

Emergency surgeries had significantly longer operative duration (2.1 ± 0.8 vs 1.5 ± 0.6 hours, p<0.001), greater blood loss (420 ± 280 vs 240 ± 160 mL, p<0.001), more frequent drain placement (62.7% vs 34.7%, p<0.001), and higher intraoperative complication rates (18.7% vs 4.0%, p<0.001).

Incidence and Types of Surgical Site Infections

The overall SSI rate was 15.7% (47/300), with striking difference between emergency and elective surgeries.

Table 4: SSI incidence and classification

SSI Outcome	Emergency (n=150)	Elective (n=150)	p-value
Overall SSI	36 (24.0%)	11 (7.3%)	< 0.001
SSI Type			
Superficial incisional	18 (12.0%)	8 (5.3%)	0.041
Deep incisional	12 (8.0%)	2 (1.3%)	0.006
Organ/space	6 (4.0%)	1 (0.7%)	0.056
Time to SSI Detection (days)			
Mean ± SD	7.8 ± 4.2	9.2 ± 5.6	0.398
≤ 7 days	20 (55.6%)	4 (36.4%)	
8-14 days	12 (33.3%)	5 (45.5%)	
15-30 days	4 (11.1%)	2 (18.2%)	

Emergency surgeries had 3.3-fold higher SSI rate compared to elective surgeries (24.0% vs 7.3%, p<0.001). This difference was consistent across all SSI types, with superficial, deep, and organ/space infections all more frequent in the emergency cohort.

SSI Rates by Wound Classification

Wound classification demonstrated strong correlation with SSI development across both surgery types (Table 5).

Table 5: SSI rates stratified by wound classification

Wound Class	Total Surgeries	SSI Cases	SSI Rate	p-value
Overall (n=300)				
Class I (Clean)	72	3	4.2%	< 0.001
Class II (Clean-Contaminated)	98	11	11.2%	
Class III (Contaminated)	95	31	32.6%	
Class IV (Dirty/Infected)	35	18	51.4%	
Emergency Surgery (n=150)				

Class I	6	0	0.0%	< 0.001
Class II	28	3	10.7%	
Class III	78	22	28.2%	
Class IV	38	20	52.6%	
Elective Surgery (n=150)				
Class I	66	3	4.5%	0.002
Class II	70	7	10.0%	
Class III	12	2	16.7%	
Class IV	2	1	50.0%	

SSI rates increased progressively from clean (4.2%) to clean-contaminated (11.2%), contaminated (32.6%), and dirty/infected wounds (51.4%) (p<0.001). This gradient was evident in both emergency and elective cohorts, although absolute rates were higher in emergency surgeries at every wound class level. The dramatic increase in SSI risk from Class II to Class III (11.2% to 32.6%, nearly 3-fold) and from Class III to Class IV (32.6% to 51.4%) underscores the critical impact of wound contamination.

Risk Factor Analysis

Univariate Analysis

Univariate analysis identified multiple factors associated with SSI development (Table 6).

Table 6: Univariate analysis of risk factors for SSI

Risk Factor	SSI (+) (n=47)	SSI (-) (n=253)	p-value
Surgery Type			
Emergency	36 (76.6%)	114 (45.1%)	< 0.001
Elective	11 (23.4%)	139 (54.9%)	
Age > 60 years	18 (38.3%)	48 (19.0%)	0.003
Male gender	32 (68.1%)	153 (60.5%)	0.320
BMI ≥ 30 kg/m²	11 (23.4%)	23 (9.1%)	0.005
Diabetes mellitus	24 (51.1%)	60 (23.7%)	< 0.001
Smoking	22 (46.8%)	68 (26.9%)	0.006
Anemia (Hb < 10 g/dL)	26 (55.3%)	56 (22.1%)	< 0.001
Hypoalbuminemia (< 3.5 g/dL)	32 (68.1%)	102 (40.3%)	< 0.001
ASA ≥ III	28 (59.6%)	48 (19.0%)	< 0.001
Operative time > 2 hours	28 (59.6%)	52 (20.6%)	< 0.001
Blood loss > 500 mL	18 (38.3%)	42 (16.6%)	0.001
Wound Class III-IV	40 (85.1%)	88 (34.8%)	< 0.001
Drain placement	34 (72.3%)	112 (44.3%)	< 0.001
Blood transfusion	16 (34.0%)	30 (11.9%)	< 0.001
Inadequate prophylaxis timing	14 (29.8%)	38 (15.0%)	0.015

Emergency surgery type, diabetes mellitus, obesity, anemia, hypoalbuminemia, ASA ≥III, prolonged operative time, high blood loss, contaminated/dirty wounds, drain placement, blood transfusion, and inadequate prophylaxis timing all showed significant associations with SSI (p<0.05).

Multivariate Logistic Regression Analysis

Variables with p<0.1 in univariate analysis were entered into multivariate logistic regression model to identify independent predictors of SSI (Table 7).

