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Surgical site infection following cesarean delivery: patient, provider and procedure specific risk factors

Raj SHREE, MD^{3,*}, Seo Young Park, PhD¹, Richard H. Beigi, MD, MSc^{2,3}, Shannon L. Dunn, MPH^{2,3}, and Elizabeth E. Krans, MD, MSc^{2,3}

Raj SHREE: swati.shree@gmail.com; Seo Young Park: parksy@upmc.edu; Richard H. Beigi: beigirh@upmc.edu; Shannon L. Dunn: dunns1@upmc.edu; Elizabeth E. Krans: kransee@upmc.edu

¹Department of Medicine, Center for Research on Health Care, University of Pittsburgh, 200 Meyran Avenue, Pittsburgh, PA 15213, (412) 864-3022, Fax (412) 586-9672

²Department of Obstetrics, Gynecology and RS, University of Pittsburgh, 300 Halket Street, Pittsburgh, PA 15213, (412) 641- 4220, Fax (412) 641-1133

³Magee-Womens Research Institute, 204 Craft Avenue, Pittsburgh, PA 15213, (412) 641-6085, Fax (412) 641-3170

Abstract

Objective—To identify risk factors for cesarean delivery (CD) surgical site infection (SSI).

Study Design—Retrospective analysis of 2739 CDs performed at the University of Pittsburgh in 2011. CD SSI's were defined using National Healthcare Safety Network (NHSN) criteria. Chi-square and *t* tests were used for bivariate analyses and multivariate logistic regression was used to identify SSI risk factors.

Results—Of 2739 CDs, 178 (6.5%) were complicated by SSI. Patients with a SSI were more likely to have Medicaid, have resident physicians perform the CD, an ASA class of 3, chorioamnionitis, use tobacco and labor prior to CD. In multivariable analysis, labor (2.35;1.65–3.38), chorioamnionitis (2.24;1.25–3.83), resident teaching service (2.15;1.54–3.00), tobacco use (1.70; 1.04–2.70), ASA class 3 (1.61; 1.06–2.39) and CDs performed for non-reassuring fetal status (0.43; 0.26–0.67) were significantly associated with CD SSI.

Conclusion—Multiple patient, provider and procedure specific-risk factors contribute to CD SSI risk which may be targeted in infection control efforts.

Keywords

cesarean delivery; surgical site infection; wound infection; pregnancy

Corresponding author and author for reprint requests: Elizabeth E. Krans, MD, MSc, Department of Obstetrics, Gynecology and RS, University of Pittsburgh, 300 Halket Street, Pittsburgh, PA 15213.

*Dr. Shree's current affiliation is Department of Obstetrics and Gynecology, Division of Maternal Fetal Medicine, University of Washington Medical Center, 1601 NE Columbia Road, Seattle, WA 98195.

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Introduction

In 2012, the rate of cesarean delivery (CD) in the United States was 32.8%, an increase of 58% from 1996.¹ With approximately one third of pregnancies ending in CD, an evaluation of factors that contribute to maternal and neonatal morbidity associated with CD is of significant clinical importance. Second only to urinary tract infections, surgical site infection (SSI) is the most common complication associated with CD with reported rates from 3% to 15%.^{2–7} Extended hospital length of stays and increased morbidity associated with SSI result in an increase in health care costs ranging from \$3,000 to \$29,000 per SSI and up to \$10 billion in annual healthcare expenditures in the United States.⁸

In 2011, the Center for Disease Control and Prevention's (CDC) National Healthcare Safety Network (NHSN) developed procedure-specific SSI risk models for 39 surgical procedures to compare rates of SSI between surgeons and hospitals and account for variability in patient case mix.⁹ The NHSN CD SSI risk model included patient and procedure specific risk factors such as BMI, age and anesthesia, in addition to three nonspecific NHSN risk index variables: ASA class (3, 4 or 5), wound classification (contaminated or dirty) and procedure duration in minutes (>75th percentile).¹⁰ Despite continued efforts to improve SSI prediction, the NHSN noted a limited number of available patient- and procedure-specific variables in their dataset associated with SSI (e.g. diabetes) for certain procedures such as CD and called for additional efforts to improve the predictive performance of procedure-specific risk models.⁹ Therefore, the purpose of this study was to identify risk factors associated with CD SSI in a large, university-affiliated, tertiary care teaching hospital and develop an improved procedure-specific risk model for CD using CDC NHSN criteria.

