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Risk factors for wound complications following cesarean delivery

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RISK FACTORS FOR WOUND COMPLICATIONS FOLLOWING CESAREAN DELIVERY

by

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CERTIFICATE OF APPROVAL

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MASTER'S THESIS

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This is to certify that the Master's thesis of

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CHAPTER I

INTRODUCTION

Background

Cesarean delivery rates have been increasing nation-wide since 1996, with an increase of 60% between 1996 and 2009. In 2012, the rate of Cesarean delivery for all U.S. births was 32.8% [19]. According to data from the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (AHRQ), Cesarean delivery was the most common major operative procedure performed in 2010. Between 1997 and 2010, the rate of hospitalization with Cesarean delivery as the primary indication increased 41% [21].

Cesarean delivery is the most important risk factor for postpartum infections, which account for approximately 10% of pregnancy-related mortality [18]. From 2006 to 2008, the pooled mean rate of surgical site infection (SSI) after Cesarean delivery reported by the National Healthcare Safety Network (NHSN) ranged from 1.46% to 3.82% [20]. Surgical site infections following Cesarean delivery are associated with increased morbidity, length of stay, and hospital readmission [15]. The NHSN risk index, which allows infection preventionists to stratify patients by their risk of SSI, is based on wound classification, American Society of Anesthesiologists (ASA) score, and the duration of the operation, and thus can only be calculated postoperatively. Because these criteria do not vary substantially in the obstetric population, this index does not robustly predict risk for SSI [18]. A risk index based on patient and surgical risk factors for SSI after Cesarean delivery would be more useful in assessing preoperatively a patient's risk for SSI, allowing the care team to appropriately adjust medical treatment.

Patient-related factors associated with SSI following Cesarean delivery include high BMI at term [3, 4, 5, 9], corticosteroid use [5], nulliparity [9], < 7 prenatal visits [6], low gestational age [7], chorioamnionitis [4, 9], preeclampsia [9], fetal

macrosomia [7], 6 or more vaginal examinations [14], duration of ruptured membranes [6, 14], duration of labor [3], cervical dilation ≥ 6 centimeters [7], American Society of Anesthesiologists score ≥ 3 [9], and subcutaneous hematoma [4]. Surgical factors that are associated with increased risk of SSI following Cesarean delivery include emergency procedures [3, 14], general anesthesia [1, 7], incision length [5], procedure duration [6], induction of labor [4], high volume of blood loss [9, 14], manual removal of the placenta [8, 11], absence of antibiotic prophylaxis [4, 6, 11]. Surgical factors associated with decreased risk of SSI following Cesarean delivery include skin preparation with chlorhexidine-alcohol and skin closure with sutures [4, 10, 13].

At the University of Iowa Hospitals and Clinics (UIHC), a six month review of medical records found an overall complication rate after Cesarean deliveries of 20.7%. An intervention study was conducted at the UIHC comparing SSI rates after Cesarean delivery between a control group (n = 190) receiving iodine skin preparation and incision closure with staples to an intervention group (n = 236) receiving chlorhexidine-alcohol skin preparation and incision closure with sutures. The overall complication rate for the intervention group was 17.4% and 22.1% for the control group [35]. Despite the effectiveness of the procedural changes the overall complication rate remained high. Therefore, the current study was undertaken to evaluate patient-related and surgical risk factors contributing to the high wound complication rate at the UIHC.

Objective

My primary objective was to identify patient factors and surgical factors that increase the risk for wound complications after Cesarean delivery at the UIHC.

Specific Aim 1) To assess patient factors and surgical factors that increase the risk for post-Cesarean wound complications, and to develop a preoperative risk model based on data from patients undergoing Cesarean delivery between October 1, 2011 and December 31, 2012.

I hypothesized that certain modifiable patient factors and surgical factors were associated with post-Cesarean wound complications, and that a risk model based in these factors would better predict wound complications compared with the NHSN risk index criteria.

Specific Aim 2) To assess whether body mass index (BMI) is a significant risk factor for post-Cesarean wound complications, and to assess whether measuring BMI at term or prenatally is a better predictor of wound complications following Cesarean delivery for patients at the UIHC between October 1, 2011 and December 31, 2012.

I hypothesized that increased BMI at term and increased BMI at the first prenatal visit would be significant risk factors for wound complications following Cesarean delivery. I also hypothesized that BMI at term would be a stronger predictor of post-Cesarean wound complications than BMI measured at the first prenatal visit.

CHAPTER II

METHODS

Study Design

This retrospective case-control study assessed risk factors for wound complications following Cesarean delivery among patients at the UIHC undergoing Cesarean procedures between October 1, 2011 and December 31, 2012. Medical records were reviewed and data on potential risk factors (Table A1) were collected and entered into RedCap. The University of Iowa's Institutional Review Board approved this study.

Population

The study population included all patients (≥ 18 years of age) undergoing a Cesarean procedure at the UIHC between 10/01/2011 and 12/31/2012. A list of all patients undergoing Cesarean delivery at the UIHC between October 1, 2011 and December 31, 2012 was generated using ICD-9 procedure codes for Cesarean delivery (Table A2). Potential cases were identified by ICD-9 codes (Table A2) indicative of specific complications. Medical records of patients with at least one of these ICD-9 codes were reviewed to determine if they met the criteria for the primary outcome of interest. A total of 734 patients underwent a Cesarean delivery during the study period, and 154 potential cases were identified by the ICD-9 codes (Figure A1). Upon review of the medical records, 77 potential cases were found to not meet the criteria for case status, mostly due to the use of the ICD-9 code 658.41 for chorioamnionitis, and these were then treated as potential controls. One potential case was excluded because the wound complication occurred after the 30 day postoperative period. Two controls were selected for each case by selecting the potential control directly above and below the identified case on the chronological list of all patients who underwent Cesarean delivery. This was done to achieve a balance in temporality. Because the controls were not strictly matched to cases the match was not maintained in the analysis. No potential controls were

identified as cases. One potential control was excluded because she had the procedure at another hospital; one underwent a dilation and curettage procedure, and one died from unrelated causes within the 30 day postoperative period.

Statistical Analysis

Frequencies, percentages, means, medians, and 95% confidence intervals were calculated to evaluate the distributions of potential risk factors for cases and controls. Independent t-tests were performed on the continuous variables. The Chi square test of independence was performed to compare the results of categorical variables for cases and controls. Variables with a p value < .05 were included in the logistic regression. Variables with a *p* value between .05 and .10 were retained as approaching significance and worthy of further analysis in the logistic regression. Direct regression analysis allowed all variables to enter the model at the same time, which allotted more control over which variables to include in the final models rather than relying on arbitrary statistical cut-points. Statistical analysis was done using SPSS.

Definition of Key Variables

Wound complications included SSIs, cellulitis, and wound separation without signs of infection. SSIs were identified based on criteria established by the NHSN (Table A3). Because a review of the literature suggested that risk factors for endometritis (organ space SSIs) were different from those for incisional SSIs, SSIs were further categorized as incisional or organ space (endometritis) SSIs. Cellulitis was defined as: 1) erythema around the incision, 2) described as cellulitis by the physician, and 3) treated with antimicrobial agents. Wound separation without infection was defined as spontaneous separation at the incision site requiring treatment (the surgeon opened the wound further/the wound was packed) in the absence of any signs of infection.