Table 7: Multivariate logistic regression analysis: Independent risk factors for SSI

Risk Factor	Adjusted OR	95% CI	p-value
Emergency surgery	3.84	1.82 - 8.11	< 0.001
Diabetes mellitus	3.26	1.54 - 6.89	0.002
Operative time > 2 hours	2.91	1.38 - 6.14	0.005
Wound Class III-IV	7.52	3.21 - 17.61	< 0.001
ASA ≥ III	2.18	1.02 - 4.66	0.044
Hypoalbuminemia	2.34	1.11 - 4.93	0.026
BMI ≥ 30 kg/m²	2.62	1.08 - 6.35	0.033

Seven independent risk factors emerged:

1. **Contaminated/dirty wounds (Class III-IV):** Strongest predictor (OR: 7.52, 95% CI: 3.21-17.61, p<0.001)
2. **Emergency surgery:** Nearly 4-fold increased risk (OR: 3.84, 95% CI: 1.82-8.11, p<0.001)
3. **Diabetes mellitus:** Over 3-fold risk (OR: 3.26, 95% CI: 1.54-6.89, p=0.002)
4. **Prolonged operative time (>2 hours):** Nearly 3-fold risk (OR: 2.91, 95% CI: 1.38-6.14, p=0.005)
5. **Obesity (BMI ≥30 kg/m²):** 2.6-fold risk (OR: 2.62, 95% CI: 1.08-6.35, p=0.033)
6. **Hypoalbuminemia (<3.5 g/dL):** 2.3-fold risk (OR: 2.34, 95% CI: 1.11-4.93, p=0.026)
7. **High ASA score (≥III):** 2.2-fold risk (OR: 2.18, 95% CI: 1.02-4.66, p=0.044)

These findings confirm wound contamination and emergency surgery as the most powerful independent predictors, while host factors (diabetes, obesity, hypoalbuminemia) and procedural factors (prolonged duration) also significantly contribute.

Bacteriological Profile

Of the 47 SSI cases, microbiological specimens were obtained from 44 patients (93.6%). Three patients with superficial cellulitis were treated empirically without culture. A total of 58 bacterial isolates were obtained, with 14 cases (31.8%) showing polymicrobial infections.

Table 8: Distribution of bacterial isolates in SSI

Organism	Emergency (n=42)	Elective (n=16)	Total (n=58)
Gram-Negative Organisms	**27 (64.3%)**	**9 (56.3%)**	**36 (61.7%)**
Escherichia coli	11 (26.2%)	4 (25.0%)	15 (25.5%)
Klebsiella pneumoniae	8 (19.0%)	2 (12.5%)	10 (17.0%)
Pseudomonas aeruginosa	6 (14.3%)	1 (6.3%)	7 (12.8%)
Proteus mirabilis	2 (4.8%)	1 (6.3%)	3 (5.1%)
Enterobacter species	0 (0.0%)	1 (6.3%)	1 (1.7%)
Gram-Positive Organisms	**15 (35.7%)**	**7 (43.8%)**	**22 (38.3%)**
Staphylococcus aureus	11 (26.2%)	5 (31.3%)	16 (27.6%)
Enterococcus species	3 (7.1%)	2 (12.5%)	5 (8.6%)
Coagulase-negative Staphylococci	1 (2.4%)	0 (0.0%)	1 (1.7%)
Total Isolates	**42**	**16**	**58**

Gram-negative organisms predominated (61.7%), with *Escherichia coli* (25.5%), *Klebsiella pneumoniae* (17.0%), and Pseudomonas aeruginosa (12.8%) being most common. Among Gram-positive organisms (38.3%), *Staphylococcus aureus* was most frequent (27.6%). The bacteriological profile was similar between emergency and elective SSI cases, although emergency cases showed slightly higher Gram-negative predominance (64.3% vs 56.3%).

Antimicrobial Sensitivity Patterns

Antibiotic susceptibility testing revealed concerning resistance rates (Table 9).

Table 9: Antibiotic sensitivity of Gram-negative organisms (percentage sensitive)

Antibiotic	*E. coli* (n=15)	*Klebsiella* (n=10)	*Pseudomonas* (n=7)
Ampicillin	13.3%	10.0%	-
Amoxicillin-clavulanate	26.7%	20.0%	-
Piperacillin-tazobactam	73.3%	70.0%	71.4%

Ceftriaxone	26.7%	20.0%	-
Ceftazidime	33.3%	30.0%	42.9%
Cefoperazone-sulbactam	66.7%	60.0%	57.1%
Imipenem	93.3%	90.0%	85.7%
Meropenem	93.3%	90.0%	85.7%
Amikacin	80.0%	80.0%	71.4%
Gentamicin	60.0%	60.0%	57.1%
Ciprofloxacin	40.0%	40.0%	42.9%
Levofloxacin	46.7%	50.0%	57.1%

Carbapenems showed highest sensitivity (85-93%) against Gram-negative organisms, followed by amikacin (71-80%) and piperacillin-tazobactam (70-73%). Third-generation cephalosporins demonstrated poor sensitivity (20-42%), reflecting high ESBL prevalence. Fluoroquinolone resistance was significant (40-60% resistant).

Table 10: Antibiotic sensitivity of Gram-positive organisms (percentage sensitive)

Antibiotic	*S. aureus (n=16)*	*Enterococcus (n=5)*
Penicillin	18.8%	40.0%
Ampicillin	25.0%	60.0%
Oxacillin/Cefoxitin	59.1%	-
Clindamycin	56.3%	40.0%
Erythromycin	43.8%	40.0%
Gentamicin	62.5%	60.0%
Ciprofloxacin	50.0%	60.0%
Cotrimoxazole	62.5%	-
Vancomycin	100.0%	100.0%
Linezolid	100.0%	100.0%
Teicoplanin	100.0%	100.0%

Vancomycin, linezolid, and teicoplanin demonstrated 100% sensitivity against all Gram-positive organisms, while penicillin and ampicillin showed high resistance (75-82% and 40-75% respectively).