Materials and Methods

Dataset

We conducted a retrospective cohort study of all cesarean deliveries (CD) performed at our institution from January 1st to December 31st 2011. *International Classification of Diseases, Ninth Revision* (ICD-9) codes for CD were used to identify the sample. Maternal demographics including age, race, body mass index (BMI), insurance status, private versus resident teaching service, gestational age at delivery, neonatal weight, number of previous CDs, maternal medical comorbidities, such as hypertensive disorders and diabetes, CD indication, and intraoperative characteristics of the procedure were extracted from the electronic medical record. Data extracted from the electronic medical record was validated through a double entry process. A team of researchers experienced in medical record extraction individually and separately extracted each variable from the medical record into two separate databases. These two datasets were then merged and analyzed for discrepancies between the entered data. Each discrepancy was reviewed and resolved by the authors (RS, EK, SD) through a third review of the medical record. This study was approved by the University of Pittsburgh Institutional Review Board, IRB # PRO14030341.

Patient Characteristics

Race was self-reported and categorized as Caucasian, African American, or other. Maternal age, body mass index (kg/m^2), gestational age and neonatal weight were studied as continuous variables. Maternal hypertensive disorders were categorized as either chronic hypertension or pregnancy related hypertensive disorders (gestational hypertension, mild pre-eclampsia, severe pre-eclampsia, superimposed pre-eclampsia, and eclampsia). Diabetes was characterized as either gestational or pregestational (type 1 and type 2). American Society of Anesthesiologists (ASA) Class was dichotomized into ASA Class 1 and 2 and ASA Class 3. Chorioamnionitis was diagnosed by the attending physician during labor based on the presence of at least two of the following clinical characteristics: maternal temperature ≥ 100.4 degrees Fahrenheit, maternal leukocytosis ($> 15,000$ cells/ mm^3), maternal tachycardia (> 100 beats/minute) or fetal tachycardia (> 160 beats/minute).

Provider Characteristics

Magee-Womens Hospital of the University of Pittsburgh is a teaching institution and virtually all CDs are performed by an attending and an obstetrics and gynecology resident physician. Private CDs are performed by an attending physician with assistance from a junior level resident or a physician assistant. Resident teaching service CDs are performed by a senior-level and a junior-level resident under the supervision of an attending physician. Labor management was performed by residents for the resident patients and by the private physician group for the private patients.

Procedure Characteristics

Non-labored, primary CDs included CDs for the following indications: elective, malpresentation (breech, transverse), placenta previa, twins, fetal growth restriction and/or anomalies, maternal history of a shoulder dystocia, maternal history of a fourth degree laceration or ano-rectal disease, or a maternal bony pelvis disorder. Non-labored, repeat CDs included elective repeat CDs. CDs performed after labor was defined as CDs performed after the onset of contractions, cervical change, ruptured membranes or administration of an induction or augmentation agent. CDs performed for non-reassuring fetal status included urgent or emergency CDs for placental abruption, cord prolapse, concern for uterine rupture or non-reassuring fetal heart rate. Intraoperative technique variables included bladder flap creation, method of placental removal (manual or spontaneous), hysterotomy closure (single or double layer), peritoneum closure, bladder flap closure, subcutaneous layer closure, and skin incision closure (sutures versus staples). Non-routine surgical variations included lysis of adhesions documented in the operative note as a separate procedure, extension repair, and management of intraoperative hemorrhage. Intraoperative hemorrhage was defined as the need for a blood transfusion, the use of intraoperative uterotonics (hemabate, methergine, and/or misoprostol aside from routine post-placental oxytocin administration), uterine artery laceration, O'Leary or B-Lynch hemostatic suture placement, or the use of a Bakri balloon. Operative time was defined as the time from skin incision to completion of skin closure in minutes as recorded by the circulating nurse in the operating room.

CD SSI

SSIs monitored by the NHSN are limited to infections occurring within 30 days after the procedure, are classified as 1) superficial incisional, 2) deep incisional and 3) organ/space and must meet specific criteria (Figure 1).¹¹ To identify patients with a CD SSI, we reviewed the medical records of patients with an ICD-9 diagnosis of a wound infection, cellulitis, seroma, hematoma, endometritis and/or who required intravenous or oral antibiotics during an intrapartum hospitalization, an inpatient readmission, emergency department visit or outpatient visit during the six week postpartum period following the CD (n=392). SSIs that meet NHSN criteria (n=178) within the identified sample were included in the analysis.¹¹ All patients with a CD SSI received preoperative antibiotics (cefazolin for patients without allergy and clindamycin and gentamycin for patients with allergy) within 60 minutes prior to the CD skin incision, received a skin preparation using chlorhexidine gluconate solution (4.0% w/v),¹² and hair removal using clippers¹³ which is standard for all cases at our institution. Vaginal preparation is not performed at our institution for CD.

