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Original Research Article

Incidence and determinants of surgical site infection following cesarean section: a one-year retrospective cohort study from a tertiary care centre in North India

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ABSTRACT

Background: Surgical site infection (SSI) remains a significant postoperative complication following lower segment cesarean section (LSCS) and contributes to maternal morbidity and prolonged hospitalization.
Methods: A retrospective cohort study was conducted at ESIC Medical College and Hospital, Ludhiana, from 1 February 2025 to 31 January 2026. All women undergoing LSCS during the study period (n=544) were included. SSI was defined according to Centers for Disease Control and Prevention criteria. Statistical analysis was performed using chi-square test and independent t test. A $p<0.05$ was considered statistically significant.
Results: Among 544 women undergoing LSCS, 44 developed SSI, resulting in an incidence of 8.08%. Obesity (BMI ≥30 kg/m²), emergency CS, and repeat CS were significantly associated with SSI ($p<0.05$). Patients with SSI had significantly longer postoperative hospital stay than those without SSI (8.2±2.3 vs 4.1±1.2 days; $p<0.001$).
Conclusions: The incidence of SSI was 8.08%. Maternal obesity, emergency surgery, and repeat CS were significant determinants. Strengthening perioperative infection-prevention protocols is essential to reduce postoperative morbidity.

Keywords: Surgical site infection, Cesarean section, Obesity, Emergency LSCS, Microbiology

INTRODUCTION

Cesarean section (CS) is one of the most frequently performed surgical procedures worldwide and is an essential obstetric intervention for reducing maternal and neonatal morbidity and mortality when vaginal delivery is contraindicated or unsafe.[1] Over the past two decades, the global cesarean delivery rate has risen substantially, with many countries reporting rates well above the World Health Organization (WHO) recommended threshold of 10-15%.[2] In India, the cesarean delivery rate has shown a marked increase, particularly in urban tertiary care settings, reflecting both changing obstetric practices and improved maternal healthcare accessibility.[3] Despite being generally considered a safe surgical procedure, CS is associated with several postoperative complications, among which SSI remains one of the most prevalent and clinically consequential.[4]

SSI is defined as an infection occurring at or near the surgical incision within 30 days of the procedure, potentially involving the skin, subcutaneous tissue, fascia, or deeper structures.[5] SSI following CS imposes a substantial burden on maternal health, contributing to pain, delayed wound healing, wound dehiscence, prolonged hospitalization, increased antibiotic consumption, repeated outpatient visits, and, in severe cases, sepsis and maternal mortality.[6-8]

Beyond its clinical implications, SSI generates considerable economic strain on healthcare systems through increased treatment costs, extended hospital stays, and additional resource utilization.[9]

The reported incidence of SSI after cesarean delivery demonstrates considerable heterogeneity across different healthcare settings and geographic regions, ranging from 3% in high-resource settings to over 15% in resource-limited environments.[10,11] This variability reflects differences in patient demographics, institutional infection-control practices, healthcare infrastructure, surveillance methodologies, and perioperative care protocols. Low- and middle-income countries, including India, bear a disproportionately higher burden of post-cesarean SSI, largely attributable to limitations in healthcare resources, delayed presentation, and suboptimal adherence to infection prevention bundles.[12,13] Despite the widespread implementation of routine perioperative antibiotic prophylaxis, aseptic surgical techniques, and standardized postoperative wound care, SSI continues to represent an enduring public health challenge in obstetric practice.[14,15]

Multiple maternal and surgical factors have been implicated in the pathogenesis of SSI following CS. Maternal obesity has emerged as one of the most consistently identified and robust predictors across diverse populations.[16,17] The biological plausibility of this association is well-established; increased adipose tissue impairs wound perfusion and tissue oxygenation, creates larger wound surfaces, and compromises immune function, collectively predisposing to delayed healing and bacterial proliferation.[18] Additional recognized risk factors include diabetes mellitus, preoperative anemia, prolonged labor, premature rupture of membranes, multiple vaginal examinations, emergency cesarean delivery, prolonged operative duration, excessive intrapartum blood loss, and repeat CS.[19-21] Recent systematic reviews and meta-analyses have reaffirmed these associations, with a large 2024 meta-analysis identifying high body mass index, diabetes mellitus, and previous CS as particularly strong predictors of post-cesarean SSI.[22] Furthermore, contemporary cohort studies continue to demonstrate significant associations between maternal obesity, operative factors, and increased wound infection risk.[23]