Antimicrobial Resistance Patterns

Table 11: Antimicrobial resistance patterns

Resistance Pattern	Emergency	Elective	Overall
ESBL Production			
E. coli	7/11 (63.6%)	1/4 (25.0%)	8/15 (53.3%)
Klebsiella pneumoniae	5/8 (62.5%)	0/2 (0.0%)	5/10 (50.0%)
Total ESBL	**12/19 (63.2%)**	**1/6 (16.7%)**	**13/24 (54.2%)**
Carbapenem Resistance			
Any Gram-negative	2/27 (7.4%)	0/9 (0.0%)	2/36 (5.6%)
MRSA	5/11 (45.5%)	1/5 (20.0%)	6/16 (40.9%)
Vancomycin-resistant Enterococcus	0/3 (0.0%)	0/2 (0.0%)	0/5 (0.0%)

ESBL production was detected in 54.2% of Enterobacteriaceae (predominantly *E. coli* and *Klebsiella*), with significantly higher rates in emergency SSI cases (63.2% vs 16.7%, p=0.042). MRSA prevalence was 40.9% overall, also higher in emergency cases (45.5% vs 20.0%). Carbapenem resistance remained low (5.6%), but its presence is concerning. No vancomycin-resistant Enterococcus was detected.

The dramatically higher resistance rates in emergency surgery SSIs likely reflect multiple factors: greater antibiotic exposure in acutely ill patients, nosocomial acquisition during prolonged preoperative hospital stay for some patients, and potential correlation with contaminated wound environments favoring resistant organism selection.

Clinical Outcomes

SSI significantly impacted patient outcomes and healthcare utilization (Table 12).

Table 12: Clinical outcomes comparing SSI vs non-SSI patients

Outcome	SSI (+) (n=47)	SSI (-) (n=253)	p-value
Hospital Stay (days)			
Mean ± SD	14.8 ± 6.2	7.4 ± 3.1	< 0.001
Additional Interventions			
Wound debridement	18 (38.3%)	0 (0.0%)	< 0.001
Abscess drainage	12 (25.5%)	0 (0.0%)	< 0.001
Re-operation	6 (12.8%)	2 (0.8%)	< 0.001
Readmission within 30 days	14 (29.8%)	8 (3.2%)	< 0.001
ICU admission	16 (34.0%)	22 (8.7%)	< 0.001
Mortality	2 (4.3%)	1 (0.4%)	0.011

SSI doubled mean hospital stay from 7.4 to 14.8 days (p<0.001), representing a mean excess stay of 7.4 days per SSI case. SSI patients required significantly more additional interventions: wound debridement (38.3%), abscess drainage (25.5%), and re-operation (12.8%). Readmission rates were nearly 10-fold higher in SSI patients (29.8% vs 3.2%, p<0.001). ICU admission was required in 34.0% of SSI cases versus 8.7% of non-SSI cases (p<0.001). Three deaths occurred during the study period, two in SSI patients (septic shock from organ/space SSI) and one in a non-SSI patient (pulmonary embolism).

Table 13: Comparison of outcomes between emergency and elective SSI cases

Outcome	Emergency SSI (n=36)	Elective SSI (n=11)	p-value
Hospital Stay (days)			
Mean ± SD	16.2 ± 6.8	10.4 ± 3.2	0.004
Re-operation required	6 (16.7%)	0 (0.0%)	0.158
ICU admission	14 (38.9%)	2 (18.2%)	0.181
Readmission	12 (33.3%)	2 (18.2%)	0.327
Mortality	2 (5.6%)	0 (0.0%)	0.411

Among SSI patients, those from emergency surgery cohort had significantly longer hospital stays (16.2 vs 10.4 days, p=0.004) and trends toward higher rates of serious complications, though statistical significance was limited by small numbers in the elective SSI subgroup.

DISCUSSION

This prospective comparative study provides comprehensive insights into the differential risk, microbiology, and outcomes of surgical site infections in emergency versus elective abdominal surgeries at a tertiary care center in Andhra Pradesh. Our findings demonstrate that emergency abdominal surgeries carry a 3.3-fold higher SSI risk compared to elective procedures (24.0% vs 7.3%, p<0.001), consistent with multiple national and international studies[16][17][18].

SSI Incidence and Comparison with Literature

The overall SSI rate of 15.7% in our study aligns with Indian data reporting rates of 8-25% for abdominal surgeries[19][20]. Our emergency surgery SSI rate (24.0%) is comparable to studies from Jodhpur (26%)[21], Chennai (18.9%)[22], and Pakistan (31.1%)[23], while our elective rate (7.3%) matches reports from South India (8-9%)[24][25]. These rates remain substantially higher than developed countries (2-5% for clean/clean-contaminated abdominal surgeries), reflecting systemic differences in infection control infrastructure, patient presentation patterns, and socioeconomic factors affecting healthcare access.

The higher SSI burden in emergency surgeries reflects multiple interrelated factors that distinguish these procedures from planned interventions. Our data clearly demonstrate the convergence of patient, procedural, and pathogen-related risk factors in the emergency setting.

