Received: 11 February 2021 | Revised: 28 June 2021 | Accepted: 19 July 2021

DOI: 10.1111/aogs.14235

ORIGINAL RESEARCH ARTICLE

Risk factors for surgical site infection following cesarean delivery: A hospital-based case–control study

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Abstract

Introduction: Cesarean section is the single most important risk factor for postpartum infection. Where the rest of the world shows increasing trends, the cesarean section rates are low in Norway and risk factors for infection after cesarean section may differ in high and low cesarean section settings. The goal of this study was to examine independent risk factors for surgical site infection after cesarean delivery in a setting of low cesarean section rates.

Material and methods: We conducted a hospital-based case-control study at Haukeland University Hospital. We included women who presented to our hospital with surgical site infection after cesarean section during the years 2014–2016 (n = 75). Controls were selected at a ratio of 2:1 (n = 148). Cases and controls were compared with respect to maternal and pregnancy characteristics using uni- and multivariable logistic regression models. Main outcome measures were anticipated risk factors for surgical site infection.

Results: The occurrence of surgical site infection was 0.4% and 5.4% after elective and emergency cesarean section, respectively. Compared to women without surgical site infection, women with surgical site infection were almost thrice more obese before pregnancy (OR 2.8, 95% CI 1.2–7.0), four times more likely to have preexisting psychiatric conditions (OR 4.4, 95% CI 1.1–17.6), and five times more likely to receive blood transfusion (OR 5.1, 95% CI 1.4–18.8). Signs of infection during labor was a marginally significant risk factor for surgical site infection (OR 2.0, 95% CI 1.0–5.4).

Conclusions: Emergency cesarean section was a significant risk factor for surgical site infection. Pregestational obesity, preexisting psychiatric conditions, and blood transfusion during or following delivery, were independent risk factors for surgical site infection. Signs of infection during labor was a marginally significant risk factor. Women with either of these risk factors should be carefully monitored and evaluated for signs of infection in the postpartum period.

Abbreviations: BMI, body mass index; CI, confidence interval; CS, cesarean section; NOIS, Norwegian Surveillance System for Antibiotic Consumption and Healthcare-Associated Infections; OR, odds ratio; PPROM, prelabor premature rupture of membranes; SSI, surgical site infection; WHO, World Health Organization.

KEYWORDS
Cesarean, delivery, infections, obesity, postpartum hemorrhage, women´s health issues

1 | INTRODUCTION

Cesarean section (CS) is a lifesaving procedure for both woman and child when indicated. CS is not, however, without risk and should only be performed when the potential benefits for mother and child are greater than the potential complications. The World Health Organization (WHO) stated in 1985 that the optimal rate of CS lies between 10% and 15%, and that other rates must be justified.[1] CS rates have, however, dramatically increased worldwide in spite of these recommendations, without an accompanying rise in obstetrical or fetal indications that should warrant CS.[2] CS is the most important risk factor for postpartum infection with a 20-fold increase compared to the vaginal delivery route.[3] We can hence expect rising trends in infectious morbidity with increasing rates of CS worldwide.[4] The Nordic countries are among the few countries where CS rates are not increasing.[5] The national average CS rate in Norway has stabilized at 16%.[6] At Haukeland University Hospital in Bergen, Western Norway, the CS rates have varied between 10 and 13 percent in the last 20 years.[6]

The term *surgical site infection* (SSI) was proposed by the Centers for Disease Control and Prevention (CDC) in 1992. SSI is defined as an infection that affects the incisional site, and might be superficial (skin and subcutaneous tissue) or deep (fascia and muscle), and organ/space infection (eg endometritis) within 30 days after surgery.[7] The reported incidence of SSI after CS varies between 3% and 15%.[8] The explanation for this spread might be different definitions applied and various follow up time.[9] SSI is the most common type of hospital infection in Europe and the US and poses a major burden to both the patient and the healthcare system, with up to a threefold lengthened stay in hospital after CS.[10] Hence, it is crucial to identify women at risk of SSI after CS to prevent such infections.