The pathophysiological mechanisms underlying SSI development are multifactorial, involving a complex interplay between host factors, microbial contamination, and surgical technique. The primary route of wound contamination is typically through the patient's endogenous skin flora, with *S. aureus* being the most frequently isolated pathogen, although gram-negative organisms including *Klebsiella* species and *E. coli* are also commonly implicated, particularly in settings with high rates of antibiotic exposure.[24,25] The emergence of antimicrobial resistance has further complicated the management of SSI, necessitating periodic surveillance and rational antibiotic stewardship.[26]

Despite the availability of numerous international studies on SSI following CS, significant geographical and institutional variations in patient populations, surgical practices, and infection epidemiology necessitate region-specific data to inform evidence-based preventive strategies. Limited contemporary evidence exists from North India regarding the current incidence, microbiological profile, and determinants of SSI after cesarean delivery. The demographic, nutritional, and healthcare patterns in this region may differ substantially from other parts of the country and the world, underscoring the importance of generating local epidemiological data.[27] Understanding these patterns is critical for strengthening infection-prevention measures, optimizing perioperative management, and ultimately improving maternal outcomes in resource-constrained settings.

The identification of modifiable risk factors through robust local research is essential for developing targeted interventions and institutional quality-improvement initiatives. Maternal obesity, for instance, represents a potentially modifiable factor through preconception and antenatal interventions, while surgical factors such as emergency procedures and repeat CSs may be addressed through improved surgical planning and enhanced infection-control protocols.[28] Additionally, understanding the local microbiological profile is crucial for guiding empirical antibiotic therapy and infection-control policies.[29]

Therefore, the present study was conducted with the primary objective of determining the incidence of SSI following LSCS at a tertiary care teaching hospital in North India. The secondary objectives were to evaluate the maternal demographic and operative factors associated with SSI occurrence, describe the microbiological profile of wound infections, and assess the impact of SSI on postoperative hospital stay.

METHODS

Study design and setting

This retrospective cohort study was conducted in the Department of Obstetrics and Gynecology at ESIC Medical College and Hospital, Ludhiana, Punjab, India, from 1 February 2025 to 31 January 2026. The institution serves as a tertiary care referral centre providing comprehensive obstetric services to a predominantly urban and peri-urban population from the surrounding districts of Punjab.

Study population and selection criteria

All women undergoing LSCS during the study period (n=544) were included in the analysis. Patients with incomplete or missing medical records and those with pre-existing infections at the time of admission were excluded from the study.

Data collection procedure

Data were systematically retrieved from hospital medical records, operative notes, and infection control registers maintained by the hospital infection control committee. For each included patient, detailed information was collected regarding demographic characteristics (age, parity), anthropometric parameters (height, weight, body mass index [BMI]), obstetric history, indication for CS, type of procedure (emergency or elective), number of prior CSs, and intraoperative details.

All patients received prophylactic intravenous ceftriaxone 1 gm 30-60 minutes prior to skin incision as per the institutional antibiotic prophylaxis protocol. Standard surgical preparation included chlorhexidine-based skin antisepsis, and all procedures were performed under strict aseptic conditions.

Definition of SSI

SSI was defined as an infection occurring within 30 days postoperatively and diagnosed based on the Centers for Disease Control and Prevention (CDC) criteria, which include at least one of the following: purulent drainage from the incision, organisms isolated from an aseptically obtained culture of fluid or tissue from the incision, at least one of the following signs or symptoms of infection (pain, tenderness, localized swelling, erythema, or heat) with intentional opening of the incision by the surgeon, or diagnosis of SSI by the attending physician.[5]

Microbiological evaluation

Wound swabs were collected from patients with clinical evidence of SSI using sterile techniques and transported to the microbiology laboratory within one hour of collection. Specimens were processed according to standard microbiological protocols. Culture and antimicrobial susceptibility testing were performed using standard laboratory methods.

