# A CASE-CONTROL STUDY ON POST-CAESAREAN SECTION SURGICAL SITE INFECTION AT A TERTIARY MEDICAL COLLEGE OF INDIA

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**ABSTRACT**

Surgical site infections (SSIs) remain the most frequent postoperative complication following lower uterine segment caesarean section (LUCS), contributing substantially to maternal morbidity and increased healthcare utilisation. This case–control study, conducted over 18 months in a tertiary care hospital, evaluated patient- and procedure-related risk factors, causative organisms, and antibiotic sensitivity patterns associated with SSIs following LUCS. Ninety-five women who developed SSI were compared with 95 age- and surgery-timing-matched controls without SSI. Relevant clinical, obstetric, perioperative, and postoperative variables were analysed. Anaemia (Hb <11 g/dL), body mass index ≥25 kg/m², hypertensive disorders of pregnancy, prolonged rupture of membranes, and prolonged labour were significant patient-related risk factors ($p<0.005$). Procedure-related factors significantly associated with SSI included ≥5 per vaginal examinations, operative duration ≥60 minutes, and intraoperative blood loss ≥750 mL ($p<0.005$). Maternal age, parity, and diabetes mellitus showed no significant association. *Staphylococcus aureus* was the predominant pathogen isolated. Gentamicin, piperacillin–tazobactam, and linezolid demonstrated the highest antimicrobial sensitivity. Secondary suturing was required in 43.16% of affected cases. SSIs following LUCS are strongly influenced by modifiable patient and intraoperative factors. Strengthening antenatal optimisation, improving labour and operative practices, and implementing institution-specific infection surveillance and evidence-based antibiotic protocols may significantly reduce SSI incidence and improve maternal outcomes.

Keyword: LUCS, SSI, Risk factor, Organism, Antibiotics.

## INTRODUCTION

Skin is a natural barrier against infection. Any surgery that causes a break in the skin can lead to an infection even after many precautions and protocols to prevent this.

Post operative wound infection is a disorder of wound healing. Surgical site infections (SSIs) are defined as infections occurring up to 30 days after surgery (or up to one year after surgery in patients receiving implants) and affecting either the incision or deep tissue at the operation site. [1]

In the developing countries, SSI is the major infection affecting more than 60% of the operated patients.[2] In USA, SSIs are responsible for about 15% of all nosocomial infections.[3]

Caesarean section (CS) is the most commonly performed major abdominal operations among women in both developed and developing countries. [4]

Since 1985, the international healthcare community has considered the ideal rate for cesarean section to be between 10% and 15%. Since then, cesarean sections have become increasingly common in both developed and developing countries. Due to this the worldwide continuous rise in the incidence of cesarean sections, the number of women with postpartum infection is expected to increase.[5] In India the rate has increased from 17.2% (NFHS-4, 2015-16) to 21.5% (NFHS-5) in last five years.[6]

The rates of SSI are considered as an indicator of the quality of surgical and postoperative care provided by the hospitals.[7]

Understanding the organisms responsible for surgical site infections (SSI) along with their antibiotic sensitivity and resistance profiles offers valuable insights into present antibiotic prescribing habits. This study aims to identify the risk factors and the pathogens associated with SSI in our hospital as well as their susceptibility to various antibiotics which will assist in developing effective prophylactic and preventive infection control strategies.

## MATERIALS AND METHODS

This case-control study was conducted in the department of obstetrics and gynaecology at Bankura Sammilani Medical College and Hospital over a period of 18 months.

- **Criteria for diagnosing SSI:**
  1. **Clinical:**
     - Purulent discharge from surgical site
     - Presence of signs of infection (Swelling, pain, tenderness, redness
     - 5 Signs of inflammation (Rubor, Calor, Tumor, Dolor & Functio laesa)
  2. **Culture:**
     - Positive bacterial / organism isolated
  3. **Others:**
     - Clinical diagnosis for superficial type
     - Abscess/Histopathological/USG evidence of infection

- **INCLUSION CRITERIA:** For Cases, all patients developing SSI following caesarean section conducted in Bankura Sammilani Medical College and Hospital. For controls, patients not developing SSI after caesarean section and having similar co-morbidities or similar indication for CS in similar ward of Bankura Sammilani Medical College.

- **EXCLUSION CRITERIA:**
  - ✓ Patients referred to BSMCH post operatively after CS from other hospitals.
  - ✓ Patients having pre-existing skin infections
  - ✓ Immunocompromised patients (AIDS, patients on steroids etc.)
  - ✓ Non-attendants with no hospital records
  - ✓ Critically ill women
  - ✓ Women who had additional surgeries (including obstetric hysterectomies and myomectomies)

- **SAMPLE SIZE:**
  Using a 95% confidence interval and 80% study power (with 10% allowance for dropouts), 190 women were enrolled—95 cases and 95 controls.