There are several known risk factors for SSI after CS,[11–13] however, studies on independent risk factors in hospitalized patients are scarce and the association of CS rates to SSI rates has previously not been studied in Scandinavia. There is need to examine whether the risk of postpartum infection is similar to countries with higher CS rates, as such knowledge would facilitate appropriate allocation of resources and planning of healthcare surveillance. The aim of our study was to define independent risk factors for SSI in our population.

Key Message

In a Norwegian case-control study of women delivering by emergency cesarean section, women with pregestational obesity, preexisting psychiatric conditions, and blood transfusion were found at risk of serious surgical site infection.

2 | MATERIAL AND METHODS

The present study was initiated by the Norwegian Surveillance System for Antibiotic Consumption and Healthcare-Associated Infections (NOIS) and conducted at Haukeland University Women´s clinic in Bergen. NOIS is coordinated by the Norwegian Institute of Public Health in collaboration with the hospitals and has been regulated by law since 2005.[14] The purpose of NOIS is to register the occurrence of postoperative infections that occur within 30 days after surgery. NOIS registers selected characteristics such as gender, age, duration of surgery in minutes, and administration of antibiotic prophylaxis. The accuracy of reported SSI by NOIS was 97.5% in 2010.[15]

Haukeland University Hospital is a tertiary referral care center and with approximately 5000 deliveries per year, it is the country´s second largest maternity unit. All emergency hospitals in Norway including maternity hospitals are public and free of cost for the patient. There are no profit incentives for performing a CS. We conducted a retrospective case-control study of women who delivered by CS between 1 January 2014 and 31 December 2016. The NOIS database identified 75 cases by searching the International Classification of Diseases, 10th Edition (ICD-10) for diagnostic codes encoding obstetric wound infection and/or endometritis (O85, O86) in combination with the surgical procedure code for CS (MCA 10) within 30 days after surgery.[16] All 75 cases were treated at our hospital. Thus, only women treated for SSI after CS at in- or outpatient level were included in the study. Patients diagnosed and treated in the primary healthcare were not included as they were not in contact with our hospital. The medical records were thoroughly reviewed to confirm that criteria according to the SSI definition were met.[7] Reoperation codes following obstetric surgery from the NCMP system were also included (MWA00, MWB00, MWC00), as was the code for uterine curettage (MBA03).[16] Controls were selected at a ratio of 2:1 and in close proximity to the case patient via the surgery activity system. The control group comprised the two patients without an infection who delivered by emergency CS before and after each case. We only included emergency CS in the control group because 73 among the 75 cases were emergency CS and we aimed that the groups be as comparable as possible.

The patients´ medical records were scrutinized to obtain information regarding health issues prior to and during pregnancy, as well as outcomes and complications in labor and surgery that seemed relevant according to existing literature on the topic of infection after CS. Maternal and pregnancy variables included

maternal age, parity, ethnicity, smoking habits, preexisting comorbidity (a group variable including preexisting pulmonary, neurological, hematological, urological, gynecological, gastrointestinal, rheumatological, and infectious disease), preexisting psychiatric morbidity (anxiety, depression, and posttraumatic stress disorder), body mass index (BMI) prior to pregnancy, weight gain during pregnancy, preexisting diabetes mellitus, gestational diabetes, previous intraabdominal surgery (predominantly previous CS), obstetric complications in the current pregnancy such as hypertension and preeclampsia, and urine tract infections in pregnancy. We also included information about prelabor premature rupture of membranes (PPROM), fetal complications eg intrauterine growth restriction and oligohydramnios.

Labor variables included whether labor had started spontaneously or by induction, method of induction, rupture of membranes and if so – for how many hours prior to delivery, the number of vaginal examinations, signs of infection during labor (clinical signs of chorioamnionitis eg temperature above 38°C, foul smelling amniotic fluid, maternal tachycardia with heart rate above 100 per minute or uterine tenderness, and fetal tachycardia with fetal heart rate above 160 per minute), and attempt of vaginal delivery either by pushing or by instrument.