Data Analysis and Model Development

Descriptive statistics were used to report demographic characteristics for the population. Chi square and t-tests were used to test for each variable's association with SSI. The continuous variable "operative time" was coded as "operative time 10" for every 10-minute increase in duration. To select the predictors to be included in our multivariate predictive model, variables with p-values < 0.10 from the bivariate analyses (chi-square tests and t-tests) or univariate logistic regression models were included as predictors as well as clinically relevant variables.¹⁴ The variables "Medicaid" and "Resident Teaching Service" were both considered related to socioeconomic status and found to be collinear (chi-square p-value <0.001). Therefore, only "Resident Teaching Service" was used in the multivariable model. Although the continuous variable "BMI" was not significant in our bivariate analysis (p=0.28), we elected to include this in our multivariable model as it is a well-established risk factor for infection. Stepwise logistic regression with backward elimination based on the p-values of the coefficient estimates was used to develop the model. That is, starting with the full model, we removed one predictor with the highest p-value from the model, then refit the model with remaining predictors, and then removed another predictor with the highest p-value from the revised model. We repeated this procedure until the p-values of all predictors become less than 0.10 and designated this as the final model.

The predictive performance of our models was assessed by misclassification rate as well as constructing receiver-operating characteristic (ROC) curves, which summarizes sensitivities and specificities of the model on the whole dataset. To evaluate the generalizability of our final model, it was validated using a 10-fold cross-validation procedure which applies the model to a simulated cohort of patients. All analyses were conducted with STATA® 12 (StataCorp, College Station, TX) and R (R Foundation for Statistical Computing, Vienna, Austria). Missing values were excluded from the analysis.

Results

Sample characteristics

The sample consisted of 2,876 CDs performed between January 1st and December 31st of 2011. Of 2,876 CDs, we excluded non-Pfannensteil skin incisions (vertical skin incisions [n=26] or unspecified [n=12]), all hysterotomies not performed in the low-transverse fashion (n=46) and all cesarean hysterectomies (n=12). In an effort to study otherwise routine low transverse CD, we also excluded cases with bladder injuries (n=11), intraoperative bladder evaluation with cystoscopy (n=24), and cases in which extra procedures were performed (oophorectomy [n=11], myomectomy [n=10], hernia repair [n=4], and vaginal laceration repair [n=8]), as these are not considered customary components of a CD. After CDs with one or more of the previous diagnoses were excluded [n=137 (4.8%)], our final sample consisted of 2,739 low transverse CDs performed via a Pfannensteil incision.

Within our final sample, 178 (6.5%) had a CD SSI. Of CD SSIs, 101 (56.7%) were superficial incisional, 8 (4.5%) were deep incisional and 69 (38.8%) were organ space. Seromas and hematomas that did not meet superficial incisional NHSN SSI criteria were not included. The patient, provider and procedure characteristics of the sample are summarized in Table 1. The majority of patients in our sample were Caucasian, had private insurance, and had their CD performed by a private attending. The mean BMI of our cohort was 33.4 kg/m² and the most common indication for CD was a CD performed following labor. The vast majority of physicians created a bladder flap and delivered the placenta spontaneously. Approximately half of the physicians closed the hysterotomy in two layers while less than 5% closed the bladder flap. Both peritoneum and subcutaneous layer closure were performed in approximately one third of cases and more than half of the physicians used staples for skin closure. Finally, approximately 19% of CDs required lysis of adhesions while 18% were complicated by intraoperative hemorrhage. The mean duration of CD operative time was approximately 51 minutes.

