Title: Risk factors for surgical site infection following Caesarean section: a retrospective cohort study

Ketcheson, Felicia, MSc[1]; Woolcott, Christy, PhD[2,3]; Allen, Victoria, MD, FRCPC[1,3]; Langley, Joanne M., MD, FRCPC[1,2,4*]

1 Department of Community Health and Epidemiology, Dalhousie University, Halifax, Nova Scotia, Canada
2 Department of Pediatrics, Dalhousie University, Halifax, Nova Scotia, Canada
3 Department of Obstetrics & Gynaecology, Dalhousie University, Halifax, Nova Scotia, Canada
4 Canadian Centre for Vaccinology, IWK Health Centre, Halifax, Nova Scotia, Canada

*Corresponding author: joanne.langley@dal.ca

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Abstract

Background: The rate of Caesarean section (C/S) is increasing in North America. Surgical site infection (SSI) following C/S can make it difficult to recover from surgery, care for a baby and return home. We aimed to determine the incidence of post-C/S SSI to 30 days, risk factors, and if risk factors differed for pre- versus post-discharge SSI.

Methods: A retrospective cohort was created by linking a provincial perinatal database to hospital admissions and physician billings databases to follow women delivering via C/S for 30 days post operatively for SSI. Women with a provincial health card who delivered a baby ≥500 g and ≥20 weeks' gestational age from 1997-2012 were eligible. Logistic regression with generalized estimating equations was used to determine risk factors.

Results: 33,991 C/Ss occurred in 25,123 women. The SSI rate of 2.72% (95% CI 2.54%-2.89%) decreased over the study period. Independent risk factors for SSI with adjusted odds ratios ≥1.5 were pre-pregnancy weight ≥87 kg, gaining ≥30 kg, chorioamnionitis, maternal blood transfusion, anticoagulation therapy, alcohol or drug abuse, labour onset before C/S, delivering in 1997-2000 and delivering in a hospital performing 130-949 C/Ss per year. Multiple gestations, smoking, C/S during first stage of labour, delivering earlier in the study period and in a hospital with130-1249 C/S deliveries per year significantly differed between pre- versus post-discharge SSI.

Interpretation: Most risk factors are known pre-delivery and some are potentially modifiable. While the rate of SSI has decreased, the rate of C/Ss warrants attention to preventive interventions to reduce the burden of illness associated with SSI.

Introduction

The percentage of pregnancies delivered by Caesarean section (C/S) has been increasing in North America. In Canada, the C/S rate was 20% in 1988 (1) and rose to 26% in 2012 (2). Surgical site infection (SSI) following C/S can adversely influence the post-partum period for mother and newborn, making it difficult to recover from surgery, care for a baby, and return home. Although Canada has no national surveillance for SSI following C/S, the U.S. National Healthcare Safety Network follows this healthcare associated infection and reported a mean SSI rate of 1.84% for the period 2006-2008 (3). An Australian study of 81 healthcare facilities from 2002-2013 found a similar rate of 2.05% (95% confidence interval [CI] 1.93%-2.18%) which decreased over the study period (4). Some hospitals conduct surveillance on C/S-SSI up until discharge and others conduct post-discharge surveillance as well. The rate of SSI until hospital discharge following C/S varies, ranging from 1.9% to 11.2% according to a review of studies from 1990-2007 (5). Rates of SSI are higher if post-discharge surveillance is conducted, but most infection prevention and control programs do not have the resources to perform this surveillance.

Risk factors for SSI following C/S have been identified in the literature. Most studies have found a significant association between obesity and risk for SSI (6,7) and further, a dose-response relationship between body mass index (BMI) and risk for SSI has been noted (8). Conversely, findings for other risk factors, such as hypertension and diabetes, have been less consistent between studies (8-10). Appropriately timed antibiotic prophylaxis (11) and chlorhexidine antiseptic skin preparation (12) have both been shown to decrease the risk of postoperative SSI.

In the current study, a population-based cohort in one province of Canada was followed from the perinatal period to 30 days after surgery to determine 1) the incidence of SSI to 30 days

postpartum and the percentage of infections presenting prior to or after discharge from the delivery hospital admission, 2) risk factors associated with the development of SSI, and 3) whether risk factors differ with time of presentation.

Methods

Study setting

This study took place in Nova Scotia (population ~950,000), which in 2011 had 8,860 births and a C/S rate of 26.6% (13). Approximately half of deliveries are performed at the regional and tertiary care centre based in the capital city (IWK Health Centre, Halifax). This study was approved by the Reproductive Care Program's Joint Data Access Committee, Health Data Nova Scotia, and the IWK Health Centre's Research Ethics Board (project number 1019575).

Study participants

Women with a Nova Scotia health card who gave birth via C/S in the province between January 1, 1997 and December 31, 2012 were eligible. Women were excluded if they delivered a baby weighing less than 500 g or less than 20 weeks' gestational age.

Study design and data sources

The retrospective cohort was created using the Nova Scotia Atlee Perinatal Database (NSAPD), a provincial database administered by the Reproductive Care Program of Nova Scotia. It contains information on all pregnancies and deliveries in Nova Scotia, which is collected by healthcare professionals using standardized forms. From the NSAPD, we obtained relevant information on pregnancy, labour, delivery, and the postpartum period, including SSI identified pre-discharge.