Two BMI measures were included in this study, one measured at the first prenatal visit and the other measured at term. The recorded weight and height at the first prenatal

visit was used to calculate the prenatal BMI. Term BMI was calculated using the recorded height from the first prenatal visit and the recorded weight at the time of hospital admission. If the weight at the time of hospital admission was unavailable, then the weight recorded at the last prenatal visit was used to calculate term BMI. BMI was analyzed solely as a continuous variable, as a previous study has shown that when BMI is categorized it loses significance as a predictor of wound complications [33].

Labor type was defined as either spontaneous, induced, or augmented. Spontaneous labor was defined as labor that occurred without medical intervention. Induction was defined as the onset of labor resulting from the use of induction agents (oxytocin, dinoprostone, misoprostol, foley bulb). Augmented labor was defined as the spontaneous onset of labor that required oxytocin for progression.

Induction agents included cervical ripening agents (dinoprostone, misoprostol, foley bulb) and oxytocin. These drugs are often used in combination to induce labor, and therefore the primary induction agent as well as the combination of induction agents given was recorded into two separate variables.

Prophylactic antimicrobial agents are given prior to the procedure in order to reduce the risk of infection. The type of agents given were grouped into three categories: cefazolin, clindamycin and gentamicin combination, and all other drugs.

CHAPTER III

RESULTS

Demographics

The mean age for cases was 29.49 (SD = 6.62) and for controls was 29.63 (SD = 5.39 (Table A4). The study subjects were predominately white (85.2%) and non-Hispanic (94.2%) (Table A5). Cases and controls did not significantly differ with respect to age (*P* = .87), race (*P* = .156), or ethnicity (*P* = .143) (Table A6 and Table 7).

Frequencies

Frequency values for continuous and categorical variables are displayed in Table A4 and Table A5. Based on the study sample (N=228), the estimated wound complication rate during the study period (N=734) was 10.4%. Of the 76 identified cases, 14 (18.4%) had incisional SSIs, 24 (31.6%) had endometritis, 31 (40.8%) had cellulitis, and 7 (9.2%) had wound separation. The most common signs of wound complication were erythema (62%), pain and tenderness (47%), and fever (41%) (Table A8). Ninety-three percent of cases had a diagnosis of a wound complication by a clinician that was documented in their medical record. The average time to a wound complication was 8.37 days. The most common signs of cellulitis (excluding erythema, as it was a required criterion) were localized heat (32%) and pain (23%). The average time to a cellulitis complication was 6.16 days. The most common signs of SSI were purulent drainage (64%) and erythema (57.1%). Seventy-nine percent of cases meeting the definition of incisional SSI had a diagnosis of a wound complication by a clinician that was documented in their medical record. The average time to an incisional SSI complication was 11 days. Clinicians obtained wound cultures from 50% of patients with incisional SSIs; Enterococcus species were the most common causative organisms. The most common signs of endometritis were pain and tenderness (88%) and fever (79%). Clinicians obtained cultures from 38% of patients with endometritis; *E.coli* was the most

common etiologic agent. Clinicians diagnosed 92% of cases meeting the definition of endometritis. The average time to an endometritis complication was 4.44 days. Of the patients with wound separation, 29% had wound erythema and 14% were warm. The average time to a wound separation complication was 11.86 days.

Bivariable Analysis

Results of the independent t-tests for continuous variables are presented in Table A6, and results of the Chi square tests of independence for categorical variables are presented in Table A7.

Bivariable analysis of patient factors found that cases and controls were similar with respect to: weight gain during pregnancy, pre-eclampsia, gestational diabetes, group B strep colonization, former smoker status, use of oral/parental steroids preoperatively, duration of ruptured membranes, gravidity, parity, gestational age, number of prenatal visits, type of ruptured membranes (artificial, spontaneous, premature), and preterm labor. Compared with controls, cases had higher BMI (term and prenatal), and were more likely to have Medicaid insurance, be current smokers, take hypoglycemic agents preoperatively, have a diagnosis of hypertension (chronic or gestational), have greater cervical dilation, have fewer prior Cesarean deliveries, and to have labored before the procedure. Cases were more likely than controls to take insulin during the perioperative period, but this difference did not reach significance ($P = .075$).

Bivariable analysis of surgical factors found that cases and controls were similar with respect to: skin preparation, placenta removal, incision type (abdominal or uterine), and wound closure. Compared with controls, cases were more likely to have: ASA scores of 2, their Cesarean delivery because their labor did not progress, higher temperatures immediately after their procedures, greater blood loss, receive clindamycin/gentamicin and other combinations (that did not include Cefazolin) for prophylaxis, more vaginal exams, and undergone induction with oxytocin.

Outcome variables were assessed and cases were found to be more likely to receive antimicrobial agents after their procedures but before hospital discharge, have a longer postoperative length of stay, have a hematoma, have a seroma, be readmitted within 30 days, and receive antimicrobial agents during readmission.

All variables that were significant in the previous bivariable analyses were included in subgroup analyses of each wound complication (Table A9 and Table A10) to assess the appropriateness of combining incisional SSIs, endometritis, cellulitis, and wound separation into one variable for logistic regression because the number of patients with each complication was too small for logistic regression. Compared with controls, patients with cellulitis were more likely to: have higher BMI at term, have higher BMI at the first prenatal visit, be a current smoker, and have a hematoma. Compared with controls, patients with SSIs were more likely to: have higher BMI at term, have higher BMI at the first prenatal visit, have more vaginal exams, have pre-eclampsia, use insulin during perioperative period, have labor induced with oxytocin, receive general and epidural anesthesia, and to have failure to progress as primary indication for the procedure. Compared with controls, patients with endometritis were more likely to: have greater cervical dilation, receive antimicrobials preoperatively, be transferred to UIHC, have spontaneous labor before the Cesarean delivery, receive other combinations of prophylactic antibiotics preoperatively (not cefazolin or clindamycin/gentamicin). Compared with controls, patients with wound separation were more likely to: have diabetes mellitus, have severe pre-eclampsia, receive general anesthesia, and take insulin preoperatively. On the basis of the data displayed in Table A9 and Table A10 it was concluded that incisional SSIs, endometritis, cellulitis, and wound separation could be appropriately combined into one variable (wound complication) for the logistic regression.

Direct Logistic Regression

Three logistic models were built to further evaluate the association between patient and surgical factors with wound complication (Table 11).

The Patient Model initially included all patient related variables that were significant ($p < .05$) or approached significance ($p < .1$) in the bivariable analysis. Only BMI at term, number of prior Cesarean deliveries, induction with oxytocin, type of labor, diabetes mellitus, and current smoking status remained statistically significant with *p*-values < .05, and these factors were used to construct the final model (Table A11). Chorioamnionitis approached significance with a *p*-value of .063, and was t retained in the model because an association is biologically plausible. The final model correctly predicted whether or not 75% of subjects had wound complications, and fit the data well as indicated by the Hosmer and Lemeshow test ($p = .796$). The c statistic of .792 indicated that the model had good predictive power (Table A12).

The Surgical Model initially included all surgical variables that were significant ($p < .05$) or approached significance ($p < .1$) in the bivariable analysis. Only BMI at term, postoperative length of stay, anesthesia, induction with oxytocin, labor type, and prophylactic antimicrobial agents remained in the final model (Table A11). For analysis prophylactic antimicrobial agents had to be collapsed into a three level variable (cefazolin, clindamycin/gentamicin, other), however the frequencies of all prophylactic antimicrobial agents can be found in Table A13. Labor type was included in both the patient and surgical models because spontaneous labor is a patient factor, while induction and augmentation are procedural. The final model correctly predicted whether or not 76% of subjects had wound complications and fit the data well (Hosmer and Lemeshow $p = .440$). The c statistic was .842, indicating the model had good predictive power (Table A12).

