Original Article

Reducing Caesarean Section Surgical Site Infection (SSI) by 50%: A Collaborative Approach

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ABSTRACT

Objective: Caesarean section surgical site infection (SSI) is a surgical wound site infection occurring within 30 days of surgery with a reported incidence of 3–15%. This quality improvement (QI) project aimed to reduce caesarean section SSI by 50% in a tertiary maternity center.

Methods: Using multidisciplinary team approach, the project was designed with evidence-based interventions. The Royal College of Physicians of Ireland/Royal College of Surgeons in Ireland "Preventing Surgical Site Infections Key Recommendations for Practice" guideline was used as standard perioperative care. A care bundle was designed targeting preoperative personal patient preparation, preoperative prophylactic antibiotics, and strict skin preparation technique, all measured using a patient survey. The rate of SSI was followed for 14 months. The Model for Improvement methodology was used to implement change.

Results: Surgical site infection rate decreased from 6.7% (n = 684 caesarean sections, n = 46 SSI) to 3.45% (n = 3,206 caesarean sections, n = 110 SSI), $p = .0006$. Reduction occurred in both elective (4.4%–2.7%) and emergency (9.1%–4.1%) caesarean section groups. There was excellent adherence to all three elements of the care bundle. The 50% reduction in caesarean section SSI was sustained over the 14-month period, significantly reducing maternal morbidity.

Conclusions: The success of this QI project is attributable to frontline ownership and empowerment of patients and staff.

Keywords: cesarean section, obstetric surgical procedure, wound infection, surgical wound infection, postoperative complications, quality improvement, quality of healthcare, pregnancy

Introduction

Delivery by caesarean section, both primary and repeat, has seen a significant increase in incidence in recent years. In 2015, global incidence of caesarean section reached 29.7 million, almost double the incidence of 16.0 million in 2000.[1] This has led to an inevitable increase in the incidence of the complications of caesarean section. Caesarean section surgical site infection (SSI) is one of the most common complications of caesarean section. It is a significant cause of maternal morbidity[2] and also places an additional burden on service provision.[3] With a reported incidence of 3–15%[4–6] internationally, it contributes to delayed postoperative recovery, increased hospital bed days and readmission rates, increased postoperative pain, and decreased mobility for the patient. There has been much work dedicated to reducing SSI for women undergoing caesarean section. To date, using quality improvement (QI) strategies has yielded significantly improved outcomes for patients across many specialties.[7–9] Collaborative QI projects using the Model for Improvement methodology[10] are reportedly extremely effective at reduction of SSIs for women delivering by caesarean section.[11] Multidisciplinary input has also been shown to improve the efficacy of evidence-based SSI care bundles[12,13] and dramatically improve patient outcomes and is recommended by the World Health Organization (WHO) for implementing a change.[14]

The tertiary referral university teaching hospital in which this project was performed is a national tertiary

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referral center for specialized services, including maternal and fetal medicine, neonatology, gynecology, and anesthesia. The hospital has a busy operating theater department, and in 2017, more than 6,000 adult surgical operations were performed, including 2,420 caesarean sections. Over the course of the year, a steady increase in the incidence of caesarean section SSIs was observed.

In August 2017, a QI project was initiated aimed at reducing the caesarean section SSI rate by 50%.

Methods

A multidisciplinary project team, with a proven track record of successful QI strategy using the Model for Improvement methodology, was assembled. Team brainstorming identified key procedures in clinical care that might benefit from intervention. Three quantitative interventions were established and combined to create an SSI reducing care bundle. These interventions consisted of (1) education for patients and staff regarding preoperative hair removal and showering, (2) reeducation for staff on the appropriate timing of preoperative administration of prophylactic antibiotics, and (3) reeducation for staff on the correct technique for skin preparation before incision, including adequate drying time.

The project was commenced in August 2017 and was conducted over a 14-month period (Figure 1). August 2017 to October 2017 was the baseline period, and November 2017 to November 2018 was the intervention period. This QI work met the criteria for operational improvement activities at our hospital and thus did not require ethics approval.

The outcome of interest was the number of caesarean section SSIs per total number of caesarean sections. The Center for Disease Control and Prevention (CDC)[15] definition of caesarean section SSI was used; a SSI is a superficial incisional site, deep incisional site, or organ-space infection occurring within 30 days of surgery. Surgical site infection was diagnosed on clinical impression and/or with a positive caesarean section wound swab culture. In our center, SSI was detected during the postoperative inpatient course, at planned hospital-based follow-up, at emergency presentation to the hospital, or by referral by the general practitioner or community midwife. Patients are not routinely contacted at 30 days postoperative to ascertain whether SSI occurred, so our figures are likely to be underestimated when compared with internationally reported incidences where all patients are followed up to 30 days postoperative. Patients diagnosed with SSI are registered with the Infection Control team who track their management and keep close surveillance of caesarean section SSIs. This process of detection and data collection preceded this project, and the methods were not altered in any way during the intervention or follow-up period.