Study outcome

The NSAPD was linked with the Canadian Institute for Health Information's Discharge Abstract Database (DAD) to capture SSI diagnosed during any hospitalization, and with the Nova Scotia Medical Services Insurance Billings (MSI) Physician Billings database to capture

post-discharge SSIs that were treated in a physician's office. The DAD used the International Classification of Diseases, edition 9 (ICD-9) until 2000 and the Canadian Enhancement of edition 10 (ICD-10-CA) from 2001 onward, and MSI used ICD-9 diagnostic codes. The outcome was SSI following C/S within 30 days of surgery. Any woman with a diagnostic code for surgical wound infection or endometritis according to any of the coding systems: the NSAPD, ICD-10-CA (N71.0, N71.9, N73.0, O86.0xx); or ICD-9 (614.3, 674.30, 674.32, 674.34, 998.51, or 998.59) was considered to have been diagnosed with a SSI. SSIs were categorized according to whether the diagnosis occurred during the hospitalization for delivery of the infant ("pre-discharge"), or the diagnosis occurred after being discharged to the community in a subsequent hospital admission or in a physician's office ("post-discharge"). The timing of pre-discharge SSI could not be defined as only admission and discharge dates are recorded. For SSI identified post-discharge, we estimated the number of days from C/S to identification of SSI based on the date of either hospital re-admission or physician visit.

Potential risk factors

A number of potential risk factors for SSI were examined (see Table 1). The NSAPD has information on smoking at various times (i.e. at first prenatal visit, 20 weeks, and delivery) from which was determined whether the woman smoked. Height was not recorded in the NSAPD until 2003 and, therefore, standard BMI categories (14) were approximated using weight cut points determined using receiver operator characteristic curve analysis: <53 kg as underweight, 53-<67 kg as normal weight, 67-<77 kg as overweight, 77-<87 as obese I, 87-<98 as obese II, and ≥98 as obese III. In supplementary analyses of deliveries from 2003 on, we examined BMI (<18.5, 18.5-<25, 25-<30, 30-<40, and ≥40 kg/m^2) for comparison. Hypertension, diabetes, and depression

variables were all combinations of both diagnostic codes and codes indicating the mother was taking medication for these medical conditions from the NSAPD.

Statistical analysis

The unit of analysis was deliveries by C/S rather than women. Descriptive statistics were used to estimate the incidence of pre-discharge, post-discharge, and total SSI to 30 days with exact CIs. Chi-square tests were used to determine which risk factors were significantly associated with SSI. Risk factors associated with SSI at $p<0.10$ were entered into a multiple logistic regression model from which risk factors that were not independently associated with SSI were removed using backward stepwise selection. Only risk factors that were associated with SSI at $p<0.05$ were retained. From the logistic models, odds ratios (OR) with 95% CIs were estimated. Risk factors for pre- and post-discharge SSI were examined using multinomial logistic regression. Generalized estimating equations were used for all logistic models to account for potential correlation between women who had more than one C/S over the study period. For risk factors with ≥5% missing, a missing category was created, but women with missing values for risk factors with <5% missing overall were excluded from regression analyses (since a missing value category would have low numbers). All analyses were conducted using STATA SE 13 (StataCorp LP, College Station, Texas).

Results

Over the 16-year study period, 25123 women (with 33991 C/S) were identified from the NSAPD and could be linked to hospital and physician billings data (>96% linkage). A total of 923 SSIs followed these 33991 C/S deliveries within 30 days, giving a rate of 2.72% (95% CI 2.54%-2.89%). There were 15 women who had more than one SSI during this period. The rate decreased from 5.2% in 1997 to 2.0% in 2012 (Figure 1). The post-discharge SSI rate of 1.59% (95% CI 1.45%-1.72%) was higher than the pre-discharge rate of 1.13% (95% CI 1.02%-1.24%) ($p<0.001$). Of the post-discharge SSIs, 370 (68.6%) were identified in hospital readmissions. Nearly 85% of women who first presented with SSI post-discharge did so within two weeks of their C/S. The mean length of postpartum stay decreased from 3.86 days (SD=1.53) in 1997-2000 to 3.23 days (SD=1.04) in 2009-2012 ($p<0.001$). Administration of antibiotic therapy for either prophylaxis or treatment during labour and delivery increased from 46.9% in 1997-2000 to 73.6% in 2009-2012. From 2003-2012, we were able to determine that in only 8.2% of women receiving antibiotics was the indication for Group B Streptococcus.

Table 2 shows the risk factors that were independently associated with the odds of developing SSI within 30 days following C/S at $p<0.05$ (see Appendix 1 for univariate associations of all potential risk factors with SSI). Women who gave birth in 1997-2000 had the highest risk of presenting with SSI (OR 2.23; 95% CI 1.81-2.75), relative to those delivering between 2009-2012. Compared to women who were primiparous, women who were multiparous had a lower risk of SSI (OR 0.78; 95% CI 0.67-0.92). A dose-response relationship was observed between pre-pregnancy weight and SSI with women weighing at least 98 kg having more than three times the odds of SSI than women weighing less than 53 kg. In supplementary analyses conducted for the period 2003-2012, BMI was similarly associated with SSI (data not shown).