Surgery variables included the type of procedure (elective vs. emergency), duration of surgery in minutes, estimated blood loss during surgery, and transfusion of blood products during or after surgery. We also included information regarding surgical complications such as organ damage or difficult head delivery, total length of hospitalization, number of reoperations, and clinical signs of sepsis for each patient. The cases registered as sepsis were ascertained in accordance with WHO´s definition of maternal sepsis with suspected or confirmed infection and organ dysfunction(s).[17]

In accordance with WHO´s recommendations, we routinely administer prophylactic antibiotics prior to surgery, which is reported to reduce up to 60%–70% of infections after CS.[18] Elective CS patients, however, are not given antibiotic prophylaxis if they are primiparous with normal pregestational BMI and otherwise healthy before and during pregnancy. For the patients receiving antibiotics, the standard practice is a first-generation cephalosporin given intravenously 60 min within surgery.

2.1 | Statistical analyses

We performed Pearson´s chi-quadrat-test to explore whether cases and controls differed from each other for each of the characteristics considered. For characteristics with a significant difference between the cases and controls at the 5% level of statistical significance, we performed univariable logistic regression with case-control status as the dependent variable. We additionally performed multivariable logistic regression including exposures that were significantly associated with case-control status into the model. Because missing values were few (Table 1) they were not included in the regression analyses.

Although the distribution of length of hospital stay was significantly different between the groups, we did not use this variable for adjustment, as we regarded it as intermediate in the causation of the exposures on infection.

We used sensitivity analyses to assess the potential influence of unmeasured confounding on the associations between the risk factors and case-control status. In a Bayesian simulation analysis we made the prior assumption that adding an influential, unmeasured confounder in the regression would zero out the associations between the exposures and outcome, decreasing the regression coefficient (β; standard deviation, SD) for the exposure to 0; SD, corresponding to an odds ratio (OR) of 1; 95% confidence interval (CI): exp(0 ± SD 1.96).

The statistical analyses were performed using SPSS version 26 (SPSS Inc.) and Stata version 16.0 (StataCorp LLC).

2.2 | Ethical approval

This project was initiated by the health authorities (NOIS) as a quality register; thus, ethics committee approval was not required. Approval of the research protocol was obtained from the data protection office at Haukeland University Hospital 21 March 2016, reference number 3670. The head of the Women´s clinic in Bergen has approved the project.

3 | RESULTS

During the study period between 1 January 2014 and 31 December 2016, we performed 1888 CSs of a total of 15460 deliveries at Haukeland University Women´s clinic (Figure 1). This resulted in a CS rate of 12.2% in the study period. The proportions of elective and emergency CS were 27.8% (524/1888) and 72.2% (1364/1888), respectively. Seventy-five (4%) of the 1888 patients were treated for SSI at our hospital, of which 69 had a prolonged stay after CS or were readmitted, while six were treated in the outpatient clinic. There were 58 superficial, 27 deep and 14 organ/space infections according to the definition by the Centers for Disease Control and Prevention.[7] Hence, a patient could have had an isolated localized infection or a combination of infection with varying tissue penetration. 80% of the patients with SSI required one or several reoperations. Only two infections (2.7%) were following planned CS, while 73 infections (97.3%) resulted from emergency CS. The rate for SSI after elective and emergency CS was 0.4% (2/524) and 5.4% (73/1364), respectively (Figure 1).

There were no statistically significant differences between case and control groups regarding age, parity, ethnicity, or preexisting comorbidities (Table 1). The groups did not differ in relation to whether labor had started spontaneously or by induction, method of induction, the degree of urgency for CS, administration of antibiotic prophylaxis, timing of antibiotic administration, duration of surgery, or estimated blood loss during surgery (Table 1). There were eight

TABLE 1 Pregnancy and labor characteristics in women with and without surgical site infection after cesarean delivery at Haukeland University Hospital, Norway, January 2014- December 2016