Bivariate analysis

Characteristics among patients with and without a SSI are compared in Table 1. Patients with a SSI were more likely to be younger (29.1 years vs. 29.8 years; p=0.15), use tobacco (14.0% vs. 7.5%; p<0.01), have gestational diabetes (10.7% vs. 7.9%; p=0.40), have an ASA class of 3 or 4 (20.5% vs. 12.4%; p<0.01), be cared for by the resident teaching service (46.0% vs. 25.4%; p<0.01), be in labor prior to their CD (71.9% vs. 52.8%; p<0.01), have an intraoperative hemorrhage (28.1% vs. 17.5%; p<0.01), a hysterotomy extension repair (18.0% vs. 13.8%; p=0.15) and a longer CD operative time (53.6 minutes vs. 50.4 minutes; p=0.02). Patients without a SSI were more likely to have a non-labored primary CD (14.5% vs. 7.3%; p=0.01), a non-labored repeat CD (30.7% vs. 19.1%; p<0.01), have their peritoneum closed (31.6% vs. 23.0%; p=0.02) and have their skin closed with sutures (40.9% vs. 32.2%; p=0.03).

Multivariable analysis

Table 2 shows the univariate and multivariate logistic regression model developed to predict CD SSI risk. Patient specific factors significantly associated with SSI risk included

chorioamnionitis (OR 2.24; 95% CI 1.25–3.83), tobacco use (OR 1.70; 95% CI 1.04–2.70) and ASA class 3 (OR 1.61; 95% CI 1.06–2.39). CDs performed by the resident teaching service (OR 2.15; 95% CI 1.54–3.00) was the provider specific risk factor significantly associated with SSI risk. Finally, procedure characteristics associated with SSI risk included CD performed after labor (OR 2.35; 95% CI 1.65–3.38). CDs performed for non-reassuring fetal status were significantly less likely to be associated with a SSI (OR 0.43; 95% CI 0.26–0.67).

Model performance

The area under the curve (AUC) for our model was 0.69 compared to the NHSN CD specific risk model's c-index (equivalent to AUC) of 0.66. Misclassification rate was 0.065. A 10-fold cross-validation was then performed which repeated the analysis 100 times to calculate an average misclassification rate of 0.065 and an average AUC of 0.68. These values are very close to those from the apparent validation, indicating that the model is not overfitted.

Comment

Our study provides a detailed evaluation of patient, provider and procedure specific risk factors for CD SSI determined by CDC NHSN criteria. Demonstrating improved predictive performance, our analysis identifies a series of clinically relevant, modifiable risk factors to target when developing quality improvement and infection control strategies at tertiary care, teaching institutions providing obstetric care. Patient level risk factors associated with CD SSI risk in our sample include tobacco use, ASA Class 3 and chorioamnionitis. Provider level risk factors include CDs performed by the resident teaching service and procedure level risk factors include CDs following labor. Consistent with previous estimates, the rate of CD SSI in our study was 6.5%.

Patient level characteristics associated with an increased risk of CD SSI should be taken into consideration when consenting and counseling patients for CD. Results of our analysis indicate that tobacco use, ASA class 3 and chorioamnionitis significantly increase the risk of CD SSI. While previous multivariable analyses have also identified increased risk associated with ASA class and chorioamnionitis,^{2, 4, 9} this study is the first to identify tobacco use as an independent risk factor for CD SSI. In an analysis of 1,759 CDs, Olsen et al. evaluated tobacco use as an independent risk factor for SSI, but did not find a significant association when tobacco use was defined as past or current use.⁶ In contrast, our analysis defined tobacco use as use during pregnancy and identified a modifiable risk factor that can be addressed with prenatal counseling and intervention.

CD performed by the resident teaching service was the provider specific risk factor significantly associated with CD SSI risk and is consistent with previous studies demonstrating a relationship between surgical trainees and risk of SSI.^{6, 15, 16} Differences in rates of SSI between patients cared for by the resident teaching service and private practice physicians in our population is likely multifactorial. In contrast to patients cared for by private practice obstetricians, patients cared for by the resident teaching service are of lower socioeconomic status and often have a relatively higher number of high-risk characteristics increasing their underlying risk of SSI. Resident involvement in CD also contributes to

longer operative times due to intraoperative teaching and instruction. While instruction during CD is essential to resident education and training, our results highlight the importance of balancing efficiency with training in the operating room to optimize patient outcomes.