The results of the multinomial logistic regression analysis comparing the risk factors for pre-discharge SSI and post-discharge SSI are found in Table 3. Women who smoked during pregnancy and women who had C/S in the first stage of labour had significantly higher odds of presenting with SSI post-discharge than pre-discharge. Deliveries that were earlier in the study period, of multiple gestations, and in a hospital that performed 130-1249 C/Ss per year had significantly higher odds of an SSI presenting pre-discharge than post-discharge.

Interpretation

In this 16-year study of nearly 34000 deliveries by C/S, the incidence of SSI to 30 days was 2.72% (95% CI 2.54%-2.89%). More SSIs presented post-discharge than pre-discharge (58.4% vs. 41.6%, respectively). Many of the risk factors identified for SSI are modifiable or known before delivery including pre-pregnancy weight and anticoagulation therapy. Some risk factors were associated differently with pre- vs. post-discharge SSI .

The incidence of SSI of 2.72% observed in the present study is comparable to the lower end of the range of 1.9%-11.2% found in a review (5). A Nova Scotian study reported the SSI rate from 1988-2002 to be 1.50%; however, the study only assessed SSI to discharge (15). The higher rate of SSI found by following women for 30 days suggests that using solely pre-discharge surveillance will underestimate the frequency of SSI. Since post-discharge surveillance is expensive, analysis of databases, as in this study, can be a feasible method to evaluate if rates are changing over time. Variation in reported SSI rates can often be attributed to different populations, time periods, SSI definitions, secular trends, and improvements in healthcare (16). The decrease in our SSI rate over a 16-year period is similar to a decreased rate of 2.05% in an Australian study (4). Possible reasons for a decrease in the SSI rate include increased administration of appropriate prophylactic antibiotics and the use of 2% chlorhexidine skin antisepsis.

We noted a number of risk factors for SSI, including higher pre-pregnancy weight and weight gain during pregnancy. A dose-response relationship was observed between pre-pregnancy weight (and BMI) and SSI, with weighing ≥98 kg (approximating obese class III) being associated with over three times the odds of SSI (OR 3.56; 95% CI 2.85-4.45), compared to weighing ≥53 to 66.9 kg (approximating normal weight). Pre-pregnancy obesity has been a

significant independent risk factor for SSI in most studies (6,7) and is therefore important given its large OR, high prevalence (estimated at 35% in the present study), and consistency of association among studies. Many other risk factors found that are theoretically modifiable included smoking, alcohol or drug abuse, gaining ≥30 kg, and no antibiotic prophylaxis, suggesting the odds of developing SSI may decrease if these risk factors are reduced or eliminated. A targeted clinical and infection prevention and control approach could decrease the SSI rate and lower the burden of SSI following C/S on patients and the healthcare system.

This study is novel in its analysis comparing pre- and post-discharge risk factors for C/S-SSI. Though many risk factors were similarly associated, there were some significant differences between pre- and post-discharge risk factors. Many risk factors associated with pre-discharge SSI may be linked to an increased potential for contamination during surgery (e.g. not receiving antibiotic therapy) and longer surgery duration (e.g. obesity and multiple gestations). In contrast, risk factors associated with post-discharge SSI may be indicative of increased potential for wound contamination (e.g. smoking and low socioeconomic status) and delayed wound healing or wound separation (e.g. obesity). These results suggest that the effect of some individual risk factors is influenced by the length of time since surgery. A previous study of different surgeries, excluding C/S, also found a significant difference between risk factors for pre- and post-discharge SSI, including age and duration of surgery (17). More studies are necessary to see if these findings are observed in other populations, and to separate the influence of location (hospital versus home) from that of time since surgery.

Limitations

An administrative database was used to capture SSI, which leads to the potential for misclassification; however, the use of administrative data for post-C/S SSI has been validated in

the literature. A Canadian study found that the sensitivity for detection of SSI after C/S was 16.7% when using hospital data and increased to 77.3% when including emergency room and physician administrative data (18). Similarly, a review of validation studies for SSI following any surgery found a pooled sensitivity for non-orthopedic surgeries to be 76.7% (95% CI 46.3%-92.6%) (19). As such, the risk for misclassification is low. Some risk factors were unavailable for the entire study period (e.g. maternal height) or had a high percentage of missing values. Finally, the NSAPD does not contain surgical information (e.g. length of surgery) so were unable to be included as potential risk factors for SSI.

Conclusion

Findings are generalizable to populations with similar healthcare systems and demographic and clinical factors as Nova Scotia. Knowing which risk factors are associated with pre- versus post-discharge SSI can assist clinicians in identifying women with specific risk factor profiles who may be at risk for SSI. This offers an opportunity to develop systematic approaches to remove or reduce risk factors through patient, public and healthcare provider education, and system approaches such as timely administration of appropriate antibiotics.