- **DATA COLLECTION AND INTERPRETATION:**

All the patients undergone caesarean section were listed from the OT Register book and from them all patients who have developed SSI are noted from patient file. Information on demographic and clinical variables as age, height, weight, obstetric complications, patient's vitals before, during and after operation, duration of labour, indication of CS, procedures done before proceeding to CS, blood transfusion, operating time, estimated blood loss, complications during operation, post operative drugs and care and hospitalization period were obtained by review of the maternal case notes. In case where all data are not available from maternal case records, proper history taking of the mother was taken. Reports from Pathology, Biochemistry and Microbiology department were studied and different medical and surgical interventions have been done to treat the patients and interpretation has been done using statistical tools (SPSS).

- **HOSPITAL PROTOCOLS:**

**(A) Peri-operative hospital protocol for reducing SSI after LUCS**

- ✓ **Antibiotic prophylaxis→** One gram of broad-spectrum antibiotic (Ceftriaxone or Ampicillin) is given to all patients before skin incision.
- ✓ **Urinary catheterization→** An indwelling urinary catheter is inserted under complete aseptic conditions and removed once the patient is mobile after the CS.
- ✓ **Skin preparation→** Antiseptic solution (Povidone-Iodine 10%) is used for skin preparation before CS.
- ✓ **Suture material→** Monofilament nylon (2-0 Ethilon) suture is used in all LUCS cases.

**(B) Post-operative hospital protocol**

- ✓ **Antibiotic coverage→** All post LUCS patients get 5 days antibiotics coverage.
- ✓ **Dressing of wound→** Aseptic dressing of the wound is done in all patients on 3$^{rd}$ post-operative day.
- ✓ **Discharge→** All the post LUCS patients with healthy wounds get discharged on day 6 after removing stiches.