In previous studies, failure to provide antibiotic prophylaxis is the most frequently described procedure level characteristic to impact CD SSI risk.^{3, 6, 17} These findings have contributed to the standard use of preoperative antibiotic prophylaxis prior to CD at our institution and current CDC and ACOG clinical guidelines emphasize the importance of antibiotic prophylaxis prior to all CDs.^{13, 18} Accordingly, this eliminated the need to include this variable in our analysis. In the setting of routine antibiotic prophylaxis, our analysis identified the onset of labor prior to CD as a significant procedure level characteristic associated with CD SSI risk and corroborates the findings of previous studies.^{9, 19} Consistent with previous reports indicating that labor and PROM (premature rupture of membranes) contribute to CD SSI risk,^{2, 20} our results reinforce the significant differences in maternal morbidity such as infection, intraoperative hemorrhage and bladder injury between CDs performed prior to and after the onset of labor.^{2, 19, 21}

Despite previous reports clearly demonstrating an association between obesity and postoperative infection,^{2-6, 17, 22} we did not find an association between maternal BMI and CD SSI in this study. The mean BMI in our cohort was 33.4 kg/m² and did not differ between patients with and without a SSI (34.0 ± 7.3 vs. 33.4 ± 7.1 ; $p=0.28$). Due to limitations in the data available in the medical record, maternal BMI was calculated using weight at the time of delivery in contrast to prepregnancy weight. As a result, failure to find a statistical association between BMI and CD SSI may be due to less variability in maternal delivery BMI between participants with and without a CD SSI. Moreover, standard interventions used at our institution for obese patients such as closure of subcutaneous layers 2cm^{23, 24} and using 2 grams compared to 1 gram of a preoperative cephalosporin for patients greater than 80kg may have also mitigated the impact of BMI on the development of SSIs. Likewise, we did not find a statistically significant association between DM and CD SSI. Only 84 (3.1%) patients in our cohort had a pregnancy complicated by pregestational DM and we were unable to account for the glycemic control of these patients. Due to these limitations, our study was inadequately powered to evaluate an association between DM and CD SSI.

This study has several strengths including a large sample size, use of CDC NHSN criteria to define SSI in our sample, standardization of preoperative antibiotic prophylaxis consistent with current clinical recommendations and the comprehensive inclusion of a large number of patient, provider and procedure specific variables for multivariable analysis. Despite these strengths, our analysis must be interpreted in light of certain limitations. This study sample represents a university-affiliated, tertiary care, teaching hospital patient population and may limit the generalizability to community hospitals with a different patient case mix. In addition, our study is retrospective and the obtained data were based on the medical record documentation by clinical providers. Additionally, this method of data extraction may have incompletely captured the rate of SSI, as many referral patients may have presented to hospitals outside of our system in the postpartum period, as well as incompletely captured

the incidence of confounders. In addition, the portion of the CD procedure actually performed by resident and attending surgeons may vary and could not be accounted for by documented roles in the operative note. Wound cultures are not routinely performed for SSIs at our institution and organisms not covered by cefazolin may have also contributed to our SSI rate. Finally, observational study designs are inherently vulnerable to selection bias and the possibility of residual confounding persists despite efforts to control for these factors in our analysis.

Identification of risk factors for CD SSI is critical for the development of quality improvement strategies and infection control interventions to reduce the incidence of CD SSI and to identify high-risk patient-populations that may necessitate increased surveillance for postoperative infection. Our results provide an improved procedure-specific risk model for CD SSI and reinforce the importance of prenatal tobacco cessation counseling to reduce adverse maternal and neonatal outcomes associated with tobacco use. Complications associated with cesarean section such as SSI should also be emphasized during the consent process with patients who have multiple medical comorbidities contributing to an ASA class

3. Efforts to minimize infection risk should be emphasized for patients cared for by the resident teaching service and teaching and instruction in the operating room, which may lead to increases in CD operative time, should be balanced with efficiency to optimize patient outcomes. Increased postpartum infection surveillance may also be necessary for patients with CD preceded by chorioamnionitis and/or prolonged labors. Future research should be devoted to the development of a preoperative risk stratification system according to patient, provider and procedure-level risk factors to guide infection prevention efforts in the postpartum period.