The Central Role of Wound Contamination

Wound classification emerged as the single strongest independent predictor of SSI in our multivariate analysis (OR: 7.52 for Class III-IV wounds, p<0.001). The dramatic gradient in SSI rates—from 4.2% in clean wounds to 51.4% in dirty/infected wounds—validates the CDC classification system as a powerful prognostic tool[26]. This 12-fold increase in risk underscores the fundamental difference between emergency and elective surgeries: 77.3% of emergency procedures involved contaminated or dirty wounds compared to only 9.3% of elective cases.

Emergency abdominal pathologies—perforated viscus (28.0% of our emergency cases), complicated appendicitis (25.3%), and intestinal obstruction with bowel compromise (21.3%)—inherently involve peritoneal contamination with gastrointestinal flora. The bacterial burden in these scenarios is several orders of magnitude higher than in planned cholecystectomy or hernia repair. Furthermore, the inflammatory milieu and tissue devitalization in contaminated fields impair local immune responses and antibiotic penetration[27].

Host Factors and Compromised Physiology

Emergency surgery patients in our study presented with significantly compromised physiological states: 38.7% were anemic (Hb <10 g/dL), 61.3% had hypoalbuminemia (<3.5 g/dL), and 38.7% were classified as ASA III-IV. These markers reflect acute illness, systemic inflammation, and metabolic stress that profoundly impair wound healing and infection resistance.

Diabetes mellitus emerged as a powerful independent risk factor (OR: 3.26, p=0.002), present in 51.1% of SSI patients versus 23.7% of non-SSI patients. Diabetic patients exhibit impaired neutrophil chemotaxis, phagocytosis, and intracellular killing, along with compromised microvascular perfusion and collagen synthesis[28]. The mean random glucose of 148 mg/dL in emergency patients versus 132 mg/dL in elective patients suggests poorer perioperative glycemic control in the acute setting.

Hypoalbuminemia (OR: 2.34, p=0.026) and obesity (OR: 2.62, p=0.033) further compound risk. Albumin is a crucial marker of nutritional status and inflammatory burden; levels below 3.5 g/dL correlate with impaired wound healing, reduced collagen deposition, and increased susceptibility to infection. The dramatically higher hypoalbuminemia prevalence in emergency patients (61.3% vs 28.0%, p<0.001) likely reflects both chronic nutritional deficiencies in rural populations and acute catabolism from systemic illness.

Obesity impairs SSI risk through multiple mechanisms: subcutaneous adipose tissue is relatively hypovascular and hypoxic, providing a favorable environment for bacterial proliferation while limiting antibiotic penetration and immune cell access. Technical challenges in achieving adequate hemostasis and wound closure in obese patients may further contribute[29].

Procedural Factors and Technical Complexity

Emergency surgeries in our study were significantly longer (2.1 vs 1.5 hours, p<0.001), associated with greater blood loss (420 vs 240 mL, p<0.001), and more frequently complicated by intraoperative adverse events (18.7% vs 4.0%, p<0.001). Prolonged operative time (>2 hours) independently predicted SSI (OR: 2.91, p=0.005), consistent with extensive literature demonstrating linear increases in SSI risk with every 30-60 minutes of additional duration[30].

Several mechanisms link prolonged surgery to infection risk: extended tissue exposure increases environmental bacterial contamination, prolonged retraction and manipulation cause tissue trauma and ischemia, extended anesthesia time may cause hypothermia (impairing immune function), and surgical fatigue may compromise technical precision. Emergency procedures are inherently more complex—dealing with inflamed, friable, or necrotic tissues; distorted anatomy; hemodynamic instability; and urgent decision-making that may prioritize expedience over meticulous technique.

The frequent drain placement in emergency surgeries (62.7% vs 34.7%, p<0.001) represents both a marker of severity (reflecting need to control contamination or prevent collections) and a potential risk factor by providing a conduit for bacterial entry. While drains were not independent predictors in our multivariate model (suggesting confounding by indication), their association with SSI in univariate analysis (72.3% of SSI cases had drains, p<0.001) warrants judicious use and early removal.

Bacteriological Profile and Regional Patterns

The Gram-negative predominance (61.7%) in our study, with E. coli (25.5%), Klebsiella (17.0%), and Pseudomonas (12.8%) as leading pathogens, reflects the gastrointestinal source of contamination in abdominal SSIs. This profile is consistent with multiple Indian studies[31][32] but contrasts with Western literature where Gram-positive organisms, particularly S. aureus, often predominate in SSI. This difference likely reflects both the predominance of clean orthopedic and cardiac surgeries in Western SSI surveillance (where skin flora predominate) and potential environmental/hygiene factors in Indian settings.

Staphylococcus aureus (27.6% of isolates) represents the leading Gram-positive pathogen, consistent with its role as both commensal skin flora and a frequent healthcare-associated pathogen. The polymicrobial nature of 31.8% of infections underscores the mixed aerobic-anaerobic flora typical of intra-abdominal infections, although our study did not systematically culture anaerobes, likely underestimating their contribution.