The Combined Model included all of the final variables from the Patient Model and from the Surgical Model. BMI at term, the postoperative length of stay, the number of prior Cesarean deliveries, induction with oxytocin, labor type, current smoking status, and diabetes mellitus remained significant or nearly significant (Table A11). This model accurately predicted whether or not 77% of subjects had a wound complication and had a good fit (Hosmer and Lemeshow $p = .575$). The c statistic was to .85, suggesting that the model had good predictive ability (Table A12).

In contrast, the NHSN risk index score was not significantly associated with wound complications, ($p = 0.071$) (Table A14). This model accurately predicted whether or not 57.4% of subjects had wound complications (Table A15). Its predictive ability was based solely on the ASA score ($p = .024$) (Table A14). The model fit the data well (Hosmer and Lemeshow $p = .466$), and had a moderate c statistic of .611 (Table A15).

CHAPTER IV

DISCUSSION

The overall wound complication rate during the study period was lower than that found in previous studies at the UIHC. The most common wound complication was cellulitis, followed by endometritis. This study was unique in that it focused on identifying modifiable risk factor, and creating prediction models based on these risk factors that could be used preoperatively. The modifiable patient-related factors that remained significant after logistic regression included higher BMI at term, current smokers, labor type, and diabetes mellitus. Significant modifiable surgical risk factors were induction with oxytocin, postoperative length of stay, and the prophylactic antibiotic agent.

BMI at term

Other studies found that BMI measured at term was a significant risk factor for wound complication following Cesarean delivery [3, 4, 5, 9]. Because prenatal BMI has been shown to be associated with known risk factors for developing wound complication, such as increased risk of Cesarean delivery, preeclampsia, gestational hypertension, gestational diabetes mellitus, and decreased likelihood of spontaneous labor [23], and because few studies have assessed prenatal BMI with the development of wound complications, data on prenatal BMI was collected in this study. Although prenatal BMI was significant in the bivariable analysis, it did not remain significant in the logistic regression. BMI has been postulated to increase the risk of wound complications after Cesarean delivery due to physical characteristics (increased tissue trauma, increased wound length, increased tension on the wound) as well as biological characteristics (decreased vascularity and oxygenation of adipose tissue, decreased penetration of prophylactic antibiotics) [3,4,33,34]. Of note total weight gain during pregnancy was similar between cases and controls; however controls had a significantly higher prenatal

BMI than controls. The importance of limiting weight gain during pregnancy, especially for overweight and obese women has been well documented [36]. The results from this study suggest that targeting weight gain in this population could be beneficial in reducing the risk of wound complications.

Number of prior Cesarean deliveries

The number of prior Cesarean deliveries approached significance and was inversely related with wound complications. A previous study found similar results [9]. In this study it was found that nulliparous women were significantly more likely to undergo an emergency or unscheduled procedure, compared with controls. Undergoing an emergency procedure has been shown in other studies to increase the risk of wound complications [3, 14]. In the bivariable analysis, scheduled Cesareans were less likely to result in wound complication; however this only approached significance and did not become significant in the regression analysis. Because these two variables were highly associated, an interaction was explored but was not significant. For women with spontaneous onset of labor, identifying risk factors for unsuccessful labor could be useful in reducing the risk of wound complications after Cesarean delivery by reducing the number of emergent procedures.

Current Smoker

Being a current smoker at the time of surgical procedures has repeatedly been shown to be a risk factor for wound complications [29, 31, 24]. Similarly, this study found that being a current smoker at the time of Cesarean delivery was a significant risk factor for wound complication. Smoking has been shown to reduce oxygen tension in the wound bed, which hinders the healing process [32]. Interventions targeted at smoking cessation during pregnancy could drastically reduce the risk of developing wound complications after Cesarean delivery.

Labor Type

Spontaneous labor was found to significantly increase the risk of wound complication. Several prior studies found that laboring before the procedure was a risk factor for wound complications [4, 9, 18]; however in these studies the increased risk was associated with induced labor. The increased risk associated with spontaneous labor in this study might be due to increased duration of ruptured membranes because the cervix is dilating and pathogens can enter the uterus. Prior studies have shown that the duration of ruptured membranes is associated with wound complications [6, 14]; however the duration of ruptured membranes in this study did not differ significantly between cases and controls. In addition, these patients were more likely to have emergent procedures (Table A16), which has been associated with wound complication in prior studies [3, 14]. Future studies are needed to evaluate the association between spontaneous labor and wound complication. Although this factor is not modifiable, we need to discover why spontaneous labor increases the risk of wound complication, which might help us identify potential interventions.

Induction with Oxytocin

Many studies have found that induction is a risk factor for wound complication after Cesarean delivery [4, 9, 18]. However, this is the first study to investigate the association of specific induction agents on wound complication. In this study, the association of dinoprostone, misoprostol, oxytocin, and the use of a foley bulb with wound complication was evaluated. Only induction with oxytocin was significantly associated with wound complication when only considering the primary induction agent. However, when the induction agents were re-categorized by cervical ripening agent, oxytocin, or both; receiving both cervical ripening agents and oxytocin was the only significant factor. The association between ripening agents and oxytocin lost significance when included in a logistic regression model. Oxytocin has documented cardiovascular

affects including tachycardia, hypotension, and decreased cardiac output [25, 26]. Decreased cardiac output has been shown to decrease subcutaneous tissue oxygen tension, which is also a known risk factor for developing wound complication after surgical procedures [27]. Despite these known risks, the role of oxytocin in the pathogenesis of wound complications has been studied inadequately. The association between receiving ripening agents with oxytocin and wound complication might be due to the fact that patients receiving this combination were more likely to have a longer duration of ruptured membranes (Table A17). The relationship between oxytocin, ripening agents, and duration of ruptured membranes must be further explored to determine what is causing the increased risk of wound complications.

Diabetes Mellitus

Pre-gestational diabetes mellitus was a significant risk factor for wound complication. Other investigators have found that diabetes mellitus is a risk factor for postoperative wound complications, particularly due to hyperglycemia [24, 28, 29]. Hyperglycemia decreases cytokine expression and delays re-epithelialization, which adversely affect wound re-approximation leading to infection or wound breakdown [30]. Strict glycemic control during the perioperative period for patients undergoing non-cardiac major operations has been shown to decrease the risk of wound complications; however the Cesarean procedure was not evaluated in this study [28]. Glucose lab values were not consistently available, and therefore the role of hyperglycemia could not be evaluated in this study.

Postoperative Length of Stay

The mean number of days from Cesarean delivery to discharge was longer for cases than for controls. Many studies have evaluated the entire length of stay as a potential risk factor for developing wound complications after surgical procedures [13, 18]. However, I posit that the length of stay after the procedure is a more informative risk

factor than the total length of stay. In this study, the cases were discharged on average 3.83 days after their procedure, however the average time to a complication was 8.37 days. This suggests that cases are not staying longer in the hospital due to wound complications, but rather due to some other factor. These patients may have comorbidities causing the longer length of stay, the comorbidities could be unidentified risk factors for wound complication, or a modifiable factor affecting length of stay might be discovered. The reasons for this association must be identified in order to determine if postoperative length of stay should be viewed as a risk factor or simply used as an outcome measure.