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Infection occurs within 30 days after NHSN operative procedure (i.e. Cesarean section) and must meet the following criteria:	
Superficial incisional SSI	Involves only skin and subcutaneous tissue of the incision <i>and</i> patient has at least <i>one</i> of the following: <ol style="list-style-type: none"> Purulent drainage from the incision Organisms isolated from an aseptically-obtained culture of fluid or tissue from the superficial incision At least <i>one</i> of the following signs or symptoms of infection: pain or tenderness; localized swelling; redness; or heat <i>and</i> superficial incision that is deliberately opened by surgeon, <i>unless</i> incision in culture-negative. Diagnosis of a superficial incisional SSI by a surgeon or attending physician.
Deep incisional SSI	Involves deep soft tissues (e.g., fascial and muscle layers) of the incision <i>and</i> patient has at least <i>one</i> of the following: <ol style="list-style-type: none"> Purulent drainage from the deep incision. A deep incision that spontaneously dehisces or is deliberately opened or aspirated by a surgeon when the patient has at least <i>one</i> of the following sign or symptoms: fever (>38°C); localized pain or tenderness, <i>unless</i> site is culture-negative. An abscess or other evidence of infection involving the deep incision found on physical examination, during reoperation or radiologic examination. Diagnosis of a deep incisional SSI by a surgeon or attending physician.
Organ/Space SSI	Infection involves any part of the anatomy (e.g., organs or spaces) deeper than the fascial/muscle layers that is opened or manipulated during the operative procedure <i>and</i> patient has at least <i>one</i> of the following: <ol style="list-style-type: none"> Purulent drainage from a drain that is placed into the organ/space Organisms isolated from an aseptically-obtained culture of fluid or tissue in the organ/space An abscess or other evidence of infection involving the organ/space found on physical examination, during reoperation or radiologic examination Diagnosis of an organ/space SSI by a surgeon or attending physician.

Figure 1.

Centers for Disease Control and Prevention's National Healthcare Safety Network classification for surgical site infection (SSI)

- Adapted from Centers for Disease Control and Prevention's National Healthcare Safety Network classification for surgical site infection (SSI). <http://www.cdc.gov/nhsn/PDFs/pscManual/9pscSSICurrent.pdf>

Table 1

Sample Characteristics, n=2739*

	All (N=2739)	No SSI (N=2561)	SSI (N=178)	p-value
PATIENT CHARACTERISTICS				
Age (years)	29.8 (5.7)	29.8 (5.7)	29.1 (6.4)	0.15
Gestational Age (weeks)	38.7 (2.3)	38.7 (2.3)	38.7 (2.4)	0.99
Neonatal Weight (grams)	3286 (±676)	3288 (±675)	3265 (±700)	0.67
Race				
Caucasian	2110 (77.7)	1983 (78.0)	127 (73.0)	0.14
African-American	460 (16.9)	421 (16.6)	39 (22.4)	
Other	145 (5.3)	137 (5.4)	8 (4.6)	
BMI (kg/m²)	33.4 (±7.1)	33.4 (±7.1)	34.0 (±7.3)	0.28
Tobacco Use	216 (7.9)	191 (7.5)	25 (14.0)	<0.01
Insurance Status				
Private payer	1577 (69.0)	1494 (70.1)	83 (53.5)	<0.01
Medicaid	710 (31.0)	638 (29.9)	72 (46.5)	
Hypertensive Disorders (HTN)				
Chronic HTN	57 (2.1)	54 (2.1)	3 (1.7)	0.88
Pre-Eclampsia	418 (15.3)	389 (15.2)	29 (16.3)	
Diabetes Mellitus (DM)				
Gestational DM	220 (8.0)	201 (7.9)	19 (10.7)	0.40
Pre-Gestational DM	84 (3.1)	79 (3.1)	5 (2.8)	
ASA Class				
ASA 1/2	2378 (87.1)	2238 (87.6)	140 (79.5)	<0.01
ASA 3/4	352 (12.9)	316 (12.4)	36 (20.5)	
Chorioamnionitis	113 (4.1)	94 (3.7)	19 (10.7)	<0.01
PROVIDER CHARACTERISTICS				
Private Practice	1955 (73.2)	1860 (74.6)	95 (54.0)	<0.01
Resident Teaching Service	714 (26.8)	633 (25.4)	81 (46.0)	
PROCEDURE CHARACTERISTICS				
Cesarean Delivery (CD) Indication				
Non-labored primary CD	384 (14.0)	371 (14.5)	13 (7.3)	0.01
Non-labored repeat CD	819 (29.9)	785 (30.7)	34 (19.1)	<0.01
Non-reassuring fetal status	498 (18.2)	474 (18.5)	24 (13.5)	0.11
Labor	1479 (54.0)	1351 (52.8)	128 (71.9)	<0.01
Intraoperative Technique				
Bladder Flap Creation	2463 (89.9)	2309 (90.2)	154 (86.5)	0.15
Placenta Delivery (spontaneous)	2329 (85.8)	2173 (85.6)	156 (88.6)	0.31
Hysterotomy Closure (single layer)	1334 (51.2)	1240 (51.0)	94 (53.7)	0.54