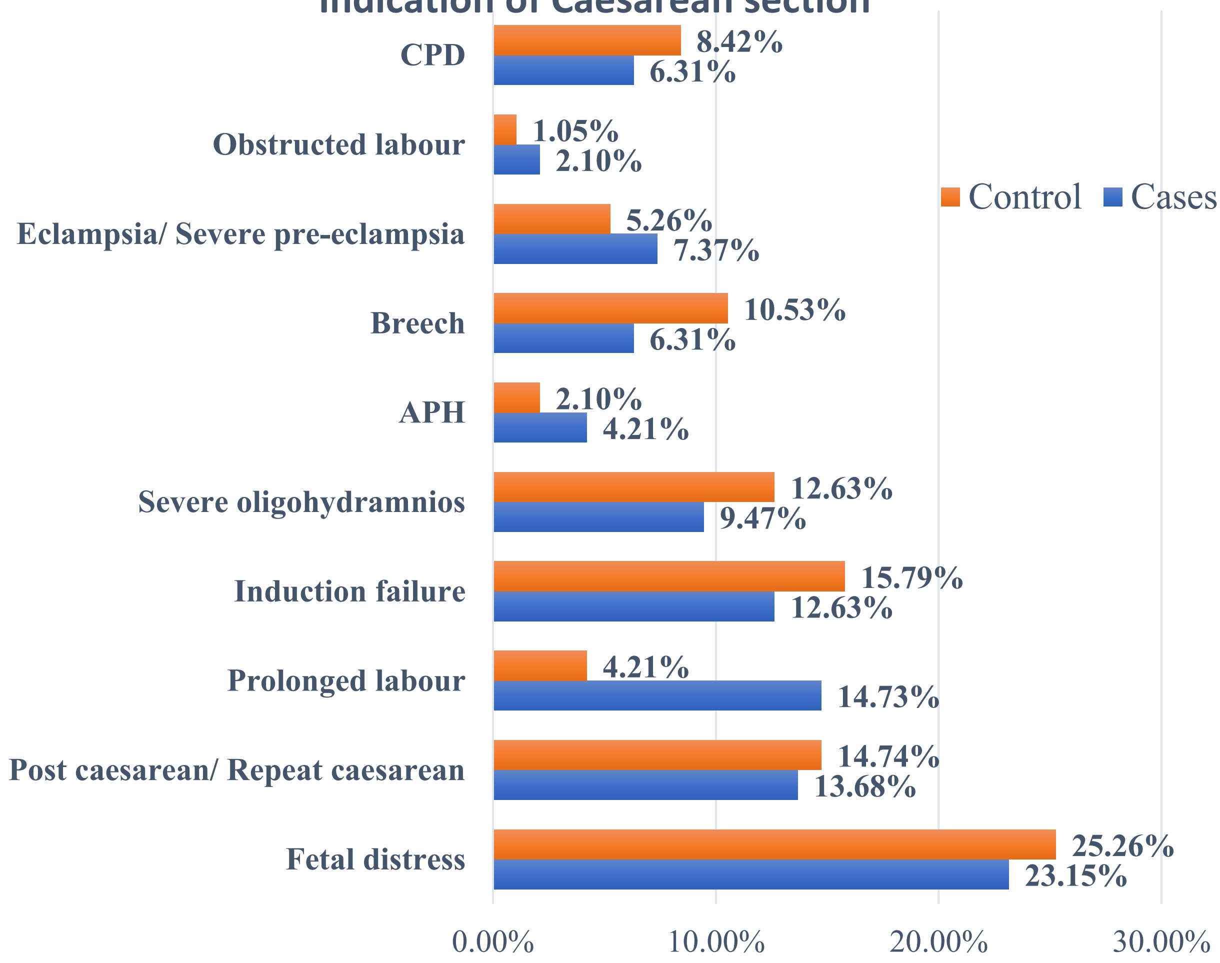
## RESULTS AND OBSERVATIONS

- In this present study, we didn't find any increasing risk of post-caesarean SSI with increasing age. In both case and control groups, most of the patients were in the age group of <20 years followed by 21-25 years. The mean age in patients with SSI was (21.4 ± 4.54) years with a p-value of 0.909 and Pearson chi-square value of 0.192.[Table 1]

**Table 1- Distribution and association between Age and Parity of patients and SSI**

| | Age group (years) | | | | Parity | | | |
|---|---|---|---|---|---|---|---|---|
| | ≤20 | 21-25 | 26-30 | >30 | P1 | P2 | P3 | P4 |
| Cases (n=95) | 50 (52.63%) | 30 (31.57%) | 10 (10.52%) | 5 (5.26%) | 65 (68.4%) | 21 (22.1%) | 7 (7.4%) | 2 (2.1%) |
| Control (n=95) | 48 (50.52%) | 34 (35.78%) | 7 (7.36%) | 6 (6.31%) | 51 (53.7%) | 31 (32.6%) | 10 (10.5%) | 3 (3.2%) |
| | **Pearson Chi- Square value- 0.192 p- value 0.909** | | | | **Pearson Chi-Square value 4.342 p- value 0.227** | | | |

**Fig 1- Distribution of study population according to Indication of Caesarean section**



- In this study, no association was found between parity of the mother and SSI. Most of the patients were primipara in both case and control group. [Table 1]
- The incidence of SSI based on the indication of LUCS are Fetal distress (23.15%), Prolonged labour (14.73%), Post caesarean/ Repeat caesarean pregnancy (13.68%). [Fig 1]
- There was significant association between anaemia and SSI. 86.32% patients in SSI group were anaemic (Hb<11gm%). The mean hemoglobin was (9.64 ± 1.60) gm%. [Table 2]
- It is found that high BMI of ≥ 25 kg/m$^2$ increase the risk of SSI in my study. 22.10% patients were of BMI ≥ 25 kg/m$^2$ in SSI group. [Table 2]