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Figure 1: Surgical site infection rate by year

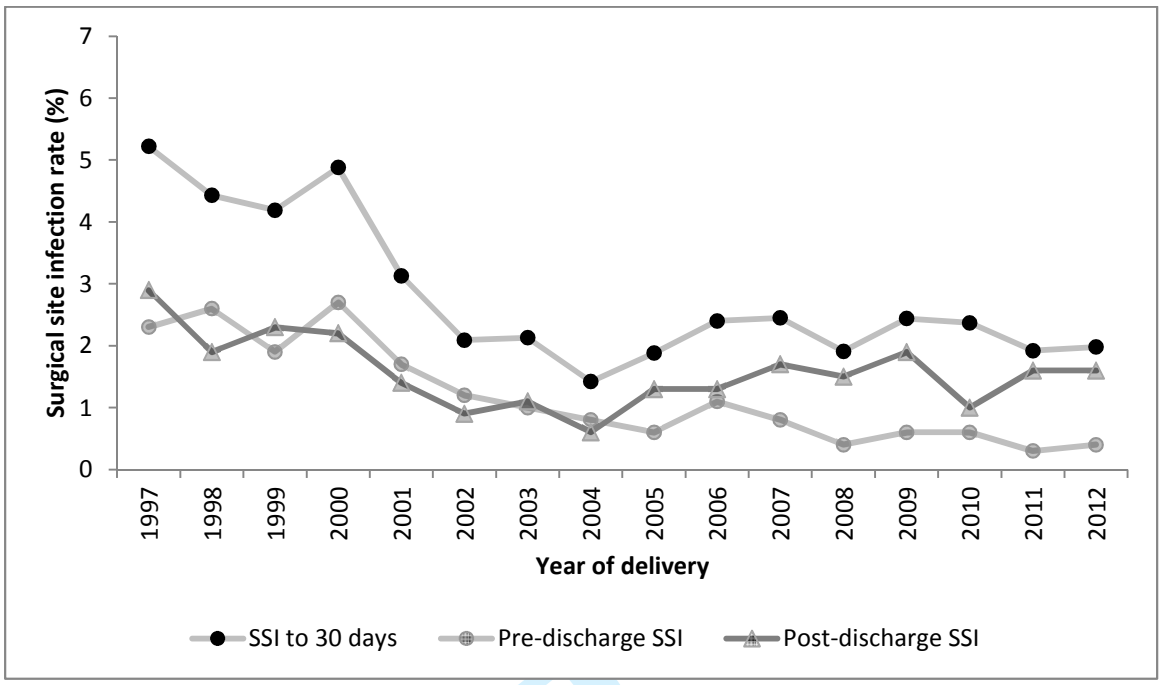

Table 1: Potential risk factors for SSI that were examined, by the level of significance in univariate analyses

Factors not associated with SSI (p≥0.10)	Factors associated with SSI (p<0.10)
Maternal residence (urban, rural) Maternal influenza immunization in pregnancy (no, yes) SSI after previous C/S (no, yes) Season of delivery (Dec-Feb, Mar-May, Jun-Aug, Oct-Nov) Type of C/S (low segment transverse, other) Instrumentation use (no, forceps or vacuum) General anesthesia during labour and/or delivery (no, yes) Other procedures performed during C/S (no, yes) Presentation at delivery (other, vertex, missing) Number of fetuses (1, ≥2) Diagnostic and/or therapeutic procedures performed on fetus (no, yes)	Number of C/S in delivery hospital (<130, 130-949, 950-1249, ≥1250) Region of maternal residence (A, B, C, D) Neighbourhood level income quintile (1, ≥2) Maternal age(<25, 25-34, ≥35 years) Pre-pregnancy weight (<53, 53-<67, 67-<77, 77-<87, 87-<98, ≥98 kg, missing) Marital status (married or common-law, other, missing) Smoking during pregnancy (no, yes) Alcohol or drug abuse during pregnancy (no, yes) Non-obstetric pre-existing health conditions affecting pregnancy (no, yes) Hypertension (no, pre-existing, gestational or unspecified, preeclampsia) Diabetes (no, pre-existing, gestational) Anemia during pregnancy (no, yes) Depression (no, yes) Anticoagulation therapy during pregnancy (no, yes) Parity (primiparous, multiparous) Mode of delivery in last pregnancy (none, vaginal, C/S) Previous C/S (none, 1, ≥2) Weight gain during pregnancy (<10, 10-<30, ≥30 kg, missing) Chorioamnionitis (no, yes) Diagnostic and/or therapeutic procedure(s) performed on mother (no, yes) Steroid use ≥48 hours before delivery for fetal lung maturity (no, yes) Cervical dilation at the last examination before Caesarean section (0, 1-3, 4-10 cm) Time between rupture of membranes to delivery (≤1, 2-11, ≥12 hour) Stage of labour before C/S (none, 1st, 2nd) Spontaneous rupture of membranes (no, yes) Length of antepartum stay (<24, 24-49, ≥50 hours) Year of delivery (1997-2000, 2001-2004, 2005-2008, 2009-2012) Delivering on a weekend (no, yes) Primary indication for C/S (breech, dystocia, fetal distress, other, previous C/S) Regional anesthesia during labour and/or delivery (no, yes) Antibiotic therapy (yes, no) Maternal blood transfusion (no, yes) Infant birth weight (<2500, 2500-4000 ≥4000 g) Apgar score at five minutes (<7, ≥7)

	Gestational age (<37, 37-39[6],≥40 weeks) Breastfeeding at discharge (yes, no)

C/S=Caesarean section; SSI=surgical site infection

Table 2: Risk factors for surgical site infection following Caesarean section to 30 days postpartum