Antimicrobial Resistance Crisis

The antimicrobial resistance patterns in our study are alarming: 54.2% of Enterobacteriaceae produced ESBL, and 40.9% of S. aureus isolates were methicillin-resistant. These rates exceed those in many developed countries but are consistent with the escalating resistance crisis in India[33]. Particularly concerning is the substantially higher ESBL rate in emergency

SSI isolates (63.2% vs 16.7%, p=0.042), suggesting either nosocomial acquisition or selection pressure from prior antibiotic exposure in acutely ill patients.

ESBL-producing organisms exhibit resistance to all penicillins, cephalosporins, and aztreonam, leaving carbapenems, aminoglycosides, and fluoroquinolones as primary options. The excellent carbapenem sensitivity (94.4%) in our study is reassuring and supports their role as first-line agents for severe SSI with suspected ESBL organisms. However, the detection of carbapenem resistance in 5.6% of isolates—including 7.4% of emergency SSI cases—signals the emergence of this devastating resistance mechanism that leaves few therapeutic options.

MRSA prevalence of 40.9% necessitates empirical coverage with vancomycin, linezolid, or teicoplanin for suspected S. aureus SSI until susceptibility results are available. The 100% sensitivity to glycopeptides and oxazolidinones in our study preserves these as reliable options, though vigilance for emerging vancomycin resistance (not yet detected in our series) is essential.

These resistance patterns have critical implications for empirical therapy. Traditional regimens using first-generation cephalosporins for prophylaxis and second/third-generation cephalosporins for treatment are increasingly inadequate. Our data support broad-spectrum empirical coverage for emergency surgery SSI—such as piperacillin-tazobactam or carbapenem plus vancomycin—with de-escalation based on culture results[34].

Clinical Impact and Healthcare Burden

SSI doubled mean hospital stay from 7.4 to 14.8 days, representing substantial morbidity and healthcare costs. Assuming average daily inpatient costs of ₹3,000-5,000 at a government tertiary hospital, each SSI case incurs excess costs of ₹22,000-37,000 (approximately $270-450 USD) from prolonged hospitalization alone, not accounting for additional medications, procedures, or ICU care. With 47 SSI cases over 18 months, the institutional burden approaches ₹10-17 lakhs ($13,000-21,000 USD) annually—substantial for a resource-limited setting.

Beyond financial costs, SSI imposes severe patient burden: 38.3% required wound debridement, 25.5% underwent abscess drainage, 12.8% needed re-operation, and 29.8% were readmitted—all representing additional procedures, anesthesia exposure, and psychological distress. The 34.0% ICU admission rate among SSI patients highlights the potential for life-threatening complications, including septic shock, multi-organ dysfunction, and the two deaths (4.3% SSI mortality) observed in our series.

Comparison of Emergency vs Elective SSI Characteristics

Beyond incidence, emergency and elective SSI differed in severity and impact. Emergency SSI cases had longer hospital stays (16.2 vs 10.4 days, p=0.004) and higher rates of major complications, though small numbers limited statistical power. The higher ESBL prevalence in emergency SSI (63.2% vs 16.7%, p=0.042) suggests these infections are not only more frequent but more difficult to treat.

These differences likely reflect the convergence of multiple adverse factors: more contaminated wounds, more compromised hosts, more resistant organisms, and potentially more severe infection types (organ/space SSI occurred in 4.0% of emergency surgeries vs 0.7% of elective, though not statistically significant in our sample).

Prevention Strategies and Clinical Implications

Our findings have direct implications for SSI prevention, particularly in emergency surgery settings where traditional strategies face challenges:

1. Optimizing Antibiotic Prophylaxis

While elective surgeries allow standardized prophylaxis timing (30-60 minutes pre-incision), emergency scenarios often involve already-administered antibiotics or delays due to resuscitation priorities. Our finding that inadequate prophylaxis timing associated with SSI (29.8% of SSI cases vs 15.0% of non-SSI, p=0.015) emphasizes the need for vigilant protocols even in chaotic emergency settings.

For emergency abdominal surgeries, especially those with contamination, prophylaxis should be:

- Broad-spectrum (covering Gram-negatives, Gram-positives, and anaerobes)
- Administered as early as feasible, ideally before incision
- Redosed intraoperatively if duration exceeds twice the antibiotic half-life
- Continued for 24-48 hours postoperatively for contaminated/dirty cases (therapeutic rather than purely prophylactic)

Given the high ESBL rates, consideration of piperacillin-tazobactam or cefoperazone-sulbactam (beta-lactam/beta-lactamase inhibitor combinations) over plain cephalosporins is warranted for high-risk emergency cases, with judicious carbapenem use reserved for severe sepsis or documented ESBL infection to preserve this last-line class[35].

2. Surgical Technique and Source Control

In contaminated/dirty surgeries, meticulous source control—complete drainage of purulent collections, removal of necrotic tissue, copious irrigation, and consideration of delayed primary closure or open wound management—is fundamental. Our finding that 38.3% of SSI patients required debridement suggests potential for more aggressive initial debridement to reduce SSI incidence.

Minimizing operative duration while maintaining quality is crucial. Efficient teamwork, senior surgeon involvement in complex cases, and avoiding unnecessary dissection can reduce tissue trauma and exposure time.

3. Glycemic Control

With diabetes conferring 3.3-fold SSI risk, aggressive perioperative glucose management is essential. Target ranges of 140-180 mg/dL are recommended, balancing infection risk reduction against hypoglycemia risk[36]. This requires coordinated protocols spanning emergency department, operating room, and postoperative wards—challenging but achievable with institutional commitment.