- A significant association was found between hypertensive disorder of pregnancy and SSI. Among the SSI group, 34.73% patients had hypertensive disorder of pregnancy. [Table 2]
- No association was found between diabetes and SSI. There were only 3.2% and 2.1% diabetic patients in case and control group respectively. [Table 2]

**Table 2- Distribution and association between patient's pre-operative health condition and SSI**

| | | Case (n=95) | Control (n=95) | Pearson chi-square value | p-value |
|---|---|---|---|---|---|
| **Hemoglobin (gm/dl)** | ≥11 | 13 (13.68%) | 28 (29.47%) | 6.998 | 0.008 |
| | < 11 | 82 (86.32%) | 67 (70.53%) | | |
| **BMI (kg/m$^2$)** | ≥ 25 | 21 (22.10%) | 9 (9.47%) | 4.924 | 0.026 |
| | <25 | 74 (77.90%) | 86 (90.53%) | | |
| **Hypertensive disorder of pregnancy** | | 33 (34.73%) | 20 (21.05%) | 4.422 | 0.0354 |
| **Non hypertensive** | | 62 (65.27%) | 75 (78.95%) | | |
| **Random Blood Sugar (mg/dl)** | ≥ 200 | 3 (3.2%) | 2 (2.1%) | 0.205 | 0.650 |
| | < 200 | 92 (96.8%) | 93 (97.9%) | | |
| **PROM/PPROM** | | 33 (34.74%) | 11 (11.58%) | 13.117 | 0.001 |
| **Number of per vaginal examination** | <5 | 44 (46.3%) | 61 (64.2%) | 6.152 | 0.013 |
| | ≥ 5 | 51 (53.7%) | 34 (35.8%) | | |
| **Duration of labour (hours)** | <5 | 44 (46.3%) | 61 (64.2%) | 8.360 | 0.004 |
| | ≥ 5 | 51 (53.7%) | 34 (35.8%) | | |
| **Operating time in minutes** | ≥ 60 | 29 (30.5%) | 10 (10.5%) | 11.647 | 0.001 |
| | < 60 | 66 (69.5%) | 85 (89.5%) | | |
| **Amount of blood loss** | ≥750 ml | 32 (33.7%) | 16 (16.84%) | 7.136 | 0.008 |
| | <750 ml | 63 (66.3%) | 79 (83.16%) | | |