Characteristic	Category	Cases (N = 75), n (%)	Controls (N=148), n (%)	*p*-value
Age	≤25.0	15 (20.0)	16 (10.8)	0.17*
	25.1–34.9	41 (54.7)	88 (59.5)	
	≥35.0	19 (25.3)	44 (29.7)	
Pregestational BMI	≤25	33 (44.0)	88 (59.5)	0.04**
	25.1–29.9	21 (28.0)	40 (27.0)	
	≥30	20 (26.7)	18 (12.2)	
	Missing	1 (1.3)	2 (1.4)	
Weight gain during pregnancy	≤10 kg	22 (29.3)	42 (28.4)	0.51**
	10.1–20 kg	34 (45.3)	74 (50.0)	
	20.1–30 kg	16 (21.3)	23 (15.5)	
	> 30 kg	0 (0.0)	4 (2.7)	
	Missing	3 (4.0)	5 (3.4)	
Parity	0	51 (68.0)	87 (58.8)	0.18*
	≥1	24 (32.0)	61 (41.2)	
Ethnicity	Norwegian	50 (66.7)	95 (64.2)	0.51**
	European	9 (12.0)	20 (13.5)	
	African	9 (12.0)	10 (6.8)	
	Asian	6 (8.0)	21 (14.2)	
	South American	1 (1.3)	2 (1.4)	
Tobacco use	No	72 (96.0)	146 (98.6)	0.21**
	Yes	3 (4.0)	2 (1.4)	
Comorbidity[a]	No	48 (64.0)	92 (62.2)	0.79*
	Yes	27 (36.0)	56 (37.8)	
Preexisting psychiatric disease[b]	No	67 (89.3)	144 (97.3)	0.01**
	Yes	8 (10.7)	4 (2.7)	
Preexisting DM 1	No	74 (98.7)	146 (98.6)	0.99**
	Yes	1 (1.3)	2 (1.4)	
Gestational DM	No	62 (82.7)	138 (93.2)	0.01*
	Yes	13 (17.3)	10 (6.8)	
Previous Intraabdominal surgery[c]	No	60 (80.0)	120 (81.1)	0.85*
	Yes	15 (20.0)	28 (18.9)	
Gestational age in weeks at delivery	28–36	11 (14.7)	28 (18.9)	0.43*
	37–41	64 (85.3)	120 (81.1)	
Preeclampsia	No	69 (92.0)	135 (91.2)	0.84*
	Yes	6 (8.0)	13 (8.8)	
Hypertension	No	67 (89.3)	141 (95.3)	0.09*
	Yes	8 (10.7)	7 (4.7)	
UTI in pregnancy	No	67 (89.3)	148 (100)	<0.001**
	Yes	8 (10.7)	0 (0.0)	
IUGR	No	72 (96.0)	133 (89.9)	0.11**
	Yes	3 (4.0)	15 (10.1)	
Oligohydramnios	No	72 (96.0)	146 (98.6)	0.21**
	Yes	3 (4.0)	2 (1.4)	

(Continues)

TABLE 1 (Continued)

Characteristic	Category	Cases (N = 75), n (%)	Controls (N=148), n (%)	*p*-value
PPROM	No	46 (97.9)	145 (98.0)	0,97**
	Yes	1 (2.1)	3 (2.0)	
Surgery duration	≤30 min	7 (9.3)	18 (12.2)	0.017**
	31–60 min	53 (70.7)	114 (72.0)	
	>61 min	7 (9.3)	14 (9.5)	
	Missing	8 (10.7)	2 (1.4)	
Number of vaginal examinations	0–5	15 (20.0)	71 (48.0)	0.05*
	≥6	60 (80.0)	77 (52.0)	
Estimated blood loss during surgery	≤500 ml	32 (42.7)	72 (48.6)	0.61*
	501–1000 ml	31 (41.3)	58 (39.2)	
	>1000 ml	12 (16.0)	18 (12.2)	
Blood transfusion during or following CS	No	61 (81.3)	143 (97.3)	<0.001**
	Yes	14 (18.7)	4 (2.7)	
Failed vaginal operative delivery	No	66 (88.0)	142 (95.9)	0.03*
	Yes	9 (12.0)	6 (4.1)	
Signs of infection prior to delivery[d]	No	51 (68.0)	128 (86.5)	0.003**
	Yes	23 (30.7)	20 (13.5)	
	Missing	1 (1.3)	0 (0.0)	
Initiation of labor	Induction	32 (42.7)	68 (45.9)	0.72**
	Contractions	28 (37.3)	46 (31.1)	
	Rupture of membranes	15 (20.0)	33 (22.3)	
	Missing	0 (0.0)	1 (0.7)	
Induced labor	No	36 (48.0)	92 (62.2)	0.09*
	Yes	39 (52.0)	55 (37.2)	
	Missing	0 (0.0)	1 (0.6)	
Induction method	No induction	36 (48.0)	91 (61.5)	0.34**
	Balloon catheter	26 (34.7)	36 (24.3)	
	Prostaglandin	8 (10.7)	13 (8.8)	
	Oxytocin	2 (2.7)	5 (3.4)	
	Amniotomy	3 (4.0)	3 (2.0)	
Type of CS	Elective	2 (2.7)	0 (0.0)	0.05**
	Emergency	73 (97.3)	148 (100)	
Pushed before CS	No	60 (80.0)	134 (90.5)	0.03*
	Yes	15 (20.0)	14 (9.5)	
The urgency of CS	0–10 min	13 (17.3)	18 (12.2)	0.16*
	11–20 min	35 (46.7)	57 (38.5)	
	21–30 min	27 (36.0)	73 (49.3)	
Antibiotic prophylaxis	No	8 (10.7)	8 (5.4)	0.22**
	Yes	67 (89.3)	138 (93.2)	
	Missing	0 (0.0)	2 (1.4)	
Antibiotics given at right time	No	1 (1.3)	4 (2.7)	0.34*
	Yes	67 (89.3)	137 (92.6)	
	Missing	7 (9.3)	7 (4.7)	
Antibiotics during labor	No	64 (85.3)	127 (85.8)	0.92*
	Yes	11 (14.7)	21 (14.2)	