	All (N=2739)	No SSI (N=2561)	SSI (N=178)	p-value
Bladder Flap Closure	83 (3.0)	79 (3.1)	4 (2.3)	0.69
Peritoneum Closure	849 (31.0)	808 (31.6)	41 (23.0)	0.02
Subcutaneous Fat Closure	979 (35.7)	914 (35.7)	65 (36.5)	0.89
Skin Closure (sutures)	1097 (40.3)	1040 (40.9)	57 (32.2)	0.03
Intraoperative Complications				
Intraoperative Hemorrhage	497 (18.1)	447 (17.5)	50 (28.1)	<0.01
Lysis of Adhesions	514 (18.8)	480 (18.7)	34 (19.1)	0.99
Extension Repair	386 (14.1)	354 (13.8)	32 (18.0)	0.15
Operative Time (cut to close in minutes)	50.6 ($\pm$ 15.7)	50.4 ($\pm$ 15.5)	53.6 ($\pm$ 17.8)	0.02

*
n (%) or mean ($\pm$ SD) unless otherwise indicated

Abbreviations: SSI, surgical site infection; BMI, body-mass index; HTN, hypertensive disorders; DM, diabetes mellitus; ASA, American Society of Anesthesiologists; CD, cesarean delivery; SD, standard deviation

Less than 3% missing data for all variables, except insurance status with 16.5% missing data.

Table 2

Patient, provider and procedure specific risk factors predictive of SSI

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
PATIENT CHARACTERISTICS		
Age (years)	0.98 (0.95–1.01)	--
Gestational Age (weeks)	1.00 (0.94–1.07)	--
Neonatal Weight	1.00 (1.00–1.00)	--
Race		
Caucasian	Ref	--
African-American	1.45 (0.98–2.08)	--
Other	0.91 (0.40–1.79)	--
Body Mass Index BMI (kg/m ²)	1.01 (0.99–1.03)	--
Tobacco Use	2.03 (1.27–3.12)	1.70 (1.04–2.70)
Medicaid	0.49 (0.35–0.69)	--
Hypertension (HTN)		
Chronic HTN	0.81 (0.20–2.22)	--
Pre-Eclampsia	1.08 (0.70–1.61)	--
Diabetes Mellitus (DM)		
Gestational DM	1.40 (0.83–2.25)	--
Pre-Gestational DM	0.94 (0.33–2.13)	--
ASA Class (ASA 3/4)	1.82 (1.22–2.65)	1.61 (1.06–2.39)
Chorioamnionitis	3.14 (1.82–5.16)	2.24 (1.25–3.83)
PROVIDER CHARACTERISTICS		
Resident Teaching Service	2.51 (1.84–3.41)	2.15 (1.54–3.00)
PROCEDURE CHARACTERISTICS		
Cesarean Delivery (CD) Indication		
Scheduled, Prime	0.47 (0.25–0.80)	--
Scheduled, Repeat	0.53 (0.36–0.77)	--
Non-reassuring fetal status	0.69 (0.43–1.05)	0.43 (0.26–0.67)
Labor	2.29 (1.65–3.24)	2.35 (1.65–3.38)
Intraoperative Technique		
Bladder Flap Creation	0.70 (0.46–1.12)	--
Placenta Delivery (Spontaneous)	1.31 (0.83–2.18)	--
Hysterotomy Closure (single layer)	1.12 (0.82–1.52)	--
Bladder Flap Closure	0.72 (0.22–1.76)	--
Peritoneum Closure	0.65 (0.45–0.92)	--
Subcutaneous Fat Closure	1.04 (0.75–1.42)	--
Skin Closure (Sutures)	0.69 (0.49–0.95)	--
Intraoperative Complications		

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Intraoperative Hemorrhage	0.54 (0.39–0.77)	--
Lysis of Adhesions	1.02 (0.69–1.49)	--
Extension Repair	1.37 (0.90–2.01)	--
Operative Time (10 minute increments)	1.01 (1.00–1.02)	--

Abbreviations: SSI, surgical site infection; OR, odds ratio; CI, confidence interval; BMI, body-mass index; HTN, hypertension; DM, diabetes mellitus; ASA, American Society of Anesthesiologists; CD, cesarean delivery