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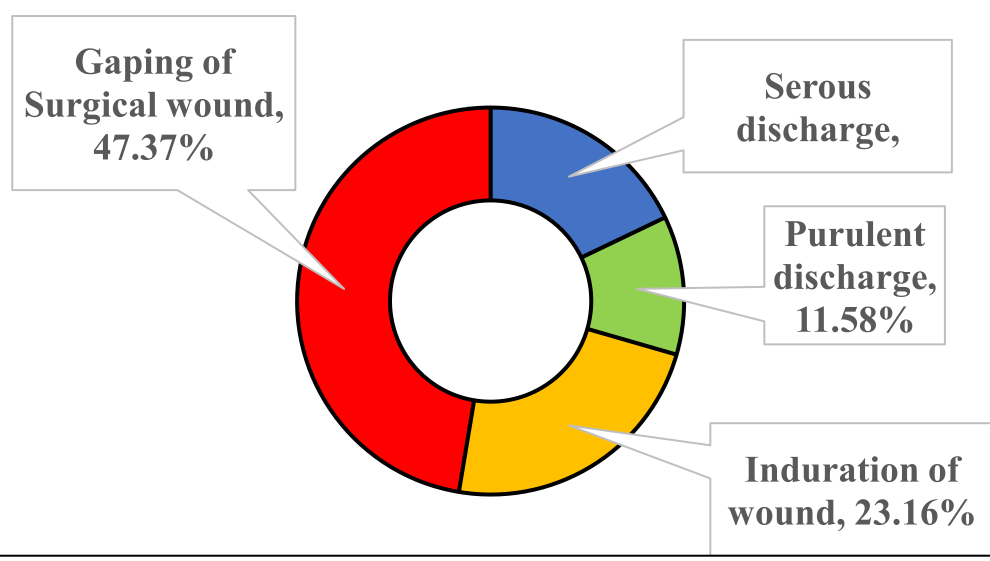
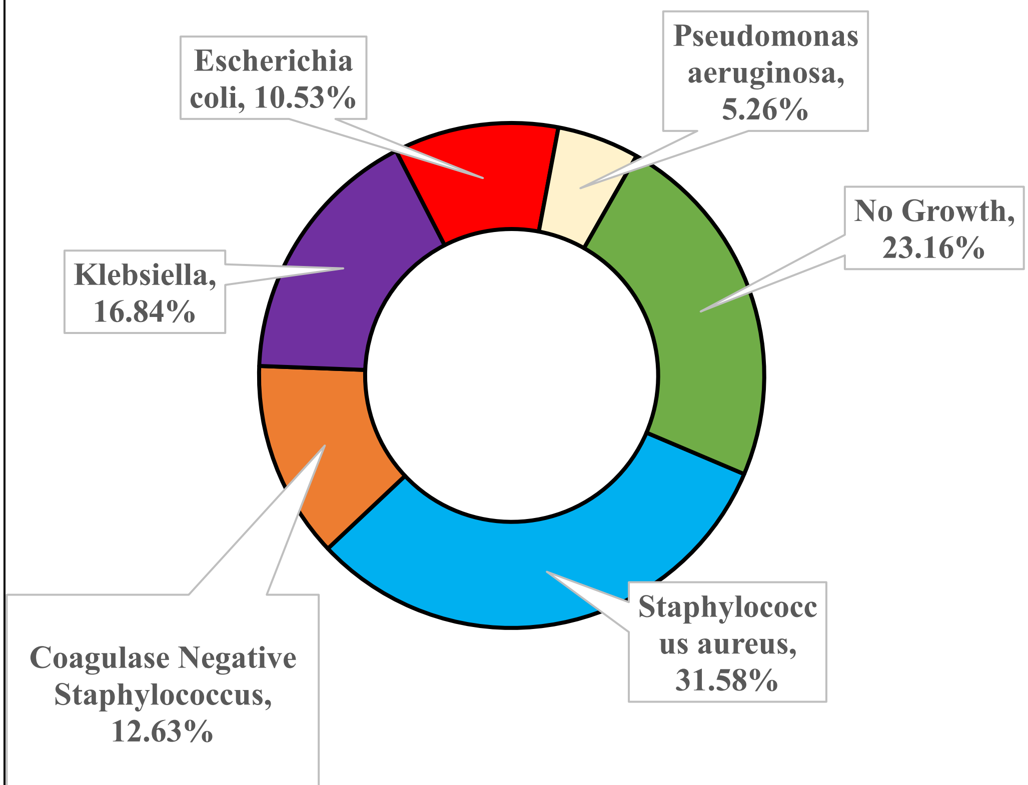
- Premature rupture of membranes (PROM)/ Preterm premature rupture of membranes (PPROM) was strongly associated with SSI. 34.74% patients in SSI group had PROM/ PPROM. [Table 2]
- Patients with multiple per vaginal examination (≥ 5) before LUCS were more predispose to develop SSI. 53.7% patients in the SSI group had ≥ 5 per vaginal examination before LUCS. [Table 2]
- 18.9% patients in SSI group had prolonged labour of ≥ 8 hours before LUCS and there was significant association between prolonged labour of ≥ 8 hours and SSI. The mean duration of labour in SSI group was (5.06 ± 3.54) hours. [Table 2]
- The mean duration of LUCS in SSI group was (49.6 ± 15.9) minutes. A strong association has been found between operating time of ≥60 minutes and SSI. 30.5% patients in the SSI group underwent LUCS for ≥60 minutes. [Table 2]
- The mean blood loss during LUCS in SSI group was (656 ± 184) ml. a blood loss of ≥750 ml during LUCS has shown association with SSI. 33.7% patients in the SSI group had blood loss of ≥750 ml during LUCS. [Table 2]
- In this study different types of SSI like Serous discharge, Purulent discharge, Induration of wound, Gaping of Surgical wound were studied. The most common type of SSI was gaping of surgical wound (47.37%) followed by induration of wound (23.16%). None of the patient developed fascial dehiscence. [Fig 2]