(Continues)

TABLE 1 (Continued)

Characteristic	Category	Cases (N = 75), n (%)	Controls (N=148), n (%)	*p*-value
Surgical complications[e]	No	42 (56.0)	102 (68.9)	0.06*
	Yes	33 (44.0)	46 (31.1)	
Surgical site infection	Superficial	58 (77.3)	0	-
	Deep	29 (39.2)	0	-
	Organ/space	14 (23.7)	0	-
Sepsis	No	67 (89.3)	148 (100)	<0.001**
	Yes	8 (10.7)	0 (0.0)	
Number of reoperations	0	15 (20.0)	0	-
	≥1	60 (80.0)	0	-
Cervix dilation before CS	0–5 cm	39 (52.0)	97 (65.5)	0.05*
	≥6 cm	36 (48.0)	51 (34.5)	
Rupture of membranes prior to CS	No rupture	5 (6.7)	36 (24.3)	0.001**
	1–10 h	21 (28.0)	49 (33.1)	
	≥11	49 (65.3)	63 (42.6)	
	Missing	2 (2.7)	4 (2.7)	
Duration of hospitalization	0–3 days	36 (48.0)	112 (75.7)	<0.001**
	≥4 days	37 (49.3)	30 (20.3)	
	Missing	2 (2.7)	6 (4.1)	

Abbreviations: BMI, body mass index; CS, cesarean section; DM, diabetes mellitus; IUGR, intrauterine growth restriction; PPROM, prelabor premature rupture of membranes; UTI, urine tract infection.

[a]Comorbidity; preexisting pulmonary, neurological, hematological, urological, gynecological, gastrointestinal, rheumatological and infectious disease

[b]Preexisting psychiatric disease; anxiety, depression, and posttraumatic stress disorder

[c]Previous intraabdominal surgery; predominantly previous cesarean section

[d]Signs of infection prior to delivery; clinical signs of chorioamnionitis eg temperature above 38°C, foul smelling amniotic fluid, maternal tachycardia with heart rate above 100 per minute or uterine tenderness, and fetal tachycardia with fetal heart rate above 160 per minute

[e]Surgical complications; tears to the cervix or uterus, adhesions and difficult head delivery

*p value for Pearson´s x^2 test.; **When expected numbers were below five, Fisher´s exact test was used.

cases (10.7%) of postpartum sepsis in the case group, and none in the control group. Additionally, there were eight cases (10.8%) of urine tract infections during pregnancy in the case group and none in the control group. The length of hospital stay was also significantly longer in the case group (Table 1).