Risk factor	% of total*	No.		Adjusted OR (95% CI)
		No SSI	SSI	
Year of delivery				
1997-2000	22.0	6891	335	2.23 (1.81-2.75)
2001-2004	26.5	8532	190	1.12 (0.90-1.39)
2005-2008	27.0	8670	193	1.02 (0.82-1.25)
2009-2012	24.5	7880	185	Reference
Maternal age, yr				
<25	18.6	5876	224	1.13 (0.94-1.36)
25-34	61.5	19719	506	Reference
≥35	19.9	6378	173	1.21 (1.01-1.44)
Parity				
Primiparous	49.5	15723	537	Reference
Multiparous	50.5	16250	366	0.78 (0.67-0.92)
Marital status				
Married/common-law	72.7	23323	572	Reference
Single/divorced/separated/widowed	22.3	7044	283	1.31 (1.10-1.55)
Missing	5.0	1606	48	1.13 (0.81-1.56)
Quintile of neighbourhood-level income				
1 (lowest)	20.1	6349	259	1.36 (1.16-1.58)
2-5	79.9	25624	644	Reference
Smoking during pregnancy				
No	78.5	25151	643	Reference
Yes	21.5	6822	260	1.18 (1.00-1.38)
Alcohol or drug abuse				
No	98.6	31543	877	Reference
Yes	1.4	430	26	1.64 (1.07-2.51)
Pre-pregnancy weight, kg				
<53	8.1	2593	61	1.03 (0.77-1.39)
53-<67	29.4	9463	194	Reference
67-<77	16.9	5410	133	1.26 (1.01-1.58)
77-<87	12.1	3868	108	1.42 (1.11-1.81)
87-<98	7.8	2480	85	1.84 (1.41-2.41)
≥98	9.5	2954	185	3.56 (2.85-4.45)
Missing	16.2	5205	137	1.48 (1.09-2.01)
Weight gain during pregnancy, kg				
<10	16.8	5353	155	0.77 (0.63-0.94)
10-<30	55.7	17809	489	Reference
≥30	1.9	599	37	1.99 (1.40-2.84)
Missing	25.7	8212	222	1.05 (0.82-1.33)

Risk factor	% of total*	No.		Adjusted OR (95% CI)
		No SSI	SSI	
Non-obstetric conditions affecting pregnancy				
No	80.9	25941	671	Reference
Yes	19.1	6032	232	1.28 (1.09-1.50)
Diabetes				
No	93.5	29923	802	Reference
Pre-existing	0.6	194	11	1.63 (0.87-3.08)
Gestational	5.9	1856	90	1.47 (1.16-1.86)
Depression during pregnancy				
No	95.6	30567	847	Reference
Yes	4.4	1406	56	1.39 (1.04-1.86)
Anticoagulation therapy during pregnancy				
No	99.1	31700	880	Reference
Yes	0.9	273	23	2.62 (1.67-4.12)
Chorioamnionitis				
No	97.8	31307	848	Reference
Yes	2.2	666	55	2.80 (2.08-3.76)
Stage of labour before Caesarean section				
None	48.6	15645	327	Reference
First	32.0	10159	349	1.21 (1.01-1.44)
Second	19.5	6169	227	1.55 (1.27-1.89)
Antibiotic therapy				
Yes	37.1	11788	400	Reference
No	62.9	20185	503	1.29 (1.11-1.50)
Maternal blood transfusion				
No	99.0	31675	878	Reference
Yes	1.0	298	25	2.69 (1.75-4.14)
Gestational age, weeks				
<37	9.7	3057	116	1.33 (1.08-1.66)
$37\text{-}39^{+6}$	57.1	18331	439	Reference
≥40	33.3	10585	348	1.10 (0.94-1.29)
Number of Caesarean sections per hospital per year				
<130	25.0	8070	155	Reference
130-949	21.8	6893	282	2.22 (1.80-2.74)
950-1249	27.7	8787	312	1.87 (1.51-2.31)
≥1250	25.5	8223	154	1.43 (1.11-1.83)

Note: CI=confidence interval, OR=odds ratio, SSI=surgical site infection

*32876 deliveries by Caesarean section included in the analysis (1115 deliveries excluded due to missing values on neighbourhood-level income (*n*=724), smoking (*n*=283), and/or gestational age (*n*=118).

Table 3: Risk factors for pre- and post-discharge surgical site infection following Caesarean section