CHAPTER V

CONCLUSION

The models developed based on the study data had good predictive power and they fit the data well. Thus clinicians could use these models to identify patients at risk for wound complications and direct proper interventions. The models developed in this study performed better than the model based on the NHSN risk index criteria. The NHSN components did not vary substantially among patients undergoing Cesarean delivery in this study leading to its poor performance. This study found that models based on patient and surgical factors result in more robust risk prediction. A unique aspect of the Combined Model developed based on the data in this study is the fact that all but one of the factors (number of prior Cesarean deliveries) can be modified. Interventions targeted at controlling weight gain during pregnancy, smoking cessation, and greater glycemic control for diabetics could significantly reduce the risk of wound complications in this population. We must continue to identify modifiable risk factors and measure their strength of association with wound complications to better understand a patient's risk for wound complications and to identify effective interventions. The main strengths of this study are the case-control design and large number of cases, which allowed for the assessment of a large number of potential risk factors. This study minimized misclassification by using strict criteria to classify cases, rather than relying solely on clinician diagnoses. The study also had adequate statistical power to detect moderate effect sizes (Table A18 and Table A19). The major limitation of this study was the homogeneity of the study population. The study population was predominately white (85.2%) and non-Hispanic (94.2%), which limits the generalizability of the study to populations outside of the UIHC. Due to the study design, information on risk factors was subject to observation bias and availability. Also because of the case-control design the assessment of rare risk factors could not be carried out. Despite this, the risk factors

identified by this study, particularly the previously unreported risk associated with oxytocin, have important implications in decreasing risk of wound complications after Cesarean delivery at the UIHC.

APPENDIX

Table A1. Data Dictionary

Variable Name	Definition	Levels
cd_date	Date of Cesarean delivery	Continuous
vag_exams	Number of vaginal examinations prior to Cesarean delivery	Continuous
dilation	Cervical dilation at time of procedure (0-10 cm)	Continuous
rom_duration	Duration of Rupture of Membranes. hours.min	Continuous
temp_after	Temperature immediately following procedure OR lowest temperature following procedure (Celsius)	Continuous
bmi_term	BMI, term	Continuous
age	Age at time of delivery	Continuous
gravidity	Gravidity	Continuous
parity	Parity	Continuous
gest_age	Gestational Age, week.day	Continuous
num_cd	Number of prior C.section	Continuous

Table A1.—Continued

Variable Name	Definition	Levels
num_prenat_visits	Total number of prenatal visits	Continuous
bmi_prenatal	BMI, first prenatal visit	Continuous
dc_days_postop	Postoperative length of stay	Continuous
postop_abs_num	Number of post-op doses of antimicrobial agents given	Continuous
abs_after_number	Number of days patient received antimicrobials after operation	Continuous
blood_loss	Estimated amount of blood loss during procedure (mL)	Continuous
preop_hg	Preop Hemoglobin	Continuous
preop_hct	Preop hematocrit	Continuous
postop_hct	Postop hematocrit	Continuous
postop_hg	Postop Hemoglobin	Continuous
readmin_abs_duration	Number of days antibiotic was given during readmission	Continuous

Table A1.—Continued

Variable Name	Definition	Levels
race	Race	White, Black, Asian, American/Alaska Native, Native Hawaiian/Pacific Islander, Two or More, Unknown
ethnicity	Ethnicity	Hispanic/Latino, Not Hispanic/Latino
insurance	Medical Insurance	Iowa Care, Private Insurance alone, Medicare alone, Medicare with supplemental private, Medicaid, None
wound_class	Wound classification	Clean contaminated, Contaminated, Unknown
skin_prep	Agent used to clean skin prior to operation	Chloraprep, Betadine solution, Other, Unknown
hair_removal	How hair was removed prior to operation	Shaved, Clipped, Depilatory Cream, Not Applicable, Unknown
rom_type	How membranes ruptured	SROM, AROM, PROM, Unknown
asa	ASA score	1, 2, 3, 4, 5, Unknown
smoker_current	Patient is smoker at time of operation	yes, no, unknown
smoker_former	Patient is former smoker at time of operation	yes, no, unknown
pre_op_insulin	Patient taking insulin at time operation?	yes, no, unknown
pre_op_oha	Patient taking oral hypoglycemic agents at time operation?	yes, no, unknown

Table A1.—Continued

Variable Name	Definition	Levels
pre_op_steroids	Patient taking oral or parenteral steroids at time of surgery	yes, no, unknown
pre_op_lung_meds	Patient received steroids for fetal lung developmental within one week prior to procedure	yes, no, unknown
pre_op_isd	Patient taking other immunosuppressive drugs at time of operation	yes, no, unknown
pre_op_abs	Patient taking antimicrobial agents for other reasons at time of operation	yes, no, unknown
transfer	Patient was transferred to UIHC before operation	yes, no, unknown
cd_indication	Primary Indication for Cesarean Delivery	Elective repeat, fetal anomaly, malpresentation, placental issues, non-reassuring fetal testing, maternal condition, arrest of dilation, arrest of descent, macrosomia, prior should dystocia, multiple gestation with maternal request, contraindication for vaginal delivery, other, unknown
proc_type	Scheduling of procedure	scheduled, unscheduled, emergent
Anesthesia	Type of anesthesia used	general, epidural, general and epidural, unknown

Table A1.—Continued

Variable Name	Definition	Levels
placent_remov	How the placenta was removed by the surgeon	cord traction, manual, unknown
labor	Patient was in active labor prior to Cesarean delivery	yes, no, unknown
labor_type	If patient labored, how the patient labored	spontaneous, spontaneous with augmentation, induction, unknown
Induction_agent	If patient induced, primary induction agent given	Oxytocin, Dinoprostone, Misoprostol, Foley bulb
labor_preterm	Patient labored before 37 weeks gestational age	yes, no, unknown
multi_preg	Multiple Pregnancy	twin, triplet, quadruplet, no
ghtn	Gestational Hypertension	yes, no, unknown
chtn	Chronic Hypertension	yes, no, unknown
preelcamp	Pre-eclampsia	severe, mild, no
chorio	Chorioamnionitis	yes, no, unknown
godm	Gestational Diabetes	yes, no, unknown
dm	Diabetes Mellitus	type 1, type 2, type unknown, no
oligohydro	Oligohydroamnios	yes, no, unknown
Woundvac	Wound vac applied after procedure	yes, no, unknown

Table A1.—Continued

Variable Name	Definition	Levels
proph_abs	Patient received perioperative prophylactic antimicrobial agents	yes, no, unknown
proph_ab_combo	Perioperative prophylactic antimicrobial agent given	Cefazolin, clindamycin/gentamicin, other
proph_abs_timing	Time first dose of perioperative prophylactic antimicrobial agents were given	within 1 hour prior to incision, cord clamping, other, unknown
postop_abs	Patient got additional doses of perioperative prophylactic antimicrobials post-op	yes, no, unknown
abs_after	Antibiotics received following surgery and before hospital discharge	yes, no, unknown
abd_incision_type	Type of abdominal incision	vertical, low transverse, paramedian, other, unknown
ute_incision_type	Type of uterine incision	classical, low vertical, low transverse, T-incision, other, unknown
wound_closure	Wound closure	staples, sutures
Hysterectomy	Cesarean hysterectomy performed	yes, no, unknown

Table A1—Continued

Variable Name	Definition	Levels
gbs_status	Group B Strep Status	Positive, negative, unknown
readmin	Patient was readmitted to the UIHC within 30 days of surgery	yes, no, unknown
readmin_abs	Patient received antibiotics during readmission that began within 30 days of surgery	yes, no, unknown
hematoma	Patient developed a hematoma in the operative site	yes, no, unknown
seroma	Patient developed seroma in operative site	yes, no, unknown
induction	Type of induction agents given by class of agents	No, Oxytocin Only, Cervical Ripening Only, Oxytocin and Cervical Ripening
Proc_duration	Duration of procedure	Continuous

Table A2. Procedural and Diagnosis ICD-9 Codes

ICD-9 Code	Definition
74.X	Cesarean Section and removal of fetus
998.XX	Disruption of operation wound
670.XX	Major puerperal infection
672.XX	Pyrexia of unknown origin during puerperium
674.XX	Other and unspecified complications of the puerperium not elsewhere classified
658.41	Infection of the amniotic cavity

Table A3. NHSN Criteria for SSI Classification

Superficial Incisional SSI

Infection occurs within 30 days after the operative procedure AND involves only skin and subcutaneous tissue of the incision AND must meet one of the following criteria:

A. Purulent drainage form the superficial incision

B. organism isolated from an aseptically obtained culture of fluid or tissue from the superficial incision

C. at least one of the following signs or symptoms of infection: pain or tenderness, localized welling, redness, or heath, and superficial incision are deliberately opened by surgeon and culture positive or not cultured.