The chi-squared test was used to compare the number of caesarean section SSIs at baseline and the number of caesarean section SSIs during the intervention period. This project had ethical approval with the institution's QI and audit committee.

The QI team used the perioperative guidelines of the Royal College of Physicians of Ireland/Royal College of Surgeons in Ireland (RCPI/RCSI)[16] as the gold standard of care, to ensure perioperative procedures were in keeping with best evidence-based practice.

The team identified three quantitative interventions for improvement that combined to create a SSI reducing care bundle:

- Education for patients and staff on preoperative patient showering and prevention of preoperative hair removal practices
- Reeducation for staff on appropriate timing of preoperative prophylactic antibiotic administration
- Reeducation for staff on the correct technique of skin preparation before incision, including adequate drying time.

Intervention 1: Education for Patients and Staff on Preoperative Patient Showering and Prevention of Preoperative Hair Removal Practices

Most systematic reviews have concluded that the link between preoperative bathing and preventing SSI is uncertain but do not suggest a contraindication.[17] Bathing/showering the night before surgery is recommended by the CDC,[18] NICE,[19] and the RCPI/RCSI[16] to reduce the risk of SSI. Hair removal preoperatively may also play a role in inoculation of microorganisms and increasing the risk of SSI, with both the NICE and the RCPI/RSCI recommend avoiding hair removal practices preoperatively, advocating single use electric clippers on the day of surgery.[16,19]

Patients were advised to shower within 24 hours before surgery and not to engage in hair removal (waxing/shaving) in the 5 days preceding surgery date. A patient information leaflet was devised and