The univariate and multivariate results of risk factors are presented in Table 2. Women with SSI had statistically higher pregestational BMI, more pregestational diabetes, and preexisting psychiatric disease than women without SSI. Compared to women without SSI, women who developed SSI had a higher number of vaginal examinations (six or more), blood transfusion during or following surgery, attempts of spontaneous or instrumental vaginal delivery, signs of infection during labor (ie clinical signs of chorioamnionitis), and rupture of membranes 11 h or more (Table 2). Figure S1 illustrates how the risk factors are interconnected as well as their contribution in the pathways between exposure (CS) and outcome (SSI).

After adjustments we identified three independent risk factors in our population; pregestational BMI more than 30 with adjusted OR 2.8 (95% CI 1.2–7.0), preexisting psychiatric conditions with adjusted OR 4.4 (95% CI 1.1–17.6), and blood transfusion during or following CS with adjusted OR 5.1 (95% CI 1.4–18.8). We found marginally significant association with signs of infection during labor with adjusted OR 2.0 (95% CI 1.0–5.4). Including the assumption of an unknown confounder to the exposures in the regression analyses, the associations persisted for pregestational BMI, preexisting psychiatric disease, and blood transfusion.

4 | DISCUSSION

Our study shows an occurrence of SSI after CS leading to re-hospitalization and outpatient contact of 4%. Emergency CS was a significant risk factor for SSI in our population. We found pregestational obesity, preexisting psychiatric disease, and blood transfusion during or after CS to be independent risk factors for developing SSI following CS. Our low CS rates do not seem to affect the SSI rates compared to those in other countries.

In an Irish case-control study by Saeed et al, 75% of women with SSI were delivered by emergency CS and 25% by elective CS and the overall rate of SSI following CS was 2%.[11] Emergency CS was an independent risk factor for CS, which is consistent with the present and other studies.[19,20] In our population, however, there were only

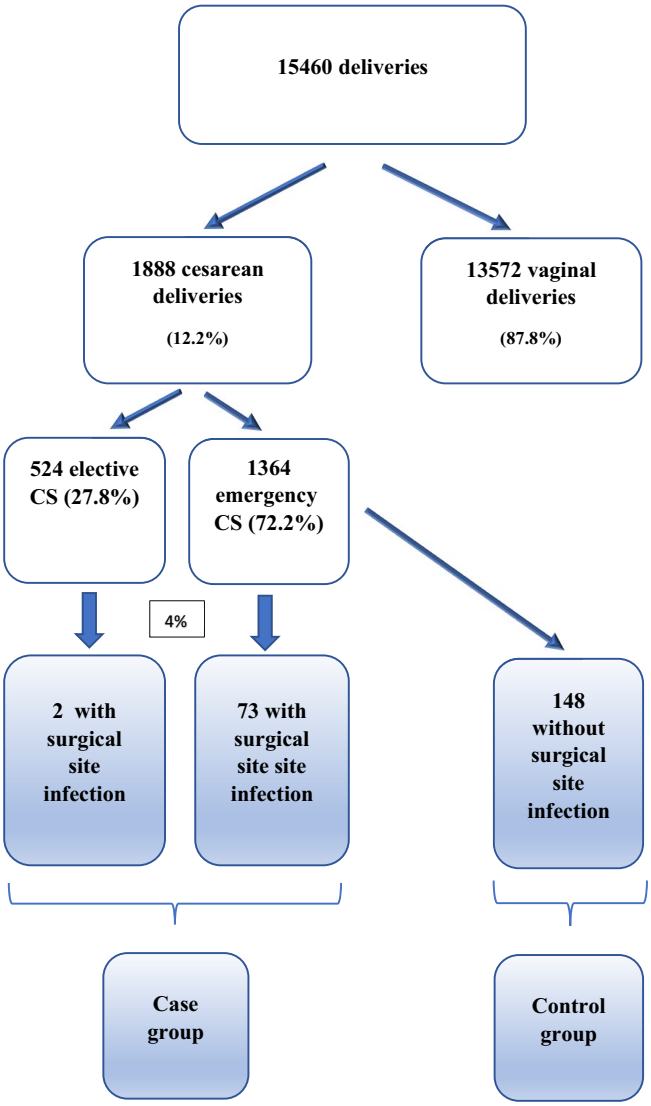

FIGURE 1 Flow chart of women delivered by elective and emergency cesarean section with surgical site infection at Haukeland University Hospital, Norway, during January 2014–December 2016. Abbreviation: CS; cesarean section