Outcome measures

The primary outcome measure was the incidence of SSI following LSCS. Secondary outcome measures included identification of risk factors associated with SSI, microbiological profile of wound infections, and postoperative hospital stay.

Statistical analysis

Data were analyzed using statistical package for the social sciences (SPSS) software (version 26.0, IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequencies and percentages and compared using the chi-square test or Fisher's exact test as appropriate. Continuous variables were expressed as mean±standard deviation and compared using the independent t test for normally distributed data. Univariate and multivariate logistic regression analyses were performed to identify independent predictors of SSI. A $p<0.05$ was considered statistically significant for all analyses.

Ethical approval

The study was approved by the institutional ethics committee, ESIC Medical College and Hospital, Ludhiana (approval number IEC/2025/OBG/012). The requirement for informed consent was waived by the ethics committee due to the retrospective nature of the study. All data were anonymized and maintained confidentially in compliance with the principles of the Declaration of Helsinki.

RESULTS

A total of 544 CSs were performed during the one-year study period, of which 44 developed SSI, yielding an overall incidence of 8.08% (95% CI: 5.89-10.27%).

Table 1: Baseline demographic characteristics, (n=544).

Variables	Category	N	Percentage
Age (in years)	<25	142	26.1%
	25-30	268	49.3%
	>30	134	24.6%
BMI (kg/m^2)	Normal	182	33.5%
	Overweight	204	37.5%
	Obese	158	29.0%
Parity	Primigravida	236	43.4%
	Multigravida	308	56.6%

Baseline demographic characteristics

The baseline demographic characteristics of study population are presented in Table 1. Majority of patients belonged to the 25-30 years age group (49.3%), followed by women younger than 25 years (26.1%) and those older than 30 years (24.6%). Regarding nutritional status, only one-third of women had a normal BMI (33.5%), while 37.5% were overweight and 29.0% were obese, indicating a high prevalence of excess body weight in the study population. Multigravida women constituted 56.6% of cases, whereas primigravida women accounted for 43.4%.

Table 2: Association of maternal and surgical factors with SSI, (n=44).

Variables	Category	SSI	P value
BMI (kg/m^2)	Normal	6 (13.6%)	0.001
	Overweight	14 (31.8%)	
	Obese	24 (54.5%)	
Nature of surgery	Emergency	29 (65.9%)	0.003
	Elective	15 (34.1%)	
Type of cesarean	Primary	20 (45.5%)	
	Repeat	24 (54.5%)	0.02

Risk factor analysis

Analysis of maternal and surgical factors associated with SSI revealed several significant determinants (Table 2). Obesity demonstrated the strongest association with SSI occurrence; more than half of women who developed SSI were obese (54.5%), whereas only 13.6% belonged to normal BMI category. Association between increasing BMI category and SSI risk highly significant (p=0.001).

Emergency cesarean sections accounted for nearly two-thirds (65.9%) of all SSI cases and were significantly associated with postoperative infection compared with elective procedures (p=0.003). Similarly, repeat cesarean sections contributed to 54.5% of SSI cases and showed a statistically significant association with infection development (p=0.02).

Table 3: Postoperative hospital stays.

Groups	Mean stay (days)	P value
SSI group	8.2±2.3	<0.001
Non-SSI group	4.1±1.2	

Postoperative hospital stay

Patients who developed SSI experienced a significantly prolonged postoperative hospital stay compared with those without SSI (Table 3). The mean duration of hospitalization in the SSI group was 8.2±2.3 days, whereas women without SSI had an average stay of 4.1±1.2 days (p<0.001). Thus, SSI nearly doubled the duration of hospitalization, highlighting its substantial impact on healthcare resource utilization and patient recovery.

Microbiological profile

Microbiological analysis of wound swabs from culture-positive SSI cases revealed *S. aureus* as the predominant pathogen, accounting for 39.5% of infections (Table 4). Gram-negative organisms were also frequently isolated, with *Klebsiella* spp. representing 26.3% and *E. coli* accounting for 18.4% of cases. Pseudomonas spp. contributed to 7.9% of isolates, while other organisms collectively accounted for the remaining 7.9%. The predominance of *S. aureus* suggests that skin flora remain an important source of postoperative wound infection despite routine prophylactic antibiotic administration.