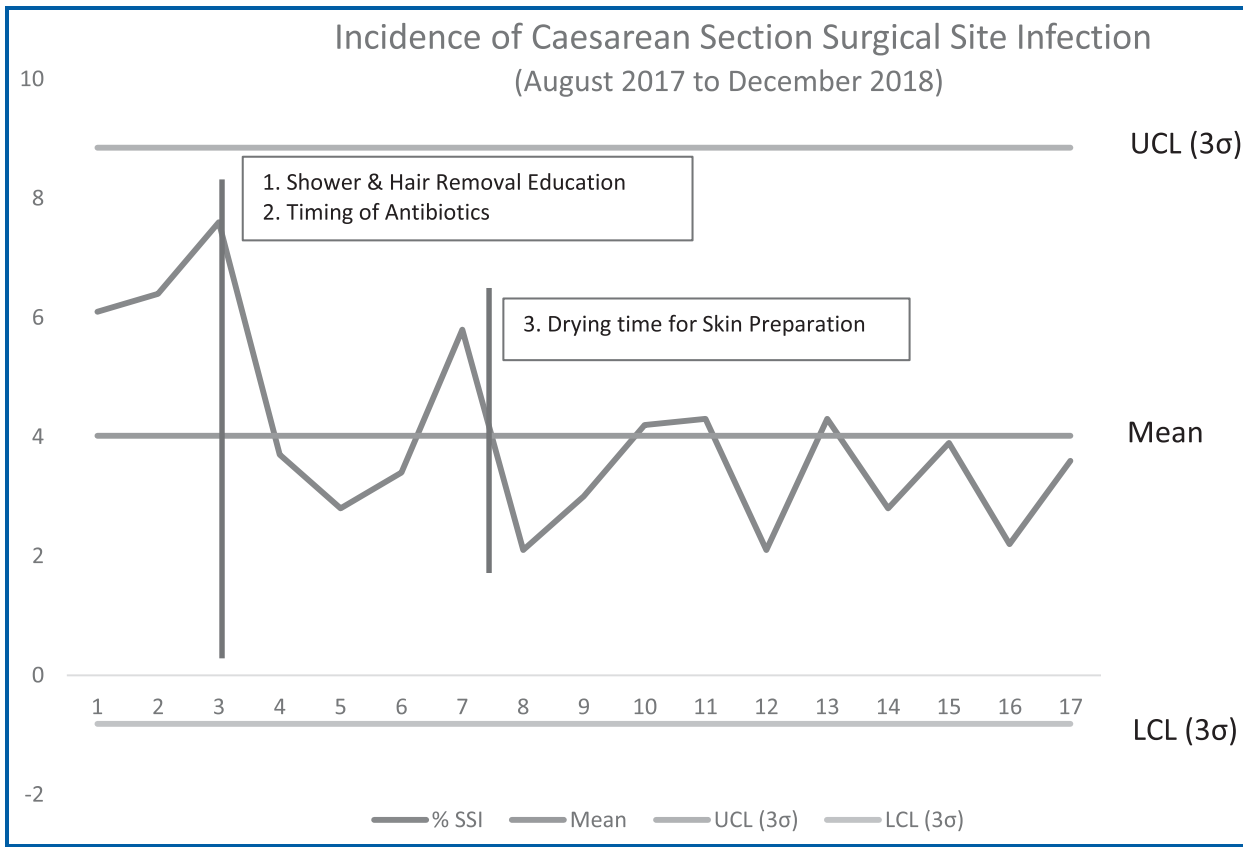

Figure 1. Control chart: Rate of SSI per month (Number of SSI ×100/Number of caesarean section), with interventions introduction points. UCL = upper control limit; LCL = lower control limit; σ = standard deviation; SSI = surgical site infection.

was administered in the preoperative anesthetic clinic, where all patients booked for elective caesarean section are seen. Patients attending the clinic were counseled on hygiene and hair preparation at this visit and were given the patient information leaflet to take home. Only patients who were undergoing elective caesarean section received this counseling and information in advance of surgery. The theater manager ran training sessions for staff of the anesthetic clinic on preoperative hygiene and hair removal practices and the patient information leaflet regarding preoperative patient care.

Intervention 2: Reeducation for Staff on Appropriate Timing of Preoperative Prophylactic Antibiotic Administration

Previous to this QI project perioperative antibiotic prophylaxis were not routinely administered before incision, but instead were administered after delivery of the baby. Preoperative administration is however associated with a significant reduction in endometritis[20] and a reduction in maternal postpartum infectious morbidity (including serious infectious complications, endometritis, wound infection, or death attributed to infection), without differences in adverse neonatal outcomes.[21] Preoperative administration of prophylactic antibiotics is recommended in the 2018 Cochrane review on preventing SSIs[22] as well as by the WHO,[23] CDC,[18] NICE,[19] and the RCPI and RCSI.[16]

Prophylactic antibiotics were administered by the anesthesiologists at least 15 minutes before skin incision. The Department of Anesthesia instituted a reeducation program, emphasizing to its staff the importance of preoperative administration of prophylactic antibiotics in preventing SSI. This consists of a 20 minutes didactic lecture, followed by a question and answer session. The lecture was delivered to the department on several occasions to ensure attendance of all anesthesiology staff.

Intervention 3: Reeducation for Staff on the Correct Technique of Skin Preparation

Skin preparation has long been used to prevent SSI at abdominal surgery. With iodine as the historical agent of choice, emerging evidence shows that when compared with povidone–iodine the combination of chlorhexidine and alcohol can reduce the incidence of cesarean section SSI.[24] Before the commencement of this project in our center, chlorhexidine–alcohol (ChloroPrep) had been recently introduced after evidence was published demonstrating its superiority to povidone–iodine, in both general surgery[25] and in caesarean section.[24]

All staff members received reeducation with group-based in-house training led by the operating theater management team on the correct use of ChloroPrep. A 120-second timer was introduced to ensure that the preparation was allowed adequate time to dry before incision.

The Model for Improvement QI framework was used to implement the SSI reducing care bundle interventions using Plan-Do-Study-Act (PDSA) tests of change cycles.[10]

The improvement team was selected using stakeholder mapping and analysis and included team members with QI experience and a proven track record with recent successful QI projects within the hospital. The team consisted of frontline staff recruited from all aspects of patient care, including obstetric, anesthetic and microbiology medical staff, midwifery staff, theater nursing management, QI, laboratory surveillance, and the infection prevention and control team specialists. The QI team was led by the consultant obstetrician. The team met fortnightly for the first 3 months of the project and monthly thereafter. A team brainstorm identified the three aspects in clinical care that may be modifiable and be of benefit in preventing SSI. A baseline period of 3 months was selected to ascertain the baseline rate of SSI to minimize the impact of factors, such as variation in staff and skill set. Using the PDSA methodology, the changes (interventions) were introduced at various times (Figure 1), and compliance was surveyed (Table 1). The caesarean section SSI rate was tracked for 14 months after the introduction of care bundle, using a long follow-up period to evaluate both the initial and the sustained impact of this project.