two cases of elective CS in the case group and no cases of elective CS in the control group. Consequently, we could not include elective and emergency CS in the multivariate analysis. We assume that most of the women delivered by emergency CS in our population have undergone trial of labor. This assumption is supported by our low CS rates in general (12.2%). The different compositions of elective and emergency CS within the case groups in these two populations (25% vs. 75% in Saeed´s and 2.3% vs. 97.3% in our study) and different CS rates (12.2% vs. 31%), might explain our finding of 4% SSI while Saeed et al. demonstrated 2%. We assume that the larger proportion of emergency CS in our population contributes to the observed difference in the occurrence of SSI in these two populations. In addition, the entire Irish CS population was given antibiotics. The antibiotic of choice, a second-generation cephalosporin, was broader than in our study.[11] In contrary, we administer a first-generation cephalosporin.

In the present study, women delivering by elective CS received antibiotic prophylaxis only by indication. The elective CS population in general differs from the emergency CS population in having intact fetal membranes which serve as a barrier and prevent cervicovaginal bacterial flora from entering the uterine cavity. The rate of SSI in this group (0.4%), implies that our approach in administering antibiotic prophylaxis by indication, seems appropriate. In contrary to our study, a prospective study conducted in Norway in 2007 showed no difference in the prevalence of SSI after elective and emergency CS.[21] However, they included patients with self-reported infection without medical examination, patients who were diagnosed with superficial SSI and treated in the primary health care, as well as outpatient contacts and re-hospitalized patients, which might explain the interstudy difference.

Obesity was found to be an independent risk factor for SSI in our study. This finding has also been demonstrated in several other studies consistent with the growing evidence that adipose tissue leads to chronic inflammation and increased vulnerability to pathogens.[11,13,22] A study from Scotland reported that obese women had increased risk of postpartum sepsis regardless of delivery mode and that obesity was an independent risk factor for infection of varying severity.[23] In 2018, 12.7% of all pregnant women in Norway were obese with pregestational BMI of 30 or higher and 22.7% were overweight with BMI more than 25 but less than 30.[6] The prevalence of obesity and overweight seems to be rising and poses an immense challenge to the public health and the healthcare services.[24]

Our study suggests that postpartum anemia requiring transfusion of blood products is an independent risk factor for SSI, although estimated blood loss during surgery was not related to SSI risk. One possible explanation might be that the estimation of perioperative blood loss is a less accurate measure than blood hemoglobin. Consistently, Olsen et al found in 2010 that perioperative blood transfusion was an independent risk factor for infectious morbidity in the form of endometritis following CS.[25] Studies from other fields than obstetrics have also demonstrated that transfusion of blood products increases the risk of infectious morbidity.[26] One possible reason is that severe blood loss requiring transfusion not only depletes the patient of erythrocytes but also white blood cells, which play an important part in providing an immune response.

Another independent risk factor in our study was preexisting psychiatric morbidity; ie anxiety and depression, as well as posttraumatic stress disorder. We know from previous studies that depression during pregnancy is associated with poorer obstetric outcomes, such as preterm delivery due to elevated cortisol.[27] Similar mechanisms could contribute in the development of infection. We only had few cases with preexisting psychiatric morbidity and the associations are likely more complex than this assumption and warrant further investigation.

Our study indicates signs of infection during labor as a marginally significant risk factor for SSI. Chorioamnionitis as a risk factor for SSI has been demonstrated in previous studies as well.[28,29] Exposure to cervicovaginal bacterial flora after rupture of fetal membranes is a possible mechanism and key contributing factor

TABLE 2 Frequencies, crude and adjusted odds ratios of surgical site infection according to maternal and obstetric characteristics in cases (women with surgical site infection following cesarean delivery) and controls (women without surgical site infection following cesarean delivery), Haukeland University Hospital, Norway, January 2014-December 2016. Adjustments are made for all factors listed in the table