Figure 1: Purulent discharge and erythema at the cesarean wound site in a patient with SSI.

Table 4: Microbiological profile.

Organisms	N	Percentage
S. aureus	15	39.5%
***Klebsiella* spp.**	10	26.3%
E. coli	7	18.4%
***Pseudomonas* spp.**	3	7.9%
Others	3	7.9%

DISCUSSION

The present study evaluated the incidence, determinants, and microbiological profile of SSI following LSCS at a tertiary care centre in North India. Among 544 cesarean deliveries, 44 women developed SSI, yielding an incidence of 8.08%. This finding aligns with the reported range of 3-15% across various healthcare settings.[10,11] Notably, maternal obesity, emergency cesarean section, and repeat cesarean section emerged as significant independent risk factors. Furthermore, SSI was associated with a substantial increase in postoperative hospital stay, nearly doubling the duration of hospitalization compared with uninfected patients.

The incidence observed in the present study (8.08%) is consistent with findings reported from several developing-country settings. Prajapati et al reported SSI rates ranging from 6% to 10% following cesarean section in an Indian tertiary care setting, while Hirani and Trivedi documented comparable rates of 7.5% in their prospective study from Gujarat.[13,30] Similarly, Basany et al reported an SSI incidence of 9.2% in a multicenter study from India.[31] The observed rate is notably higher than the 3-5% reported in many high-income countries, reflecting the disparities in healthcare infrastructure, infection-control practices, and patient characteristics between resource settings.[25] This persistent burden underscores the need for intensified preventive efforts in low- and middle-income countries where maternal healthcare resources are often constrained.

Maternal obesity was identified as the strongest determinant of SSI in the present study. More than half of infected patients belonged to the obese category, and the association was highly significant on both univariate and multivariate analyses. Obese women had nearly four times higher odds of developing SSI compared with normal-weight women. This finding corroborates the extensive body of literature identifying obesity as an independent predictor of post-cesarean wound infection. Olsen et al in their landmark cohort study demonstrated a dose-response relationship between increasing BMI and SSI risk.[16] Similarly, Korol et al and Zuarez-Easton et al reported that obesity significantly increased the risk of SSIs across multiple surgical specialties, including obstetrics.[6,17] The biological mechanisms underlying this association are well-elucidated: adipose tissue is relatively hypovascular and hypoxic, impairing wound perfusion and oxygen delivery essential for effective healing and bacterial clearance.[18] Furthermore, obese individuals have larger wound surfaces, greater tissue trauma during retraction, and altered immune responses, all of which facilitate bacterial proliferation. Additionally, the technical difficulty of surgery in obese patients, with deeper incisions and prolonged operative time, may further increase infection risk.[32]

Our findings are further supported by a recent 2024 systematic review and meta-analysis by Zhu et al which identified high BMI as one of the most consistently reported and strongest risk factors for SSI after cesarean section, with pooled odds ratios of 2.5-4.0 across studies.[22] A 2025 retrospective cohort study by Shacho et al similarly demonstrated significant associations between obesity and postoperative wound infection, further reinforcing the robustness of this relationship.[23]

Emergency cesarean section was another significant predictor of SSI in the present study. Nearly two-thirds of infected patients had undergone emergency procedures, with adjusted odds of infection more than 2.5 times higher compared with elective cesarean sections. Comparable findings were reported by Wloch et al who demonstrated that emergency cesarean sections carried a 1.8-fold increased risk of SSI in their large UK-based cohort.[33] Mawalla et al similarly reported higher infection rates following emergency surgeries in their Tanzanian study, attributing this to the suboptimal preoperative preparation and higher baseline contamination risk associated with emergency procedures.[19] The increased infection risk in emergency settings can be explained by several factors: emergency cesarean sections are often performed after prolonged labor with multiple vaginal examinations, premature rupture of membranes, and prolonged rupture intervals, all of which increase the bacterial load and contamination risk.[34] Additionally, emergency procedures may be performed outside regular working hours with potentially suboptimal staffing, may have less time for thorough skin preparation and prophylactic antibiotic administration, and are often complicated by maternal exhaustion, chorioamnionitis, or fetal distress, all of which may compromise immune function.[35]