Risk factor	No SSI, no.*	Pre-discharge SSI		Post-discharge SSI		*p* value†
		No.*	Adjusted OR (95% CI)	No.*	Adjusted OR (95% CI)	
Year of delivery						
1997-2000	6947	173	5.46 (3.85-7.74)	164	1.26 (0.98-1.63)	<0.001
2001-2004	8551	102	2.84 (1.95-4.14)	88	0.62 (0.47-0.81)	<0.001
2005-2008	8687	64	1.52 (1.03-2.25)	130	0.87 (0.68-1.11)	0.017
2009-2012	7896	40	Reference	145	Reference	
Maternal age, yr						
<25	5906	83	1.11 (0.84-1.46)	142	1.19 (0.94-1.50)	0.703
25-34	19782	212	Reference	296	Reference	
≥35	6393	84	1.38 (1.06-1.79)	89	1.05 (0.83-1.34)	0.137
Marital status						
Married/common-law	23381	251	Reference	323	Reference	
Single/divorced/separated/widowed	7087	112	1.36 (1.06-1.78)	172	1.30 (1.05-1.61)	0.750
Missing	1613	16	1.26 (0.73-2.17)	32	1.08 (0.73-1.61)	0.652
Quintile of neighbourhood-level income						
1 (lowest)	6378	97	1.20 (0.94-1.53)	162	1.48 (1.22-1.80)	0.172
2-5	25703	282	Reference	365	Reference	
Smoking during pregnancy						
No	25222	283	Reference	362	Reference	
Yes	6859	96	0.97 (0.76-1.25)	165	1.41 (1.15-1.73)	0.020
Pre-pregnancy weight, kg						
<53	2610	28	1.06 (0.69-1.62)	35	1.10 (0.74-1.63)	0.895
53-<67	9502	92	Reference	102	Reference	
67-<77	5419	51	1.02 (0.72-1.44)	82	1.46 (1.09-1.97)	0.117
77-<87	3876	46	1.26 (0.88-1.81)	62	1.52 (1.10-2.10)	0.451
87-<98	2484	37	1.64 (1.11-2.42)	48	1.94 (1.36-2.77)	0.521
≥98	2966	72	2.91 (2.11-4.01)	114	3.93 (2.92-5.30)	0.170
Missing	522	53	1.03 (0.65-1.62)	84	1.90 (1.24-2.89)	0.051

Risk factor	No SSI, no.*	Pre-discharge SSI		Post-discharge SSI		*p* value†
		No.*	Adjusted OR (95% CI)	No.*	Adjusted OR (95% CI)	
Stage of labour before Caesarean section						
None	15701	156	Reference	172	Reference	
First	10190	133	1.02 (0.79-1.31)	218	1.48 (1.18-1.86)	0.030
Second	6190	90	1.37 (1.04-1.80)	137	1.75 (1.35-2.26)	0.191
Antibiotic therapy						
Yes	11848	192	Reference	211	Reference	
No	20233	187	1.47 (1.18-1.84)	316	1.17 (0.96-1.41)	0.105
Maternal blood transfusion						
No	31782	369	Reference	512	Reference	
Yes	299	10	2.86 (1.47-5.55)	15	2.78 (1.60-4.80)	0.944
Number of fetuses						
Singleton	31045	352	Reference	516	Reference	
Multiples	1036	27	2.14 (1.41-3.26)	11	0.66 (0.36-1.21)	<0.001
Number of Caesarean sections per hospital per year						
<130	8086	51	Reference	105	Reference	
130-949	6933	126	3.21 (2.30-4.50)	157	1.75 (1.34-2.29)	0.005
950-1249	8816	143	2.58 (1.81-3.67)	170	1.56 (1.19-2.05)	0.027
≥1250	8246	59	1.81 (1.20-2.75)	95	1.24 (0.91-1.70)	0.150

Note: CI=confidence interval, OR=odds ratio, SSI=surgical site infection

* 32987deliveries by Caesarean section included in the analysis (1004 deliveries excluded due to missing values on neighbourhood-level income (*n*=724) and/or smoking (*n*=283).

† *p* value for the association between the risk factor and SSI timing (pre- vs. post-discharge).

Appendix 1: Univariate associations between surgical site infection following Caesarean section and potential risk factors

Potential Risk Factor	No SSI n(%)	SSI n(%)	*p*
Year of delivery (n=33,991)			
1997-2000	7045 (95.3)	346 (4.7)	<0.001
2001-2004	8672 (97.8)	192 (2.2)	
2005-2008	8806 (97.8)	194 (2.2)	
2009-2012	8545 (97.8)	191 (2.2)	
Season of delivery (n=33,991)			
December-February	7474 (97.4)	201 (2..6)	0.943
March-May	8525 (97.3)	238 (2.7)	
June-August	8659 (97.2)	246 (2.8)	
September-November	8410 (97.3)	238 (2.8)	
Delivering on a weekend (n=33,991)			
No	27441 (97.4)	741 (2.6)	0.032
Yes	5627 (96.9)	182 (3.1)	
Region of maternal residence (n=33,991)			
A	15584 (97.4)	424 (2.7)	<0.001
B	5880 (96.4)	217 (3.6)	
C	6135 (97.4)	163 (2.6)	
D	5469 (97.9)	119 (2.1)	
Maternal residence (n=33,971)			
Urban	22978 (97.2)	655 (2.8)	0.342
Rural	10071 (97.4)	267 (2.6)	
Maternal age, years (n=33,991)			
<25	6077 (96.4)	228 (3.6)	<0.001
25-34	20392 (97.5)	516 (2.5)	
≥35	6599 (97.4)	179 (2.6)	
Parity (n=33,991)			
Primiparous	16268 (96.8)	545 (3.2)	<0.001
Multiparous	16800 (97.8)	378 (2.2)	
Marital status (n=33,991)			
Married/common-law	24102 (97.6)	587 (2.4)	<0.001
Single/divorced/separated/widowed	7286 (96.2)	287 (3.8)	
Missing	1680 (97.2)	49 (2.8)	
Quintile of neighbourhood-level income (n=33,267)			
1 (lowest)	6441 (96.1)	262 (3.9)	<0.001
2-5	25912 (97.6)	652 (2.45)	
Smoking during pregnancy (n=33,708)			
No	25820 (97.5)	651 (2.5)	<0.001
Yes	6973 (96.4)	264 (3.7)	