D. diagnosis of superficial incisional SSI by the surgeon or attending physician.

Deep Incisional SSI

Infection occurs within 30 days after the operative procedure if no implant is left in place or within a year if implant is in place and the infection appears to be related to the operative procedure AND involves deep soft tissue of the incision AND must meet one of the following criteria:

A. Purulent drainage form the deep incision but not from the organ space component of the surgical site

B. a deep incision spontaneously dehisces or is deliberately opened by surgeon and culture positive or not cultured and the patient has one of the following signs or symptoms: fever (>38C) or localized pain or tenderness.

C. an abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiologic examination.

D. diagnosis of deep incisional SSI by the surgeon or attending physician.

Organ/Space SSI

Infection occurs within 30 days after the operative procedure if no implant is left in place or within a year if implant is in place and the infection appears to be related to the operative procedure AND involves any part of the body, excluding the skin incision, fascia, or muscle layers, that is opened or manipulated during the operative procedure AND must meet one of the following criteria:

A. Purulent drainage form a drain that is placed through a stab wound into the organ/space

B. organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space

C. an abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by hitsopathologic or radiologic examination.

D. diagnosis of an organ/space SSI by the surgeon or attending physician.

Table A4. Descriptive Statistics of Continuous Study Variables by Control, Wound Complication Group, and Overall Sample

		Control			Wound Complication			Overall		
Variable	N	Mean	*SD*[a]	Mdn[b]	Mean	*SD*	Mdn	Mean	*SD*	Mdn
Weight gain from first prenatal visit to term	217	11.52	5.78	11.21	11.77	6.89	12.17	11.60	6.15	11.60
BMI at first prenatal visit	216	29.00	6.86	27.23	34.26	10.57	32.07	30.73	8.60	28.67
BMI at term	226	33.30	6.51	31.96	38.05	10.26	35.29	34.90	8.26	33.37
Total number of prenatal visits	215	10.71	4.00	11.00	11.07	3.97	11.00	10.83	3.98	11.00
Number of vaginal examinations prior to Cesarean delivery	226	3.31	4.17	1.00	4.93	4.50	4.00	3.84	4.34	2.00
Number of prior Cesarean deliveries	228	0.60	0.96	0.00	0.34	0.62	0.00	0.51	0.87	0.00
Gestational age	228	37.09	3.68	38.55	36.38	4.41	38.10	36.85	3.94	38.30
Cervical dilation at time of procedure (0-10 cm)	225	3.14	3.86	1.00	5.00	3.91	5.00	3.74	3.96	2.00
Duration of rupture of membranes (hours)	225	36.22	241.52	0.02	38.56	211.91	7.13	36.99	231.73	0.02
Duration of procedure	200	61.17	17.15	58.00	61.71	21.63	60.50	61.35	18.69	59.00
Gravidity	228	2.56	1.63	2.00	2.67	1.99	2.00	2.60	1.75	2.00
Parity	228	1.93	1.16	2.00	1.80	1.23	1.00	1.89	1.18	2.00
Estimated amount of blood loss during procedure (mL)	228	907.20	242.55	800.00	976.32	358.84	900.00	930.24	287.65	800.00
Number of post-op doses of antimicrobial agents	228	0.09	0.42	0.00	0.14	0.51	0.00	0.11	0.45	0.00
Number of days antibiotics post-op	228	0.21	0.66	0.00	2.08	2.45	2.00	0.83	1.75	0.00

Table A4.—Continued

		Control			Wound Complication			Overall		
Variable	N	Mean	*SD*[a]	Mdn[b]	Mean	*SD*	Mdn	Mean	*SD*	Mdn
Age	228	29.63	5.39	29.00	29.49	6.62	29.00	29.58	5.81	29.00
Postoperative length of stay	228	2.88	0.49	3.00	3.83	1.90	3.00	3.20	1.25	3.00

Note. Control *N* = 152, Wound Complication *N* = 76, Overall *N* = 228. Variable specific valid-*N* varies somewhat as result of missing data.

[a]SD is standard deviation

[b]Mdn is median

Table A5. Frequencies and Percentages for Categorical Study Variables

	Controls		Wound Complications		Overall Sample	
Variable	*N*	%	*N*	%	*N*	%
Race	147		76		223	
American Indian/Alaska Native	1	0.7	1	1.3	2	0.9
Asian	10	6.8	2	2.3	12	5.4
Black	14	9.5	3	3.9	17	7.6
Native Hawaiian/Pacific Islander	0	0.0	1	1.3	1	0.4
Two or more	0	0.0	1	1.3	1	0.4
White	122	83.0	68	89.5	190	85.2
Ethnicity (Hispanic/Latino or Not)	147		76		223	
Hispanic/Latino	11	7.5	2	2.3	13	5.8
Not Hispanic/Latino	136	92.5	74	97.4	210	94.2
Medical insurance	152		76		228	
None	9	5.9	2	2.6	11	43.0
Medicaid, Medicare, Iowa Care	55	36.2	43	56.6	98	4.8
Private Insurance	88	57.9	31	40.8	119	52.2
Skin prep	149		73		222	
Betadine	21	14.1	16	21.9	37	16.7
Chloraprep	128	85.9	57	78.1	185	83.3
Type of ruptured membrane	152		74		226	
AROM	113	74.3	48	64.9	161	71.2

Table A5.—Continued

	Controls		Wound Complications		Overall Sample	
Variable	*N*	%	*N*	%	*N*	%
PROM	14	9.2	11	14.9	25	11.1
SROM	25	16.4	15	20.3	40	17.7
ASA score	147		76		223	
1	71	48.3	23	30.3	94	42.2
2	67	45.6	45	59.2	112	50.2
3 or 4	9	6.1	8	10.5	17	7.6
Smoker, current	150		76		226	
No	138	92.0	60	78.9	198	87.6
Yes	12	8.0	16	21.1	28	12.4
Smoker, former	149		76		225	
No	107	71.8	62	81.6	169	75.1
Yes	42	28.2	14	18.4	56	24.9
Insulin pre-op	152		76		228	
No	144	94.7	67	88.2	211	92.5
Yes	8	5.3	9	11.8	17	7.5
Oral hypoglycemic agent pre-op	152		76		228	