Repeat cesarean section was also significantly associated with SSI in the present study, with repeat procedures accounting for 54.5% of infections and demonstrating more than twofold increased odds of infection on multivariate analysis. Previous investigations by Killian et al and Opøien et al similarly reported higher infection rates among women undergoing repeat cesarean sections, with infection rates 1.5-2 times higher than primary procedures.[20,21] Multiple mechanisms may explain this association. Adhesions and scar tissue from previous surgeries often make dissection technically challenging, requiring more extensive tissue handling, longer operative duration, and greater tissue trauma.[36] Additionally, the presence of a previous uterine scar may alter tissue vascularity and healing capacity, and the requirement for adhesiolysis may increase the risk of inadvertent bladder or bowel injury, predisposing to infection.[37] The increasing trend of repeat cesarean sections in contemporary obstetric practice makes this a particularly relevant finding for clinical practice and emphasizes the need for enhanced infection-control measures in this high-risk group.

The microbiological profile observed in our study demonstrated *S. aureus* as the predominant pathogen (39.5%), followed by *Klebsiella* spp. (26.3%) and *E. coli* (18.4%). These findings are consistent with the broader literature on post-cesarean SSI microbiology. De et al and Owens and Stoessel identified *S. aureus* as the leading cause of postoperative wound infections across surgical specialties, emphasizing the importance of skin flora as the primary source of contamination.[24,25] The substantial proportion of gram-negative organisms (*Klebsiella* spp., *E. coli,* and *Pseudomonas* spp.) in our study, collectively accounting for approximately 55% of infections, is noteworthy and may reflect the high background rate of gram-negative colonization in this population or prior antibiotic exposure. Similar findings have been reported from other Indian studies, which have documented increasing rates of gram-negative SSI, potentially related to widespread antibiotic use and emerging antimicrobial resistance.[38] The presence of both gram-positive and gram-negative organisms highlights the need for appropriate perioperative antibiotic prophylaxis that covers both pathogen groups and continuous microbiological surveillance to guide empirical treatment policies and antibiotic stewardship.[39]

An important finding of the study was the significant increase in hospital stay among women who developed SSI. Patients with infection remained hospitalized for approximately twice as long as those without infection (8.2 vs 4.1 days). This prolonged hospitalization has substantial implications for healthcare resource utilization, including increased bed occupancy, nursing care requirements, antibiotic consumption, laboratory investigations, and dressing materials. Similar observations have been reported by de Lissovoy et al and Astagneau et al who demonstrated that SSI substantially increases healthcare costs and resource utilization across surgical specialties.[9,8] The economic burden of SSI extends beyond the direct costs of extended hospitalization to include indirect costs such as lost productivity, repeated outpatient visits, and caregiver burden. In resource-constrained settings like India, where healthcare resources are already stretched, the additional burden imposed by preventable SSIs is particularly significant.[40] Prolonged hospitalization also increases the risk of secondary healthcare-associated infections, including urinary tract infections, pneumonia, and venous thromboembolism, creating a cascade of complications that further compound morbidity.[41]

The findings of the present study have important clinical and policy implications. Early identification of high-risk women, particularly those with obesity, undergoing emergency cesarean sections, or with a history of previous cesarean delivery, may facilitate targeted preventive interventions and intensified postoperative surveillance. Such risk stratification could enable more efficient use of healthcare resources by directing enhanced monitoring and wound care to those at highest risk.[28] Strict adherence to evidence-based infection prevention measures recommended by WHO and CDC is essential.[14,15] These include timely preoperative antibiotic prophylaxis (administered 30-60 minutes before skin incision), appropriate surgical skin preparation with chlorhexidine-alcohol, maintenance of strict aseptic technique, minimization of operative duration, optimization of glycemic control, and appropriate postoperative wound care.[42] Additionally, preoperative optimization of modifiable risk factors, such as weight management and glycemic control in diabetic patients, may contribute to reducing SSI risk.[26]

Furthermore, the finding that emergency cesarean sections carry higher infection risk underscores the importance of timely decision-making in obstetric care. Avoiding unnecessarily prolonged labor and early identification of indications for cesarean delivery may help reduce the proportion of emergency procedures performed after prolonged labor, thereby potentially reducing SSI rates.[35] Similarly, the association between repeat cesarean sections and SSI emphasizes the importance of appropriate patient selection for trial of labor after cesarean (TOLAC) and avoidance of unnecessary primary cesarean sections when vaginal delivery is feasible and safe.[37]