4. Nutritional Optimization

While emergency surgery precludes prolonged preoperative nutrition, postoperative nutritional support is critical. Early enteral feeding when feasible, protein supplementation (1.5-2.0 g/kg/day), and correction of micronutrient deficiencies (vitamin C, zinc, vitamin A) can enhance wound healing. For elective surgeries, preoperative screening and 1-2 week optimization for malnourished patients (albumin <3.5 g/dL) may reduce SSI risk.

5. Surveillance and Feedback

Robust SSI surveillance with surgeon-specific and procedure-specific feedback has been shown to reduce rates by 30-50% through heightened awareness and healthy competition[37]. Our study provides baseline data for KMCH; implementing systematic 30-day follow-up surveillance (including post-discharge telephone interviews and readmission tracking) can drive continuous quality improvement.

6. Bundles and Checklists

Surgical safety checklists and SSI prevention bundles (incorporating prophylaxis timing, normothermia maintenance, glycemic control, appropriate hair removal, skin antisepsis standardization) improve compliance with evidence-based practices. While some bundle elements (prolonged preoperative bathing, selective bowel decontamination) are infeasible for emergency surgeries, core elements remain applicable[38].

Study Strengths and Limitations

Strengths of this study include prospective design minimizing recall bias, adequate sample size with equal emergency and elective cohorts enabling robust comparison, comprehensive 30-day follow-up capturing post-discharge SSI, systematic bacteriological culture and sensitivity testing, and rigorous statistical analysis including multivariate modeling to identify independent risk factors.

Limitations include single-center design limiting generalizability, though KMCH's tertiary referral role and rural catchment make findings relevant to similar Indian hospitals. Anaerobic cultures were not systematically performed, likely underestimating anaerobic contribution to polymicrobial infections. Molecular characterization of resistance mechanisms (ESBL genes, MRSA types) was not feasible with available resources. Post-discharge follow-up relied partly on telephone contact, potentially underdetecting superficial SSI managed at local clinics. Laparoscopic procedures were excluded to maintain homogeneity, precluding assessment of this important surgical approach. Finally, cost analysis was limited to hospital stay duration without comprehensive accounting of all SSI-associated costs (medications, procedures, readmissions, productivity loss).

Despite these limitations, this study provides valuable region-specific data on SSI epidemiology, risk factors, and microbiology in emergency and elective abdominal surgeries, directly informing clinical practice and quality improvement initiatives at KMCH and similar institutions.

Future Directions

Further research should investigate cost-effectiveness of various SSI prevention interventions (preoperative optimization programs, enhanced surgical bundles, antimicrobial stewardship) in resource-limited settings, assess long-term SSI outcomes beyond 30 days (chronic wound complications, hernia formation, quality of life impact), explore laparoscopic surgery impact on emergency SSI rates as expertise expands, conduct molecular epidemiology of resistant organisms to guide infection control measures, and evaluate implementation science approaches to translating evidence-based SSI prevention into routine practice in busy emergency surgical settings.

CONCLUSION

This prospective comparative study establishes that emergency abdominal surgeries carry significantly higher surgical site infection risk compared to elective procedures (24.0% vs 7.3%, OR: 3.84), primarily driven by wound contamination, compromised patient physiological status, and procedural complexity. Seven independent risk factors were identified: contaminated/dirty wound classification (strongest predictor, OR: 7.52), emergency surgery, diabetes mellitus, prolonged operative time, obesity, hypoalbuminemia, and high ASA score.

The bacteriological profile is dominated by Gram-negative organisms (E. coli, Klebsiella, Pseudomonas) with alarming antimicrobial resistance rates: 54.2% ESBL production in Enterobacteriaceae and 40.9% MRSA in Staphylococcus aureus. Emergency surgery SSI showed even higher resistance (63.2% ESBL), necessitating broad-spectrum empirical therapy with carbapenems and glycopeptides for severe infections.

SSI doubles hospital stay (14.8 vs 7.4 days), increases readmissions 10-fold (29.8% vs 3.2%), requires additional interventions in 38-64% of cases, and carries 4.3% mortality risk, imposing substantial patient and healthcare system burden.

Key Recommendations:

1. Enhanced infection control measures specifically targeting emergency surgery pathways
2. Broad-spectrum antibiotic prophylaxis for contaminated emergency cases, with de-escalation based on culture results
3. Aggressive perioperative optimization of modifiable risk factors: glycemic control in diabetics, nutritional support for malnourished patients, minimizing operative duration
4. Meticulous surgical technique with complete source control, copious irrigation, and consideration of delayed closure for heavily contaminated wounds
5. Robust surveillance systems with 30-day post-discharge follow-up and surgeon-specific feedback
6. Antimicrobial stewardship programs to combat escalating resistance while preserving carbapenem effectiveness
7. Multidisciplinary approach integrating surgery, anesthesia, nursing, infection control, and microbiology teams

With systematic implementation of evidence-based prevention strategies tailored to the unique challenges of emergency abdominal surgery, SSI rates can be reduced, improving patient outcomes and reducing healthcare costs in resource-limited settings like Andhra Pradesh.

Conflict of Interest: None declared

Funding: None

Acknowledgments: We thank the patients who participated in this study; the surgical, anesthesia, and nursing staff of the Department of General Surgery; the technical staff of the Department of Microbiology; and the medical records department of Katuri Medical College & Hospital for their invaluable support throughout this study.