Fig 2- Distribution of different types of Surgical site infection



- The mean hospital stay in SSI group was (15.4 ± 4.01) days. 71.58% patients with had a hospital stay of ≥14 days.
- In this study, no growth on wound swab culture was found in 23.16% cases. [Fig 3]
- Most common organisms found to be involved was Staphylococcus aureus (31.58%) followed by Klebsiella sp. (16.84%). [Fig 3]

Fig 3- Distribution of causative organisms in Swab culture




- Staphylococcus aureus was found sensitive mostly to Linezolid (80%) and Teicoplanin (66.67%) and Klebsiella sp. was mostly sensitive to Linezolid (75%), Gentamicin (68.75%) and Amikacin (56.25%). [Fig 4]
- Gentamicin, Piperacillin + Tazobactum and Linezolid were effective against most of the organisms. [Fig 4]

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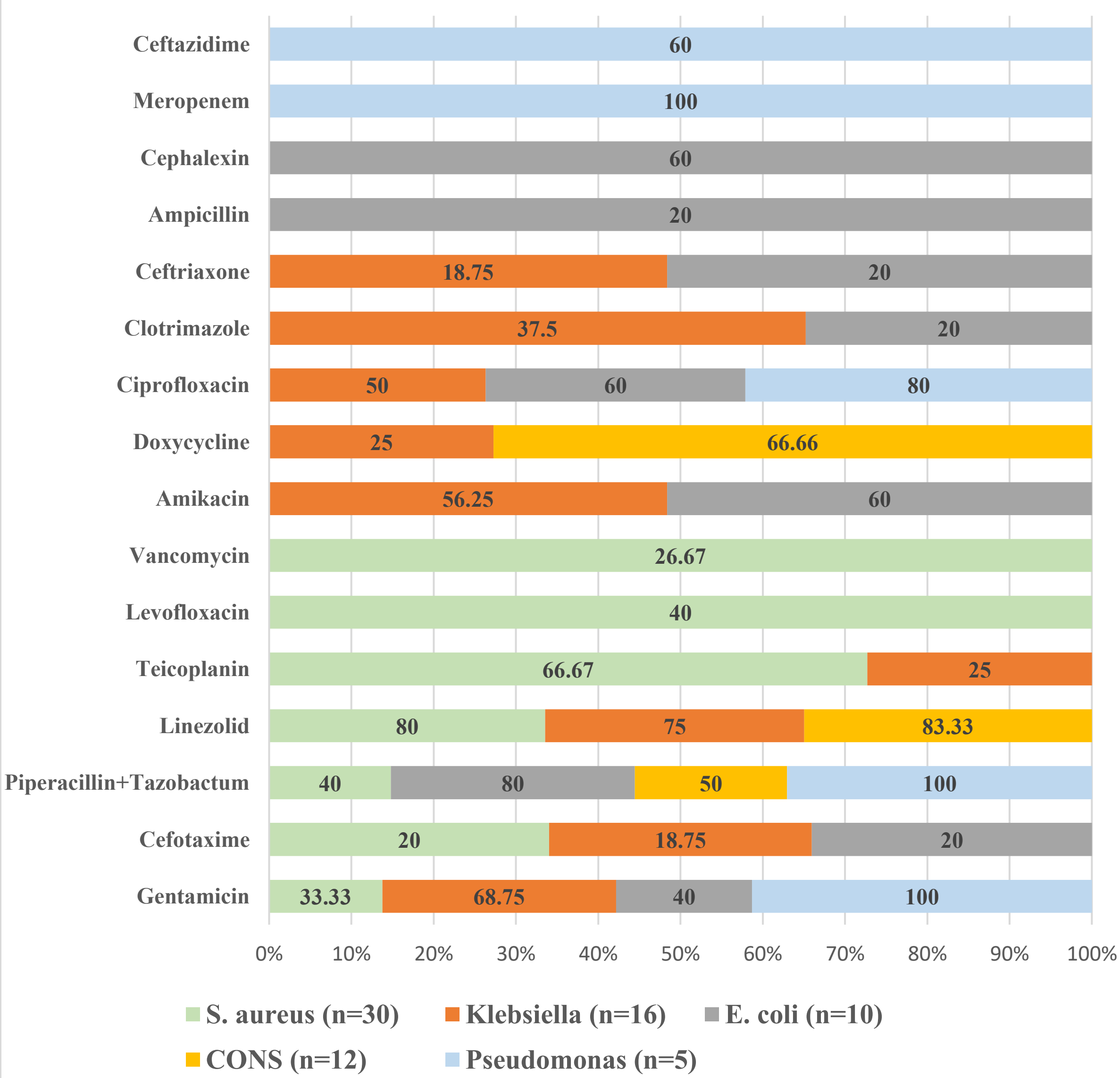
Fig 4- Composite distribution of Antibiotics sensitive against different organisms causing SSI




- In this study only local dressing and medical treatment with higher antibiotics were sufficient in the treatment of 56.84% cases of SSI. Rest 43.16% SSI patients needed secondary suturing along with local dressing of the wound and medical management.

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Wound gaping and condition of the wound before local dressing

Discharge From the Post-caesarean Scar site

Condition of the wound (appearance of healthy granulation tissue) after medical management and before Secondary suturing

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## DISCUSSION

Surgical Site Infection (SSI) remains a significant concern following caesarean deliveries, especially in resource-limited settings. This case-control study was conducted at Bankura Sammilani Medical College and Hospital between December 2022 and August 2023 to analyze the various risk factors, patient profiles, and perioperative contributors associated with SSI after caesarean section (LUCS). Ninety-five cases of post-caesarean SSI were compared with an equal number of matched controls without infection.

While the incidence of SSI could not be directly estimated due to the study design, reference to recent literature by C. N. Onuzo et al, 2022[8], Gomaa et al, 2021[9], Mpogoro et al, 2014[10] show that SSI following caesarean section typically ranges between 5–12%, consistent with the reported 5.46% incidence in our institution the previous year.

Our findings suggest no significant association between maternal age and development of SSI (p = 0.909), which contrasts with study by C. N. Onuzo et al, 2022[8] where increased maternal age was a risk factor. This may be attributed to the younger age distribution in our population, with a predominance of teenage pregnancies.

There is a dilemma whether multiparous women are more associated with post caesarean SSI or not. Few studies shows that nulliparity is mostly associated with SSI and the reasons behind it are nulliparous women are mainly of younger age and they have less knowledge about the labour process, chance of contracted pelvis, prolonged labour as well as incidence of pregnancy induced hypertension and anaemia are more common in nulliparous women. On the other hand, few studies show the association of SSI with multiparity because multiparous women are mainly older in age and there is a chance of reduced immunity related SSI and multiparous women may also have underlying age-related medical co-morbidities which increase the chance of SSI. No statistically significant association was found between parity and SSI (p = 0.227), though most affected women were primigravidae, which might reflect the underlying demographic pattern rather than a direct etiological link.

Worldwide the most common indication for emergency caesarean section interchanges between Fetal distress and post caesarean pregnancy. In my current study, most common indication was fetal distress (23.15%) followed by Prolonged labour (14.73%) followed by post-caesarean or repeat caesarean pregnancy (13.68%).