Characteristic	Category	cOR (95% CI)	aOR (95% CI)
Pregestational BMI	≤25	Reference	Reference
	25.1–29.9	1.4 (0.7–2.6)	1.4 (0.6–3.0)
	≥30	2.9 (1.4–6.3)	2.8 (1.2–7.0)
	Missing	-	-
Preexisting psychiatric disease[a]	No	Reference	Reference
	Yes	6.5 (1.9–22.8)	4.4 (1.1–17.6)
Gestational DM	No	Referance	Referance
	Yes	2.9 (1.2–7.0)	2.2 (0.8–4.7)
Number of vaginal examinations	0–5	Reference	Reference
	≥6	3.7 (1.9–7.1)	2.0 (0.8–4.8)
Blood transfusion during or following CS	No	Reference	Reference
	Yes	8.2 (2.6–25.9)	5.1 (1.4–18.8)
Failed vaginal operative delivery[b]	No	Reference	Reference
	Yes	3.2 (1.1–9.4)	1.5 (0.3–7.0)
Signs of infection prior to delivery[c]	No	Reference	Reference
	Yes	2.9 (1.5–5.7)	2.0 (1.0–5.4)
	Missing	-	-
Attempt of spontaneous delivery before CS	No	Reference	Reference
	Yes	2.4 (1.1–5.3)	2.3 (0.7–7.5)
Rupture of membranes before CS	No rupture	Reference	Reference
	1–10 h	3.1 (1.1–9.0)	1.7 (0.5–6.5)
	≥11 h	5.6 (2.0–15.3)	0.6 (0.1–6.3)

Abbreviations: aOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; cOR, crude odds ratio; CS, cesarean section; DM, diabetes mellitus

[a]Preexisting psychiatric disease; anxiety, depression, and posttraumatic stress disorder

[b]Attempt of vaginal operative delivery; failed vacuum or forceps delivery

[c]Signs of infection prior to delivery; clinical signs of chorioamnionitis eg temperature above 38°C, foul smelling amniotic fluid, maternal tachycardia with heart rate above 100 per minute or uterine tenderness, and fetal tachycardia with fetal heart rate above 160 per minute

for infection.[20] Consequently, we suggest that antibiotic prophylaxis still is justified in the setting of emergency CS as suggested by WHO.[10]

We consider the main strength in our study to be the inclusion of several characteristics in accordance with existing literature that could contribute to infection. Additionally, our sensitivity analyses suggested that the observed associations are robust to confounding.

Our study had several limitations. The study was hospital-based and conducted at a university hospital with a low CS rate. Consequently, our results may not be generally applicable to other hospitals or populations. However, the independent risk factors obesity and blood transfusion are likely applicable to other obstetric populations. Our SSI rate of 4% does not include patients with less serious SSI diagnosed in the primary health care, leading to a possible underestimation of SSI in total.

The present study was designed without previous estimation of statistical power, as the primary intention was to create a quality register. However, the study by Saeed et al,[11] with nearly the same study size of 80 cases and 160 controls (vs. 75 cases and 148 controls in our study), managed to achieve 80% power to detect an odds ratio of 2.5 for a risk factor when using the standard 5% level of statistical significance.

5 | CONCLUSION

Our study indicates that emergency CS is a significant risk factor for serious SSI in patients delivered by CS, while pregestational obesity, preexisting psychiatric disease, and blood transfusion during or following CS are independent risk factors. We recommend that women with either of the demonstrated independent risk factors for SSI following emergency CS, are monitored carefully postpartum. We advocate for keeping rates of CS low as the most important prevention of infection, as suggested by WHO.[30] Hence, we must reserve CS to those with definite medical indication and especially avoid CS without medical indication in obese women.

CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

HFT collected the data and helped with the conception of the study. SAK carried out the analyses and wrote the first draft of the paper. EB and SR supervised the analyses. All authors have contributed to the design of the study, drafting the paper and revising it critically for important intellectual content and approved it for publication.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: Kvalvik SA, Rasmussen S, Thornhill HF, Baghestan E. Risk factors for surgical site infection following cesarean delivery: A hospital-based case-control study. *Acta Obstet Gynecol Scand*. 2021;100:2167–2175. https://doi.org/10.1111/aogs.14235