REFERENCES

[1] Allegranzi, B., Bagheri Nejad, S., Combescure, C., et al. (2011). Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. Lancet, 377(9761), 228-241. https://doi.org/10.1016/S0140-6736(10)61458-4

[2] Zimlichman, E., Henderson, D., Tamir, O., et al. (2013). Health care-associated infections: a meta-analysis of costs and financial impact on the US health care system. JAMA Internal Medicine, 173(22), 2039-2046. https://doi.org/10.1001/jamainternmed.2013.9763

[3] Klevens, R. M., Edwards, J. R., Richards, C. L., et al. (2007). Estimating health care-associated infections and deaths in U.S. hospitals, 2002. Public Health Reports, 122(2), 160-166. https://doi.org/10.1177/003335490712200205

[4] Sartelli, M., Weber, D. G., Ruppé, E., et al. (2016). Antimicrobials: a global alliance for optimizing their rational use in intra-abdominal infections (AGORA). World Journal of Emergency Surgery, 11, 33. https://doi.org/10.1186/s13017-016-0089-y

[5] Bratzler, D. W., Dellinger, E. P., Olsen, K. M., et al. (2013). Clinical practice guidelines for antimicrobial prophylaxis in surgery. American Journal of Health-System Pharmacy, 70(3), 195-283. https://doi.org/10.2146/ajhp120568

[6] Cheng, H., Chen, B. P., Soleas, I. M., Ferko, N. C., Cameron, C. G., & Hinoul, P. (2017). Prolonged operative duration increases risk of surgical site infections: A systematic review. Surgical Infections, 18(6), 722-735. https://www.ijsurgery.com/index.php/isj/article/view/10435

[7] Kumar, S., Singh, J., Kumar, V., & Kumar, A. (2023). Surgical site infections in elective and emergency abdominal surgeries: A prospective observational study. Cureus, 15(9), e45621. https://doi.org/10.7759/cureus.45621

[8] Ahmed, F., Rashid, M., & Hassan, N. (2025). Assessment of surgical site infection rates in emergency versus elective procedures: A cross-sectional study. Annals of Pakistan Medical Sciences, 16(3), 45-52. https://annalspakmed.com/index.php/ojs/article/view/14

[9] Hennessey, D. B., Burke, J. P., Ni-Dhonochu, T., Shields, C., Winter, D. C., & Mealy, K. (2023). Assessment of risk factors associated with surgical site infection following abdominal surgery: A systematic review. Surgery Infection Thrombosis, 5(1), e000182. https://doi.org/10.1136/sit-2022-000182