Several risk factors demonstrated significant association with post-caesarean SSI in our study:

Anaemia (Hb <11 gm%) was highly prevalent among SSI cases (86.32%) with a significant p-value (0.008), reinforcing the known role of anemia in compromising immune response and wound healing.

High BMI (≥25 kg/m²) was observed in 22.1% of cases (p = 0.026), consistent with studies showing increased adiposity impairs vascularity and increases surgical complexity. This is consistent with the study of Gomaa et al, 2021.[9]

Hypertensive disorders of pregnancy were found in 34.73% of cases (p = 0.0354), aligning with literature that suggests hematoma formation and compromised immunity may predispose to SSI. This is also consistent with several studies conducted by Gomaa et al, 2021[9], Devi et al, 2018[11], Mpogoro et al, 2014[10].

PROM/PPROM (34.74%, p = 0.001) and ≥5 per vaginal examinations (53.7%, p = 0.013) significantly contributed to the risk, highlighting the importance of aseptic handling during labor and delivery. These findings are consistent with the study conducted by Gomaa et al, 2021[PROM/PPROM- 43.60%, OR 4.93, p= ≤ 0.001] [9] and Mpogoro et al, 2014 [PV examination >4 times→ 21.5%, OR 3.3, p= 0.001][10].

Prolonged labor (≥8 hours) was associated with an increased risk of SSI (18.9% cases, p = 0.004), likely due to ascending infections and prolonged exposure to potential contaminants and it is consistent with the findings of the study by C. N. Onuzo et al, 2022 [AOR 3.48, p= 0.01][8].

Duration of surgery ≥60 minutes was significantly associated with SSI (30.5%, p = 0.001), emphasizing the role of surgical time in infection risk, possibly due to reduced antibiotic prophylaxis efficacy and increased contamination. Shapiro et al reported that with each hour of surgery the infection rate almost doubles. The incidence of SSI increased 3-fold (2.1 to 6.4%) as operation went from 2 to 4 hours in duration [12].

Blood loss ≥750 ml was significantly associated with SSI (33.7%, p= 0.008), which may lead to immune suppression and delayed healing. Gomma et al, 2021 also found that blood loss of >1000 ml in caesarean section increase the risk of SSI [10.7%, OR 2.58, p= 0.011].[9]

Hyperglycemia has various negative effects on the host immune function. In various studies, it is shown that the incidence of SSI is higher in diabetics than non-diabetics. Poor control of blood glucose level during operation and in peri-operative period increases the incidence of wound infection in diabetics. The study by Gomma et al, 2021 found a statistically significant association [OR 1.19, p=0.011] between Diabetes and SSI.[9] In contrast, diabetes (both GDM and Type II DM) showed no significant association (p = 0.650), likely due to the low prevalence of diabetes in our study population.

Most common causative organisms was found to be Staphylococcus aureus and Klebsiella sp. This finding is consistent with the finding of C. N. Onuzo et al, 2022 [8] and Devi et al, 2018 [11]. Gentamicin, Piperacillin + Tazobactum and Linezolid were found to be most effective antibiotics. No growth was found in many cultures from SSI wounds in our cases, which might be attributed to prior empirical antibiotic therapy, suboptimal specimen collection, or the presence of anaerobic organisms not detected by standard culture methods. Future studies should incorporate anaerobic cultures and molecular diagnostics for more comprehensive microbial identification.

For the treatment of SSI regular dressing of the wound and higher antibiotics are needed in every cases. But in cases of wound gaping and uncontrollable wound discharge (43.16% in my study), besides regular wound dressing and higher antibiotics coverage secondary suturing is needed after formation of healthy granulation tissue locally. In study by Gomma et al, 2021[9] and Devi et al, 2018 [11] the rate of secondary suturing was 22% and 63.2% respectively.

The SSI ultimately increase the hospital stay and financial and extra-financial burden over the patients, their family and health infrastructures. Due to SSI, in my study the mean duration of hospital stay had increased from 7 days to 15.4 ± 4.01 days.

In several studies different pre-operative and intra-operative factors were found to be a cause of Post-caesarean SSI. But due to our hospital protocols and other reasons these factors can't be studied.