The adherence data were collected at baseline and after the interventions were implemented. A patient questionnaire on perioperative practice was designed to measure preoperative practices with showering and hair removal instructions. This questionnaire was performed at baseline, before intervention, on 33 consecutive patients undergoing caesarean section over a 7-day period. These patients were undergoing both elective and emergency caesarean sections. This survey was used as a snapshot for adherence to the care bundle recommendations at a given time point.

Interventions 1 (personal hygiene education) and 2 (appropriate antibiotic timing) were implemented in November 2017, Figure 1. The patient survey was repeated in February 2018, 3 months postimplementation of the care bundles, on another randomly but consecutively selected 30 patients who were undergoing caesarean section.

Intervention 3 (skin preparation drying time) was commenced in February 2018 in addition to continuing Interventions 1 and 2. Throughout these PDSA cycles, the concurrent monthly caesarean section SSI rate was observed. This project had ethical approval with the institution's QI and audit committee.

Results

A total of 3,890 women underwent a caesarean section in our hospital during this QI project, 1,969 by elective and 1,921 by emergency caesarean section. During the baseline period of 3 months (August 2017–October 2017), 684 caesarean sections were performed. Within this group, 46 patients developed a SSI. This gave a baseline SSI rate of 6.7%. In the 14-month period of follow-up (November 2017 to December 2018), 3,206 caesarean sections were performed. Of this group, 110 patients developed a SSI (Table 2). The incidence of caesarean section SSI after introduction of the care bundle was 3.4%. This represents a reduction rate of 50%, $p = .001$. The SSI rate for throughout this QI project is demonstrated in Figure 1. Despite a transient rise in incidence of SSI in February 2018, overall the SSI incidence was reduced by half after the commencement of this QI project. The number needed to treat for the absolute risk reduction of 3.4% in this study is 29.

In the elective group, the rate of SSI in the baseline period was 4.4%, dropping to 2.7% after introduction of this care bundle (Table 3). The cohort who had emergency caesarean section also saw a reduction in the SSI rate with this care bundle, from 9.1% during the baseline period to an average

Table 1. Rates of Adherence to Interventions, at Baseline and Three Months Into the Commencement of Quality Improvement (QI) Project

	Adherence to intervention	
Intervention	**Baseline**	**3 months after QI introduction**
Preoperative showering and avoidance of hair removal	93%	100%
Preoperative antibiotics	0%	68%
Correct skin preparation technique and drying time	0%	97%

4.1% during the 14 months after introduction of this care bundles (Table 3).

The adherence data include the compliance rates with the interventions implemented as part of the care bundle. From the baseline survey of 33 women preintervention, 93% of patients showered before surgery, and 93% of patients undertook shaving/waxing hair removal within 5 days of surgery. None of the patients (0%) received antibiotics preoperatively (Table 1) or were waiting a full 120 seconds for the skin preparation to dry.

A repeat survey was completed at 3 months after introduction of Intervention 1 and 2 of the care bundle, on 30 patients. One hundred percent of patients were showering preoperatively, and 54% of patients were undertaking hair removal preoperatively. This represents an improvement of 42% in compliance with the hair removal instructions. After the initial 3-month intervention, 68% of patients were receiving antibiotics preoperatively (the baseline was 0%), and 97% of patients had full 120 seconds drying time between preparation wash and knife to skin.

Limitations

There are a number of limitations to this study. First, the diagnostic criteria and detection of SSI in our hospital omits patients who may have had a SSI but do not attend the hospital and are managed by their GP, meaning the incidence is likely underestimated. However, with a diligent infection prevention and control team in place in our center before launching this project, it must be noted that the methods of detection of SSI did not change. As such, the improvement in SSI rates are most likely attributable to the QI project.

In addition, the numbers involved in measuring adherence to perioperative interventions were small and prevent us from drawing conclusions on the specific interventions themselves, instead we looked at the QI project in its totality. This QI project proves the effectiveness of the strategies used to implement numerous interventions, rather than supporting the efficacy of the intervention itself.

The other factor to consider is that patient leaflets were given only to patients undergoing elective caesarean section and not those undergoing emergency caesarean section. This is a limitation of the study design, where it was purposely limited to this group as a provisional test of efficacy. However, our results have shown despite this that both groups saw a dramatic reduction in the SSI rate, which interestingly was more marked in the emergency caesarean section group (absolute risk reduction 54.9% vs. 38.6%). This cause of greater reduction is likely be multifactorial. In emergency settings, steps to ensure correct technique of skin preparation may be less likely to have been taken before the intervention and reeducation of staff. Observer bias may also play a role, although this is applicable to both cohorts. Given this, SSI reduction in the emergency setting was seen with patients only having two of the three interventions (no preoperative education on hygiene and hair removal), and it will be interesting to note the further effect (if any) of introducing preoperative education into routine antenatal care.