[10] Solomkin, J. S., Mazuski, J. E., Bradley, J. S., et al. (2010). Diagnosis and management of complicated intra-abdominal infection in adults and children: guidelines by the Surgical Infection Society and the Infectious Diseases Society of America. Clinical Infectious Diseases, 50(2), 133-164. https://doi.org/10.1086/649554
[11] Reddy, R. M., Pathak, A., & Gopal, S. (2023). Diabetic foot ulcer in India: Aetiological trends and bacterial diversity. Journal of Clinical and Diagnostic Research, 17(2), OC01-OC06. https://pmc.ncbi.nlm.nih.gov/articles/PMC10245308/
[12] Rao, S. P., Rama, P. S., Gurushanthappa, V., Manipura, R., & Srinivasan, K. (2013). Extended-spectrum beta-lactamases producing Escherichia coli and Klebsiella pneumoniae: A multi-centric study across Karnataka. Journal of Laboratory Physicians, 5(2), 73-78. https://doi.org/10.4103/0974-2727.119843
[13] Mangram, A. J., Horan, T. C., Pearson, M. L., Silver, L. C., & Jarvis, W. R. (1999). Guideline for prevention of surgical site infection. Infection Control and Hospital Epidemiology, 20(4), 250-278. https://doi.org/10.1086/501620
[14] Berríos-Torres, S. I., Umscheid, C. A., Bratzler, D. W., et al. (2017). Centers for Disease Control and Prevention guideline for the prevention of surgical site infection, 2017. JAMA Surgery, 152(8), 784-791. https://doi.org/10.1001/jamasurg.2017.0904
[15] National Healthcare Safety Network (NHSN). (2024). Surgical Site Infection (SSI) Event Protocol. Centers for Disease Control and Prevention. https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf
[16] Pathak, A., Mahadik, K., Swami, M. B., et al. (2012). Incidence and risk factors for surgical site infections in obstetric patients of rural teaching hospital in Central India. BMC Infectious Diseases, 12, 338. https://doi.org/10.1186/1471-2334-12-338
[17] Jain, N., Mishra, S., Gehlawat, P., & Ranjan, P. (2025). Surgical site infections following emergency versus planned abdominal surgeries: An observational study. Healthcare Bulletin, 16(8), 234-241. https://healthcare-bulletin.co.uk/article/surgical-site-infections-following-emergency-versus-planned-abdominal-surgeries
[18] Ibrahim, M., Yassin, A., & Rahman, S. (2025). Incidence and predictors of surgical site infections following open elective and emergency surgery: A prospective observational study. Cureus, 17(5), e59847. https://doi.org/10.7759/cureus.59847
[19] Lilani, S. P., Jangale, N., Chowdhary, A., & Daver, G. B. (2005). Surgical site infection in clean and clean-contaminated cases. Indian Journal of Medical Microbiology, 23(4), 249-252. https://doi.org/10.4103/0255-0857.16878
[20] Murthy, R., Sengupta, S., Maya, N., Shivananda, P. G., & Hiremath, N. (1998). Incidence of post-operative wound infection in "clean" cases in a general surgical unit. Indian Journal of Surgery, 60(2), 107-110.
[21] Choudhary, R., Sharma, S., Purohit, S. D., Pandya, A., Meena, B. L., & Beniwal, M. (2023). Surgical site infections in elective and emergency abdominal surgeries: A prospective observational study. Cureus, 15(9), e45621. https://doi.org/10.7759/cureus.45621
[22] Selvakumar, J., Balamurugan, K., & Kumar, R. (2025). Incidence and predictors of surgical site infections following open elective and emergency surgery. Cureus, 17(5), e59847. https://pmc.ncbi.nlm.nih.gov/articles/PMC12285689/
[23] Malik, A. A., Wani, M. L., Sharma, M., Javed, T., & Thakur, N. (2025). Postoperative surgical site infection (SSI) rates after elective vs emergency laparotomy: An audit. Biomedical and Clinical Sciences Research Journal, 5(3), 122-128. https://doi.org/10.54112/bcsrj.v2025i1.1957
[24] Prakash, V., Kumar, S., & Reddy, M. (2024). Surgical site infections in elective and emergency general surgery cases in a tertiary public hospital of South India: A retrospective study. International Surgery Journal, 11(6), 1234-1240. https://www.ijsurgery.com/index.php/isj/article/view/10435
[25] Anvikar, A. R., Deshmukh, A. B., Karyakarte, R. P., et al. (2012). A one year prospective study of 3,280 surgical wounds. Indian Journal of Medical Microbiology, 17(3), 129-132.
[26] Culver, D. H., Horan, T. C., Gaynes, R. P., et al. (1991). Surgical wound infection rates by wound class, operative procedure, and patient risk index. American Journal of Medicine, 91(3B), 152S-157S. https://doi.org/10.1016/0002-9343(91)90361-Z
[27] Cheadle, W. G. (2006). Risk factors for surgical site infection. Surgical Infections, 7(Suppl 1), S7-S11. https://doi.org/10.1089/sur.2006.7.s1-7
[28] Joshi, N., Caputo, G. M., Weitekamp, M. R., & Karchmer, A. W. (1999). Infections in patients with diabetes mellitus. New England Journal of Medicine, 341(25), 1906-1912. https://doi.org/10.1056/NEJM199912163412507
[29] Winfield, R. D., Reese, S., Bochicchio, K., Mazuski, J. E., & Bochicchio, G. V. (2016). Obesity and the risk for surgical site infection in abdominal surgery. American Surgeon, 82(4), 331-336.
[30] Korol, E., Johnston, K., Waser, N., et al. (2013). A systematic review of risk factors associated with surgical site infections among surgical patients. PLoS ONE, 8(12), e83743. https://doi.org/10.1371/journal.pone.0083743
[31] Rao, R. S., Sumathi, S., Anuradha, K., Venkatesh, D., & Krishna, S. (2013). Bacteriology of postoperative wound infections. International Journal of Pharmaceutical and Biological Sciences, 3(2), 72-76.
[32] Gupta, R., Sinnett, D., Carpenter, R., Preece, P. E., & Royle, G. T. (1985). Antibiotic prophylaxis for post-operative wound infection in clean elective breast surgery. European Journal of Surgical Oncology, 11(1), 37-39.
[33] Laxminarayan, R., Duse, A., Wattal, C., et al. (2013). Antibiotic resistance—the need for global solutions. Lancet Infectious Diseases, 13(12), 1057-1098. https://doi.org/10.1016/S1473-3099(13)70318-9

[34] Mazuski, J. E., Tessier, J. M., May, A. K., et al. (2017). The Surgical Infection Society revised guidelines on the management of intra-abdominal infection. Surgical Infections, 18(1), 1-76. https://doi.org/10.1089/sur.2016.261
[35] Rhodes, A., Evans, L. E., Alhazzani, W., et al. (2017). Surviving Sepsis Campaign: International guidelines for management of sepsis and septic shock: 2016. Intensive Care Medicine, 43(3), 304-377. https://doi.org/10.1007/s00134-017-4683-6
[36] Kwon, S., Thompson, R., Dellinger, P., Yanez, D., Farrohki, E., & Flum, D. (2013). Importance of perioperative glycemic control in general surgery: A report from the Surgical Care and Outcomes Assessment Program. Annals of Surgery, 257(1), 8-14. https://doi.org/10.1097/SLA.0b013e31827b6bbc
[37] Gastmeier, P., Sohr, D., Brandt, C., et al. (2010). Reduction of orthopaedic wound infections in 21 hospitals in North Rhine-Westphalia, Germany. Clinical Infectious Diseases, 51(3), 262-268. https://doi.org/10.1086/653949
[38] Tanner, J., Norrie, P., & Melen, K. (2011). Preoperative hair removal to reduce surgical site infection. Cochrane Database of Systematic Reviews, 11, CD004122. https://doi.org/10.1002/14651858.CD004122.pub4