Potential Risk Factor	No SSI n(%)	SSI n(%)	*p*
Alcohol or drug abuse during pregnancy (n=33,991)			
No	32621 (97.3)	897 (2.7)	<0.001
Yes	447 (94.5)	26 (5.5)	
Pre-pregnancy weight, kg (n=33,991)			
<53	2680 (97.7)	63 (2.3)	<0.001
53-66.9	9787 (98.0)	199 (2.0)	
67-76.9	5553 (97.6)	136 (2.4)	
77-86.9	3976 (97.4)	108 (2.6)	
87-97.9	2548 (96.7)	86 (3.3)	
≥98	3043 (94.2)	187 (5.8)	
Missing	5481 (97.4)	144 (2.6)	
Weight gain during pregnancy, kg (n=33,991)			
<10	5493 (97.2)	158 (2.8)	<0.001
10-29.9	18355 (97.4)	498 (2.6)	
≥30	615 (94.2)	38 (5.8)	
Missing	8605 (97.4)	229 (2.6)	
Non-obstetric pre-existing health conditions affecting pregnancy (n=33,991)			
No	26761 (97.5)	681 (2.5)	<0.001
Yes	6307 (96.3)	242 (3.7)	
Hypertension (n=33,991)			
No	28719 (97.5)	738 (2.5)	<0.001
Pre-existing	515 (95.7)	23 (4.3)	
Gestational or unspecified	2605 (96.0)	110 (4.1)	
Preeclampsia	1229 (95.9)	52 (4.1)	
Diabetes (n=33,991)			
No	30955 (97.4)	819 (2.6)	<0.001
Pre-existing	203 (94.9)	11 (5.1)	
Gestational	1910 (95.4)	93 (4.6)	
Anemia during pregnancy (n=33,991)			
No	30551 (97.3)	837 (2.7)	0.063
Yes	2517 (96.7)	86 (3.3)	
Depression during pregnancy (n=33,991)			
No	31592 (97.3)	866 (2.7)	0.021
Yes	1476 (96.3)	57 (3.7)	
Anticoagulation therapy during pregnancy (n=33,991)			
No	32774 (97.3)	900 (2.7)	<0.001
Yes	294 (92.7)	23 (7.3)	
Chorioamnionitis during pregnancy (n=33,991)			
No	32383 (97.4)	867 (2.6)	<0.001
Yes	685 (92.4)	56 (7.6)	
Maternal influenza vaccination during pregnancy (n=33,991)			
No	32105 (97.3)	901 (2.7)	0.360
Yes	963 (97.8)	22 (2.2)	

Potential Risk Factor	No SSI n(%)	SSI n(%)	*p*
Mode of delivery in last pregnancy (n=33,991)			
Not applicable	18188 (96.9)	589 (3.1)	<0.001
Vaginal	4187 (97.4)	111 (2.6)	
Caesarean section	10693 (98.0)	223 (2.0)	
Number of previous Caesarean sections (n=33,991)			
None	20748 (96.9)	663 (3.1)	<0.001
One	9695 (98.0)	199 (2.0)	
Two or more	2625 (97.7)	61 (2.3)	
SSI after previous Caesarean section(n=33,991)			
No	32731 (97.3)	908 (2.7)	0.405
Yes	337 (95.7)	15 (4.3)	
Steroid use ≥48 hrs before delivery for fetal lung maturity (n=33,991)			
None	31919 (97.3)	873 (2.7)	0.002
Yes	1149 (95.8)	50 (4.2)	
Length of antepartum stay, hrs (n=33,969)			
<24	27786 (97.5)	722 (2.5)	<0.001
24-49	3029 (96.8)	99 (3.2)	
≥50	2231 (95.6)	102 (4.4)	
Stage of labour before Caesarean section (n=33,990)			
None	16225 (98.0)	339 (2.1)	<0.001
First	10478 (96.7)	354 (3.3)	
Second	6364 (96.5)	230 (3.5)	
Cervical dilation in the last examination before Caesarean section, cm (n=33,130)			
None	16758 (98.0)	346 (2.0)	<0.001
1-3	3371 (96.8)	113 (3.2)	
4-10	12104 (96.5)	438 (3.5)	
Time between rupture of membranes to delivery, hrs (n=33,690)			
<1	16501 (97.8)	370 (2.2)	<0.001
2-11	8044 (96.9)	254 (3.1)	
≥12	8228 (96.6)	293 (3.4)	
Spontaneous rupture of membranes (n=33,646)			
No	23614 (97.4)	630 (2.6)	0.021
Yes	9116 (97.0)	286 (3.0)	
Primary indication for Caesarean section (n=33,991)			
Breech	4471 (97.6)	109 (2.4)	<0.001
Dystocia	8602 (96.5)	311 (3.5)	
Fetal distress	5066 (96.6)	176 (3.4)	
Other	5120 (97.4)	139 (2.6)	
Previous Caesarean section	9809 (98.1)	188 (1.9)	
Type of Caesarean section (n=33,991)			
Low segment transverse	32338 (97.3)	902 (2.7)	0.845
Other	730 (97.2)	21 (2.8)	