In one study, SSI rates are 5.6% in patients who had hair removed by Razor shave compared to a 0.6% rate among those who had hair removed by depilatory or who had no hair removal [13] and it is due to microscopic cuts by razor allowing foci for bacterial multiplication. Tuuli et al found that the use of chlorhexidine–alcohol resulted in a significantly lower risk of overall SSI (4.0%) after caesarean section compared to iodine–alcohol (7.3%). In a Cochrane review, vaginal preparation with povidone–iodine solution before caesarean section reduced the risk of post-caesarean endometritis from 29 7.2% to 3.6% (RR: 0.39, 95% CI: 0.16–0.97), particularly in women with ruptured membranes. Surgical antimicrobial prophylaxis (AMP) refers to an antimicrobial agent initiated just before an operation begins. It reduces the microbial burden of intra-operative contamination to a level that can't overwhelm host defenses. AMP does not prevent SSI caused by postoperative contamination. Study shows use of prophylactic antibiotics significantly reduced the incidence of wound infection (RR: 0.40, 95% CI: 0.35–0.46), endometritis (RR: 0.38, 95% CI: 0.34–0.42), and maternal serious infectious complications (RR: 0.31, 95% CI: 0.20–0.49) [14].

Charnley and Eftaknan found in their study that vertical laminar airflow systems and exhaust-ventilation in operating room decrease SSI rate from 9% to 1% [15]. Davidson et al (1971) detected glove puncture in 39.5 percent cases of SSI [15]. Cole showed that near about 18,960 Staphylococcus could pass through a single needle hole from the gloved finger in 20 minutes.

Garibaldi et al (1991)[16] shows rate of SSI is 11.5 % as compared to 4% with no puncture of gloves. Surgeon should change the gloves immidiately after tear or puncture to prevent bacterial contamination. The safest way is to wear 2 pairs of gloves to reduce the risk of getting contaminated by patient's blood and keeping surgeon's bacteria out of patient's wound. Always follow 6 steps of hand washing for 40-60 seconds as per WHO guidelines. In study by Khanal

(2015) [17] it is found that of 204 health care worker (HCWs), 32(15.7 %) were nasal carriers of *S. aureus* and among them 7(21.9 %) were carrier of MRSA. The overall nasal carriage rate of MRSA was 3.4 % (7/204). Nasal carriage among male and female HCWs were 19.4 % (21/108) and 11.5 % (11/96) respectively ($P > 0.05$). It was found that when both adhesive plastic drapes and routine draping was used then SSI rate was 2.3% (214 of 9252) as compared to 1.5% (405 of 26,303) when plastic drapes were not used. Skin bacteria can proliferate in the warm, moist environment below the plastic drape may enter the wound causing SSI.

## CONCLUSION

This case-control study conducted at Bankura Sammilani Medical College and Hospital provides critical insights into the risk factors associated with surgical site infections (SSI) following lower uterine segment caesarean sections (LUCS). Although the study design did not permit estimation of SSI incidence, several patient-related and procedure-related factors were found to significantly contribute to the development of SSI.

Among patient-related factors, anemia (Hb <11 gm%), high body mass index (≥25 kg/m²), hypertensive disorders of pregnancy, prolonged rupture of membranes (PROM/PPROM), and prolonged labour demonstrated statistically significant associations with SSI. Additionally, procedure-related risk factors such as a high number of per vaginal examinations (≥5), prolonged duration of surgery (≥60 minutes), and excessive intraoperative blood loss (≥750 ml) were also significantly linked to increased SSI risk.

Interestingly, no significant association was observed between SSI and maternal age, parity, or diabetes mellitus, which may reflect the relatively young and low-risk population in our study cohort. Fetal distress was the most frequent indication for emergency LUCS among cases, consistent with broader clinical patterns.

The findings underscore the importance of strengthening antenatal care, particularly addressing anemia and hypertensive disorders, optimizing intrapartum management, and enforcing surgical best practices. Strategies such as minimizing the number of vaginal examinations, reducing operative time, and managing blood loss effectively may reduce the burden of SSI. Ongoing monitoring and microbiological surveillance are essential to inform institutional antibiotic policies and improve maternal outcomes.

## LIMITATION

- After discharge of the patients from the hospital, follow up is not possible in each and every cases. So, the treatment success or failure can’t be determined.

- In this study only caesarean section performed by horizontal incision is included and LUCS by vertical incision are not taken into consideration. So, the association of SSI with vertically incised wound can't be measured.
- The number of diabetic mothers was very less and that's why a known association of diabetes with post-surgical SSI can't be proved.
- Due to the hospital protocol, all the mothers undergoing LUCS got pre-operative antibiotics. So, the preventive role of pre-operative antibiotics from SSI can't be studied.
- Risk factors due to intra-operative issues are not studied.

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## Compliance with Ethical Standards

**Conflict of interest:** There is no conflict of interest among authors.

**Ethical Approval:** The research involves human participants, and ethical clearance has been taken from institute's ethical committee.

**Informed Consent**: Informed consent was taken from the participants before conduction of the study.

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