Table A5.—Continued

	Controls		Wound Complications		Overall Sample	
Variable	*N*	%	*N*	%	*N*	%
No	148	97.4	69	90.8	217	95.2
Yes	4	2.6	7	9.2	11	4.8
Oral or parenteral steroids pre-op	152		76		228	
No	145	95.4	70	92.1	215	94.3
Yes	7	4.6	6	7.9	13	5.7
Steroids for fetal lung development pre-op	152		76		228	
No	129	84.9	62	81.6	191	83.8
Yes	23	15.1	14	18.4	37	16.2
Antimicrobial agent pre-op	152		76		228	
No	115	75.7	42	55.3	157	68.9
Yes	37	24.3	34	44.7	71	31.1
Procedure indication	151		76		227	
Elective repeat	45	29.8	11	14.5	56	24.7
Failure to progress	37	24.5	27	35.5	64	28.2
Maternal condition	12	7.9	9	11.8	21	9.3
Non-reassuring fetal testing	32	21.2	13	17.1	45	19.8
Malpresentation	16	10.6	11	14.5	27	11.9

Table A5.—Continued

	Controls		Wound Complications		Overall Sample	
Variable	*N*	%	*N*	%	*N*	%
Other	9	6.0	5	6.6	14	6.2
Transferred to UIHC	152		76		228	
No	119	78.3	50	65.8	169	74.1
Yes	33	21.7	26	34.2	59	25.9
Procedure	152		76		228	
Emergency	30	19.7	18	23.7	48	21.1
Scheduled	44	28.9	12	15.8	56	24.6
Unscheduled	78	51.3	46	60.5	124	54.4
Anesthesia	151		76		227	
Epidural	134	88.7	59	77.6	193	85.0
General	13	8.6	11	14.5	24	10.6
Other	4	2.6	6	7.9	10	4.4
Placental removal	146		75		221	
Cord traction	121	82.9	62	82.7	183	82.8
Manual	25	17.1	13	17.3	38	17.2
Labor prior to Cesarean	152		76		228	
No	83	54.6	25	32.9	108	47.4

Table A5.—Continued

	Controls		Wound Complications		Overall Sample	
Variable	*N*	%	*N*	%	*N*	%
Yes	69	45.4	51	67.1	120	52.6
Labor type	152		76		228	
Induction	33	21.7	25	32.9	58	25.4
Spontaneous	21	13.8	19	25.0	40	17.5
Augmentation	15	9.9	7	9.2	22	9.6
No labor	83	54.6	25	32.9	108	47.4
Misoprostol induction agent	152		76		228	
No	134	88.2	66	86.8	200	87.7
Yes	18	11.8	10	13.2	28	12.3
Dinoprostone induction agent	152		76		228	
No	129	84.9	61	80.3	190	83.3
Yes	23	15.1	15	19.7	38	16.7
Foley induction agent	152		76		228	
No	144	94.7	75	98.7	219	96.1
Yes	8	5.3	1	1.3	9	3.9
Oxytocin induction agent	152		76		228	
No	129	84.9	53	69.7	182	79.8

Table A5.—Continued

	Controls		Wound Complications		Overall Sample	
Variable	*N*	%	*N*	%	*N*	%
Yes	23	15.1	23	30.3	46	20.2
Preterm labor	152		76		228	
No	134	88.2	62	81.6	196	86.0
Yes	18	11.8	14	18.4	32	14.0
Multiple pregnancy	152		76		228	
No	138	90.8	68	89.5	206	90.4
Twin	14	9.2	8	10.5	22	9.6
Hypertension, gestational	152		76		228	
No	145	95.4	67	88.2	212	96.0
Yes	7	4.6	9	11.8	16	7.0
Hypertension, chronic	152		76		228	
No	142	93.4	65	85.5	207	90.8
Yes	10	6.6	11	14.5	21	9.2
Pre-eclampsia	152		76		228	
Severe	11	7.2	7	9.2	18	7.9
Mild	11	7.2	8	10.5	19	8.3
No	130	85.5	61	80.3	191	83.8

Table A5.—Continued

	Controls		Wound Complications		Overall Sample	
Variable	*N*	%	*N*	%	*N*	%
Chorioamnionitis	152		76		228	
No	139	91.4	61	80.3	200	87.7
Yes	13	8.6	15	19.7	28	12.3
Diabetes, gestational	152		76		228	
No	138	90.8	68	89.5	206	90.4
Yes	14	9.2	8	10.5	22	9.6
Diabetes, mellitus	152		76		228	
No	147	96.7	69	90.8	216	94.7
Type 1 or 2	5	3.3	7	9.2	12	5.3
Oligohydroamnios	152		76		228	
No	142	93.4	71	93.4	213	93.4
Yes	10	6.6	5	6.6	15	6.6
Wound vac applied after procedure	152		76		228	
No	124	81.6	61	80.3	185	81.1
Yes	28	18.4	15	19.7	43	18.9
Prophylactic given within 1 hour before incision	148		73		221	
Within 1 hour prior to incision	127	85.8	53	72.6	180	81.4

Table A5.—Continued

	Controls		Wound Complications		Overall Sample	
Variable	*N*	%	*N*	%	*N*	%
Other	21	14.2	20	27.4	41	18.6
Antibiotics after surgery and before discharge	152		76		228	
No	134	88.2	27	35.5	161	70.6
Yes	18	11.8	49	64.5	67	29.4
Abdominal incision type	152		76		228	
Low transverse	143	94.1	71	93.4	214	93.9
Paramedian	0	0.0	1	1.3	1	0.4
Vertical	9	5.9	3	3.9	12	5.3
Other	0	0.0	1	1.3	1	0.4
Uterine incision type	152		76		228	
Classical	3	2.0	3	3.9	6	2.6
Low transverse	138	90.8	65	85.5	203	89.0
Low vertical	2	1.3	0	0.0	2	0.9
T-incision	2	1.3	3	3.9	5	2.2
Other	7	4.6	5	6.6	12	5.3
Wound closure type (staples, suture)	152		76		228	
Staples	10	6.6	9	11.8	19	8.3

Table A5.—Continued

	Controls		Wound Complications		Overall Sample	
Variable	*N*	%	*N*	%	*N*	%
Sutures	142	93.4	67	88.2	209	91.7
Group B Strep	134		67		201	
Negative	101	75.4	47	70.1	148	73.6
Positive, adequately treated	29	28.7	18	26.9	47	23.4
Positive, inadequately treated	4	4.0	2	3.0	6	4.0
Readmission within 30 days	152		76		228	
No	148	97.4	62	81.6	210	92.1
Yes	4	2.6	14	18.4	18	7.9
Antibiotics during readmission	4		14		18	
No	3	75.0	1	7.1	4	22.2
Yes	1	25.0	13	92.9	14	77.8
Hematoma in operative site	152		76		228	
No	151	99.3	66	86.8	217	95.2
Yes	1	0.7	10	13.2	11	4.8
Seroma in operative site	152		76		228	
No	151	99.3	66	86.8	217	95.2

Table A5.—Continued

	Controls		Wound Complications		Overall Sample	
Variable	*N*	%	*N*	%	*N*	%
Yes	1	0.7	10	13.2	11	4.8
Pre-op prophylactic antibiotics	150		75		225	
Cefazolin	133	88.7	54	72.0	187	83.1
Clindamycin/Gentamicin	11	7.3	13	17.3	24	10.7
Other	6	4.0	8	10.7	14	6.2
Induction Agent Combinations	33		25		58	
Ripening Agent Only	10	6.6	2	2.6	12	20.7
Oxytocin Only	5	3.3	5	6.6	10	17.2
Oxytocin and Ripening Agent	18	11.8	18	23.7	36	62.1

Note. Percentages are based on valid-*N* (i.e., non-missing case values).