Potential Risk Factor	No SSI n(%)	SSI n(%)	*p*
Instrumentation used during Caesarean section (n=33,991)			
No	30492 (97.3)	843 (2.7)	0.360
Forceps or vacuum	2576 (97.0)	80 (3.0)	
General anesthesia during labour or delivery (n=33,991)			
No	30301 (97.4)	821 (2.6)	0.005
Yes	2767 (96.4)	102 (3.6)	
Regional anesthesia during labour or delivery (n=33,991)			
No	2100 (96.8)	70 (3.2)	0.152
Yes	30968 (97.3)	853 (2.7)	
Diagnostic and/or therapeutic procedure(s) performed on mother (n=33,991)			
No	32112 (97.3)	885 (2.7)	0.034
Yes	956 (96.2)	38 (3.8)	
Diagnostic and/or therapeutic procedure(s) performed on fetus (n=33,991)			
No	31702 (97.3)	883 (2.7)	0.770
Yes	1366 (97.2)	40 (2.8)	
Other procedures performed during Caesarean section (n=33,991)			
No	26875 (97.3)	756 (2.7)	0.556
Yes	6193 (97.4)	167 (2.6)	
Antibiotic prophylaxis (n=33,991)			
Yes	20909 (97.6)	510 (2.4)	<0.001
No	12159 (96.7)	413 (3.3)	
Maternal blood transfusion (n=33,991)			
No	32749 (97.3)	896 (2.7)	<0.001
Yes	319 (92.2)	27 (7.8)	
Number of fetuses (n=33,991)			
Singleton	31992 (97.3)	884 (2.7)	0.116
Multiples	1076 (96.5)	39 (3.5)	
Presentation at delivery (n=33,991)			
Other	8906 (97.2)	260 (2.8)	0.314
Vertex	22243 (97.4)	601 (2.6)	
Missing	1919 (96.9)	62 (3.1)	
Gestational age, weeks (n=33,873)			
<37	3195 (96.4)	121 (3.7)	<0.001
37-39+6	18900 (97.7)	450 (2.3)	
≥40	10858 (96.9)	349 (3.1)	
Infant birth weight, g (n=33,967)			
<2,500	2235 (96.9)	72 (3.1)	0.001
2500-3900	29186 (97.4)	779 (2.6)	
≥4000	1626 (95.9)	69 (4.1)	
Apgar score at 5 minutes (n=33,794)			
0-6	619 (94.9)	33 (5.1)	<0.001
7-10	32256 (97.3)	886 (2.7)	

Potential Risk Factor	No SSI n(%)	SSI n(%)	*p*
Breastfeeding at discharge (n=33,677)			
Yes	23129 (97.6)	572 (2.4)	<0.001
No	9645 (96.7)	331 (3.3)	
Number of Caesarean sections in the delivery hospital, per year (n=33,991)			
<130	8364 (98.1)	162 (1.9)	<0.001
130-949	7107 (96.1)	286 (3.9)	
950-1249	9133 (96.6)	321 (3.4)	
≥1250	8464 (98.2)	154 (1.8)	

SSI=surgical site infection

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Page 2
Objectives	3	State specific objectives, including any prespecified hypotheses Page 2, paragraph 3
Methods		
Study design	4	Present key elements of study design early in the paper Page 4, paragraph 3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Location - page 4, paragraph 1 Dates - page 4, paragraph 2 Exposure - page 5, paragraph 2 Follow-up - page 5, paragraph 1 Data collection - page 4, paragraph 3 & paragraph 4
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up Eligibility criteria - page 4, paragraph 2 Selection of participants - page 4, paragraph 3 *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed N/A *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Outcomes - page 4, paragraph 4 Outcome diagnostic criteria - page 5, paragraph 1 Exposures/predictors - page 5, paragraph 2
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Outcomes - page 5, paragraph 2
Bias	9	Describe any efforts to address potential sources of bias N/A

Study size	10	Explain how the study size was arrived at Page 4, paragraph 2
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Page 5, paragraph 2
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding Statistical methods: page 6, paragraph 2 Confounding: page 6, paragraph 2
		(*b*) Describe any methods used to examine subgroups and interactions N/A
		(*c*) Explain how missing data were addressed Page 6, paragraph 2
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed N/A *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses N/A

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed Page 7, paragraph 1
		(b) Give reasons for non-participation at each stage N/A
		(c) Consider use of a flow diagram N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Page 7, paragraph 2
		(b) Indicate number of participants with missing data for each variable of interest Appendix 1
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount) Page 7, paragraph 1
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time Page 7, paragraph 1
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included Page 7, paragraph 2, Page 8 paragraphs 1
		(*b*) Report category boundaries when continuous variables were categorized See methods: page 5, paragraph 2
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Page 7, paragraph 2
Discussion		
Key results	18	Summarise key results with reference to study objectives Page 9, paragraphs 1-3; page 10, paragraphs 1-2
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Page 10, paragraph 1
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Pages 9-11
Generalisability	21	Discuss the generalisability (external validity) of the study results Page 11, paragraph 2
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable,

for the original study on which the present article is based
See title page

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.