Discussion

After the implementation of the reducing SSI care bundle in our hospital, the caesarean section SSI rate reduced by 50%, from 6.7% to 3.4% over a sustained 14-month period. These figures were deduced from a large cohort of almost 4,000 patients who underwent caesarean section.

This clinically and statistically significant reduction in SSI has reduced morbidity for new mothers and is associated with reduced readmission rates, inpatient bed days, postoperative antibiotic prescribing, treatment cost,[26] and workload for the infection prevention and control team. Compliance with the

Table 2. Breakdown of Total Surgical Site Infections (SSI) and Caesarean Sections per Month, Both Before and After Intervention

	Monthly rate of caesarean sections and SSIs		
	No. of SSIs	No. of caesarean sections	SSI rate (%)
Baseline			
August 2017	13	213	6.1
September 2017	15	234	6.4
October 2017	18	237	7.6
Total baseline	46	684	6.7
QI project			
November 2017	9	243	3.7
December 2017	6	214	2.8
January 2018	8	233	3.4
February 2018	12	206	5.8
March 2018	5	239	2.1
April 2018	7	231	3.0
May 2018	11	262	4.2
June 2018	9	210	4.3
July 2018	5	243	2.1
August 2018	10	230	4.3
September 2018	6	212	2.8
October 2018	9	232	3.9
November 2018	5	228	2.2
December 2018	8	223	3.6
Total after intervention	110	3,206	3.4

care bundle interventions in this QI project demonstrates that effective care bundle implementation relies on multidisciplinary team (MDT) planning, key stakeholder engagement, and the collaborative efforts of the QI team. Involving healthcare providers from all disciplines and aspects of perioperative care allowed comprehensive and effective project design, implementation, and ownership, and enabled our care bundle interventions to be implemented with a high level of compliance.

Our aim of a 50% reduction was achieved. This hugely successful multidisciplinary frontline led QI project demonstrates that effective prevention of adverse outcomes relies on patient and staff engagement and reviewing the system of care delivery as a totality. It also supports QI and the Model for Improvement methodology as an extremely dynamic and effective way to deliver improvements in patient outcomes in a short timeframe. When comparing this project with other SSI QI projects, both locally[27] and internationally,[28] we have shown a dramatic reduction in SSI rates using a similar technique of evidence-based interventions implemented by a MDT.

Table 3. Rates of Surgical Site Infection (SSI) by Caesarean Section Subgroup

		No. of caesarean sections	No. of SSI in caesarean section group	Subgroup SSI rate (%)
Elective caesarean section cohort				
Baseline	August 2017 to October 2017	338	15	4.4
Quality improvement project	November 2017 to December 2018	1,631	44	2.7
Emergency caesarean section cohort				
Baseline	August 2017 to October 2017	339	42	9.1
Quality improvement project	November 2017 to December 2018	1,582	65	4.1

In addition to demonstrating its efficacy, the key to this project as with any QI project is its sustainability. The reduction in SSI has continued for 14 months since the initial intervention, and this project is still ongoing within our center. The next steps will involve rolling out preoperative patient leaflets to all antenatal patients by inclusion in the antenatal information pack at the booking visit and by integration into routine antenatal education.

Conclusion

With increasing rates of caesarean section SSIs and the associated morbidity for patients as well as the additional demand it places on service provision, measures to minimize and prevent this complication are vital in maintaining the highest quality perioperative care. After implementation of the reducing SSI care bundle in our center, the caesarean section SSI rate reduced by almost 50% from 6.7% to 3.4% over a sustained 14-month period This multidisciplinary QI project supports the growing evidence that QI projects with collaborative team efforts can result in dramatic improvements in patient outcomes. The success of this QI project is attributed to frontline ownership and empowerment of patients and staff to reduce the SSI for women having a caesarean section.

Implications

The use of the reducing SSI care bundle described in this article could be easily adopted by any center providing caesarean section perioperative care. Its design and methodology may be of particular benefit in obstetric centers where there is a need to update perioperative practices to preventing SSI. Indeed its efficacy may not be limited to obstetrics but is applicable for use outside of the specialty, to patients undergoing general surgery with abdominal wound incisions.

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