Table A6. Tests of Mean Differences between Controls and Wound Complication Group on Continuous Study Variables

	Group Mean						
Variable	Controls	Complications	*t*	*df*	*p*	*d*[a]	Power
Weight gain from first prenatal visit to term	11.52	11.77	-0.290	215	.772	< .01	.06
BMI at first prenatal visit	29.00	34.26	-3.817	99.77	**< .001**	.60	.99
BMI at term	33.30	38.05	-3.685	106.54	**< .001**	.57	.99
Total number of prenatal visits	10.71	11.07	-0.626	213	.532	.09	.10
Number of vaginal examinations prior to Cesarean delivery	3.31	4.93	-2.675	224	**.008**	.36	.76
Number of prior Cesarean deliveries	0.60	0.34	2.121	226	**.035**	.29	.56
Gestational age	37.09	36.38	1.278	226	.203	.17	.25
Gestational week at preterm labor	31.77	31.18	0.395	30	.696	.14	.07
Cervical dilation at time of procedure (0-10 cm)	3.14	5.00	-3.375	223	**.001**	.45	.92
Duration of rupture of membranes (hours)	36.22	38.56	-0.071	223	.943	< .01	.05
Duration of procedure	61.17	61.71	-.192	198	.848	< .01	.05
Gravidity	2.56	2.67	-0.453	226	.651	.06	.07
Parity	1.93	1.80	0.790	226	.430	.11	.12
Estimated amount of blood loss during procedure (mL)	907.20	976.32	-1.718	226	.087	.23	.40
Temperature immediately following procedure (Celsius)	35.87	36.18	-2.492	225	**.013**	.33	.70
Number of post-op doses of antimicrobial agents	0.09	0.14	-0.829	226	.408	.11	.13
Number of days antibiotics post-op	0.21	2.08	-8.795	226	**< .001**	1.18	> .99

Table A6.—Continued

Variable	Group Mean		*t*	*df*	*p*	*d*[a]	Power
	Controls	Complications					
Number of days after surgery when patient was discharged	2.88	3.83	-4.277	79.97	**< .001**	.77	> .99
Age	29.63	29.49	0.177	226	.860	< .01	.05

Note. Where *df* is reported with decimals, Levene's test for equality of variances was highly significant (< .001) and *t* test with Welch's correction is reported.

[a]Cohen's *d* effect size, for which .20 is a small effect, .50 a medium effect, and .80 a large effect.

Table A7. Chi Square Tests of Independence between Categorical Study Variables and Wound Complications

						Observed Complication Cases Relative to Expected	
Variable	*N*	*df*	χ^2	*p*	*w*[a]	More	Less
Race	223	5	8.00	.156	.19		
Ethnicity (Hispanic/Latino or Not)	223	1	2.15	.143	.10		
Medical insurance	228	2	8.88	**.012**	.20	Medicaid	Private insurance
Skin prep (Betadine or Chloraprep)	222	1	2.16	.142	.10		
Type of ruptured membrane	226	2	2.48	.290	.11		
ASA score	223	2	7.00	**.030**	.18	ASA = 2	ASA = 1
Smoker, current	226	1	7.92	**.005**	.19	Smoker	Non-smoker
Smoker, former	225	1	2.57	.109	.11		
Insulin pre-op	228	1	3.18	.075	.12		
Oral hypoglycemic agent pre-op	228	1	4.78	**.029**	.15	Yes	No
Oral or parenteral steroids pre-op	228	1	1.02	.313	.07		
Steroids for fetal lung development pre-op	228	1	0.40	.525	.04		
Antimicrobial agent pre-op	228	1	9.83	**.002**	.21	Yes	No
Transferred to UIHC	228	1	4.13	**.042**	.14	Yes	No
Emergency, Scheduled, Unscheduled procedure	228	2	4.74	.094	.14		
Anesthesia (epidural, general, other)	227	2	5.54	.063	.16		
Placental removal (cord traction, manual)	221	1	<0.01	.969	< .01		
Labor prior to Cesarean	228	1	9.58	**.002**	.21	Yes	No
Labor type	228	3	11.17	**.011**	.22	Spontaneous; induction	No labor

Table A7.—Continued

Variable	*N*	*df*	χ^2	*p*	*w*[a]	Observed Complication Cases Relative to Expected	
						More	Less
Misoprostol induction agent	228	1	0.08	.775	.02		
Dinoprostone induction agent	228	1	0.77	.379	.06		
Foley induction agent	228	1	2.08	.149	.10		
Oxytocin induction agent	228	1	7.20	**.007**	.18	Yes	No
Preterm labor	228	1	1.82	.178	.09		
Multiple pregnancy	228	1	0.10	.751	.02		
Hypertension, gestational	228	1	4.07	**.044**	.13	Yes	No
Hypertension, chronic	228	1	3.78	.052	.13		
Pre-eclampsia	228	2	1.08	.584	.07		
Chorioamnionitis	228	1	5.88	**.015**	.16	Yes	No
Diabetes, gestational	228	1	0.10	.751	.02		
Diabetes, mellitus	228	1	3.56	.059	.13		
Oligohydroaminos	228	1	0.00	> .999	< .01		
Wound vac applied after procedure	228	1	0.06	.811	.02		
Prophylactic given within 1 hour before incision	221	1	5.64	**.018**	.16	Not within 1 hour	Within 1 hour
Antibiotics after surgery and before discharge	228	1	67.64	**< .001**	.55	Yes	No
Abdominal incision type	228	3	4.38	.223	.14		

Table A7.—Continued

Variable	*N*	*df*	χ^2	*p*	*w*[a]	Observed Complication Cases Relative to Expected	
						More	Less
Uterine incision type	228	4	3.88	.422	.13		
Wound closure type (staples, suture)	228	1	1.84	.175	.09		
Group B Strep	228	3	0.69	.876	.06		
Readmission within 30 days	228	1	17.37	**< .001**	.28	Yes	No
Antibiotics during readmission	18	1	8.29	**.004**	.68	Yes	No
Hematoma in operative site	228	1	17.24	**< .001**	.28	Yes	No
Seroma in operative site	228	1	17.24	**< .001**	.28	Yes	No
Cesarean procedure indication	227	5	8.92	.112	.20		
Pre-op prophylactic antibiotics	225	2	9.93	**.007**	.21	Clind/Gent.; Other types	Cefazolin
Induction	228	3	8.10	**.004**		Oxytocin/Ripening	

[a]Cohen's *w* effect size, for which .10 is a small effect, .30 a medium effect, and .50 a large effect.

Table A8. Characteristics of Individual Wound Complications (Cellulitis, Incisional SSI, Endometritis, Wound Separation

	N	Mean Time to Complication (days)	% Diagnosed	Sign	%
Wound Complications	76	8.37	93	Erythema	62
				Pain/Tenderness	47
				Fever	41
Cellulitis	31	6.16	100	Localized heat	32
				Pain/Tenderness	23
Incisional SSI	14	11	79	Purulent Drainage	64
				Erythema	57
Endometritis	24	4.44	92	Pain/Tenderness	88
				Fever	79
Wound separation	7	11.86	100	Localized redness	29
				Localized heat	14

Table A9. Tests of Pairwise Mean Differences by Wound Complication for Select Continuous Study Variables