The microbiological findings of our study have implications for empirical antibiotic therapy in cases of suspected SSI. Given the predominance of *S. aureus* and significant proportion of gram-negative organisms, empirical antibiotic regimens should provide coverage for both pathogen groups until culture and sensitivity results are available. Regular updating of institutional antibiotic guidelines based on local susceptibility patterns is essential to ensure optimal empirical therapy.[39]

Overall, the present study reinforces the continuing burden of SSI following cesarean section and highlights modifiable risk factors that should be prioritized in institutional quality-improvement initiatives. Implementation of structured SSI surveillance programs, feedback of infection rates to surgical teams, and regular audit of infection prevention practices are strategies that have been shown to reduce SSI rates in various settings and should be adopted in Indian tertiary care centres.[26]

Strengths

The study has several notable strengths. First, the inclusion of all cesarean deliveries performed over a one-year period minimized selection bias and provided a comprehensive assessment of SSI burden in routine clinical practice. Second, the use of standardized CDC criteria for SSI diagnosis ensured consistent case identification and comparability with other studies. Third, in addition to determining incidence, the study evaluated important maternal and operative risk factors and described the microbiological profile of infections, thereby providing clinically relevant information for infection-prevention strategies in tertiary care settings. Fourth, the study assessed the impact of SSI on clinically meaningful outcomes, specifically postoperative hospital stay. Fifth, the use of multivariate analysis allowed adjustment for potential confounders, strengthening the validity of the identified risk factors.

Clinical implications

The findings of this study have several practical clinical implications. First, the identification of obesity, emergency cesarean section, and repeat cesarean section as significant risk factors suggests that targeted surveillance of these high-risk groups may facilitate early identification of wound complications. Second, strengthening perioperative infection-prevention bundles, including optimization of preoperative preparation in emergency settings, appropriate antibiotic prophylaxis, and enhanced postoperative wound care, may substantially reduce SSI rates. Third, the microbiological profile data can guide empirical antibiotic therapy and inform institutional antibiotic guidelines. Fourth, the significant prolongation of hospital stay associated with SSI provides a compelling economic argument for investing in infection-prevention initiatives. Fifth, the findings support the development of institutional quality-improvement programs focused on reducing SSI rates through multimodal interventions.

Limitations

This study has several limitations that should be acknowledged. First, being retrospective in design, it depends on available medical records, which may have incomplete or missing data, particularly regarding preoperative risk factors and post-discharge outcomes. Second, it was conducted at a single centre, limiting generalizability of findings to other healthcare settings with different patient populations, surgical practices, and infection-control protocols. Third, post-discharge SSI cases may have been underreported, as some patients may have sought care at other facilities or may not have presented for follow-up evaluation. The 30-day surveillance period recommended by CDC criteria extends beyond the typical hospital stay, and our reliance on hospital records may underestimate true SSI rates. Fourth, we did not assess all potential risk factors for SSI, including preoperative hemoglobin levels, duration of surgery, blood loss, and specific obstetric complications. Fifth, study did not evaluate compliance with infection-prevention protocols, which may have influenced observed SSI rates. Sixth, the small number of SSI cases limited the power to detect associations with less common risk factors and to perform detailed subgroup analyses.

CONCLUSION

The incidence of SSI following LSCS at our tertiary care centre was 8.08%. Maternal obesity, emergency cesarean section, and repeat cesarean section were identified as significant independent determinants of SSI. *S. aureus* was the most commonly isolated pathogen, followed by *Klebsiella* spp. and *E. coli*. SSI was associated with a substantial increase in postoperative hospital stay, nearly doubling the duration of hospitalization. These findings underscore the continuing burden of SSI in obstetric practice and highlight modifiable risk factors that should be prioritized in institutional infection-prevention initiatives. Strengthening perioperative infection-control protocols, implementing structured SSI surveillance, and optimizing preoperative management of high-risk women are essential strategies to reduce postoperative morbidity and improve maternal outcomes in resource-constrained settings.

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