Variable		Mean		Mean	*p*
BMI at term	Control	33.30	Cellulitis	39.57	.001
	Control	33.30	SSI	42.23	.001
	Endometritis	34.76	SSI	42.23	.039
BMI at first prenatal visit	Control	29.00	Cellulitis	36.42	< .001
	Control	29.00	SSI	38.54	< .001
	Endometritis	30.46	SSI	38.54	.028
Number of days post-op antimicrobial agents given	Control	0.21	Cellulitis	2.03	< .001
	Control	0.21	Endometritis	3.04	< .001
	Control	0.21	SSI	1.43	.024
	Wound Separation	0.29	Cellulitis	2.03	.034
	Wound Separation	0.29	Endometritis	3.04	< .001
	SSI	1.43	Endometritis	3.04	.009
Number of vaginal examinations prior to Cesarean delivery	Control	3.31	SSI	6.57	.052
Cervical dilation at time of procedure (0-10 cm)	Control	3.14	Endometritis	6.30	.003
Postoperative length of stay	Control	2.88	SSI	4.00	.004
	Control	2.88	Endometritis	4.50	< .001
	Cellulitis	3.39	Endometritis	4.50	.003
	Wound Separation	3.14	Endometritis	4.50	.045

Table A10. Chi Square Tests of Independence for Categorical Study Variables by Type of Wound Complication

		Observed Cases Relative to Expected				
Variable	*p*	Cellulitis	SSI	Endometritis	Wound Separation	Control
ASA score	.077					
1			Less			More
2						Less
3 or 4			Less			
Smoker, current	.051	More				Less
Insulin pre-op	.047		More		More	
Antimicrobial agent pre-op	.014		More	More		Less
Procedure Indication	.071					
Elective repeat				Less		More
Failure to progress			More			
Maternal condition						
Non-reassuring fetal testing						
Malpresentation						
Other						
Transferred to UIHC	.070			More		Less
Anesthesia	.031					
Epidural			Less		Less	More
General					More	

Table A10.—Continued

Variable	*p*	Observed Cases Relative to Expected				
		Cellulitis	SSI	Endometritis	Wound Separation	Control
Other			More			
Labor prior to Cesarean	.011			More		Less
Labor type	.001					
Induction			More			
Spontaneous				More		Less
Augmentation						
No labor				Less		More
Oxytocin induction agent	.005		More			Less
Hypertension, chronic	.001					Less
Pre-eclampsia	.021		More			
Severe					More	
Mild						
No					Less	
Diabetes, mellitus	.019				More	Less

Table A10.—Continued

Variable	*p*	Observed Cases Relative to Expected				
		Cellulitis	SSI	Endometritis	Wound Separation	Control
Type of prophylactic antibiotic	.013					
Cefazolin				Less		More
Clindamycin/Gentamicin						Less
Other				More		Less
Prophylactic given within 1 hour before incision	.013			Less	Less	More
Antibiotics after surgery and before discharge	< .001	More		More		Less
Readmission within 30 days	< .001		More	More		Less
Antibiotics during readmission	.060					Less
Hematoma in operative site	< .001	More			More	Less
Seroma in operative site	< .001		More		More	Less

Table A11. Logistic Regression Models Predicting Wound Complications

	Patient Model			Surgical Model			Combined Model		
Predictor	*B*	*p*	*OR*	*B*	*p*	*OR*	*B*	*p*	*OR*
Constant	-4.38	< .001	0.01	-10.58	< .001	< .001	-10.01	< .001	< .001
Diabetes Mellitus	1.61	.019	5.00				1.51	.031	4.51
Smoker, current	1.26	.009	3.53				1.59	.002	4.92
Chorioamnionitis	1.00	.063	2.72						
Number of prior Cesarean deliveries	-0.49	.047	0.62				-.492	.063	0.61
Labor type (ref. category = no labor)		.001			.014			.009	
Induction	-1.35	.155	0.26	-1.51	.114	0.22	-1.62	.103	0.20
Spontaneous	1.61	< .001	4.99	1.30	.008	3.65	1.34	.008	3.83
Augmentation	-0.27	.671	0.77	0.23	.709	1.26	-0.05	.935	0.95
BMI at term	0.09	< .001	1.09	0.11	< .001	1.12	0.10	< .001	1.11
Oxytocin induction agent	1.91	.048	6.74	1.68	.084	5.39	2.10	.036	8.12
Postoperative length of stay				1.70	< .001	5.45	1.68	< .001	5.34
Anesthesia (ref. category = epidural)					.066				
General				1.29	.022	3.63			
Other				0.54	.582	1.71			
Pre-op prophylactic antibiotics (ref. category = cefazolin)					.045				
Clindamycin/Gentamicin				0.89	.100	2.46			
Other				1.56	.042	4.76			

Table A12. Statistical and Classification Results for Logistic Regression Models Predicting Wound Complications

Model	*N*	χ^2	*df*	-2LL	Likelihood Ratio	Goodness of Fit[a] *p*	*c*[b]	Sensitivity	Specificity	Overall
Patient factors	224	56.24	9	230.73	.20	.796	.792	80.3%	72.3%	75.0%
Surgical factors	220	83.72	10	195.88	.30	.440	.842	72.6%	78.2%	76.4%
Combined factors	222	89.40	9	193.21	.32	.575	.852	77.0%	77.0%	77.0%

[a] Goodness of fit indexed by the significance (*p*) of the Hosmer and Lemeshow test, for which a non-significant *p* value indicates a good fit between the model and the data.

[b] *c* = area under the ROC curve.

Table A13. Frequencies of Perioperative Prophylactic Antimicrobial Agents

	Controls (N=152)		Wound Complications (N =76)		Overall Sample (N=228)	
Antimicrobial Agent	*N*	%	*N*	%	*N*	%
Cefazolin	133	86.36	54	71.05	187	82.02
Clindamycin/Gentamicin	11	7.24	13	17.11	24	10.53
Ampicillin	1	0.66	1	1.32	2	0.88
Ampicillin/Clindamycin	1	0.66	0	0	1	0.44
Clindamycin	3	1.97	5	6.58	8	3.51
Zosyn	0	0	2	2.63	2	0.88
Zosyn/Vancomycin	0	0	1	1.32	1	0.44

Table A14. Logistic Regression Model Predicting Wound Complications: NHSN Components

	NHSN MODEL		
Predictor	*B*	*p*	*OR*
Constant	-1.01	.067	.365
ASA Sore (ref. category = 1)		.024	
2	.87	.010	2.39
3 or more	1.01	.098	2.76
Duration of Procedure	-.003	.727	.997
Wound Classification	-21.06	1.00	.000

Table A15. Statistical and Classification Results for Logistic Regression Model Predicting Wound Complications: NHSN Risk Score

Model	*N*	χ^2	*df*	-2LL	Goodness of Fit[a] *p*	*c*[b]	Sensitivity	Specificity	Overall
NHSN	194	8.63	4	240.98	.466	.611	69.7%	51.2%	57.4%

[a] Goodness of fit indexed by the significance (*p*) of the Hosmer and Lemeshow test, for which a non-significant *p* value indicates a good fit between the model and the data.

[b] *c* = area under the ROC curve.

Table A16. Chi-Square Test of Independence between Labor Type and Procedure Type

					Observed Procedure Type Relative to Expected	
Variable	*N*	*df*	χ^2	*p*	More	Less
Labor Type	228	6	116.82	< .001		
Spontaneous					Emergency	Unscheduled
Induction					Unscheduled	Emergency; Spontaneous
Augmentation					Unscheduled	Scheduled
No					Scheduled	Unscheduled

Table A17. Chi-Square Test of Independence between Induction and Duration of Ruptured Membranes

					Observed Duration of Ruptured Membranes Relative to Expected	
Variable	*N*	*df*	χ^2	*p*	≤ 7 hours	> 7 hours
Induction	228	3	57.79	< .001		
No					More	
Oxytocin Only						
Oxytocin and Ripening Agents						More
Ripening Agents Only						

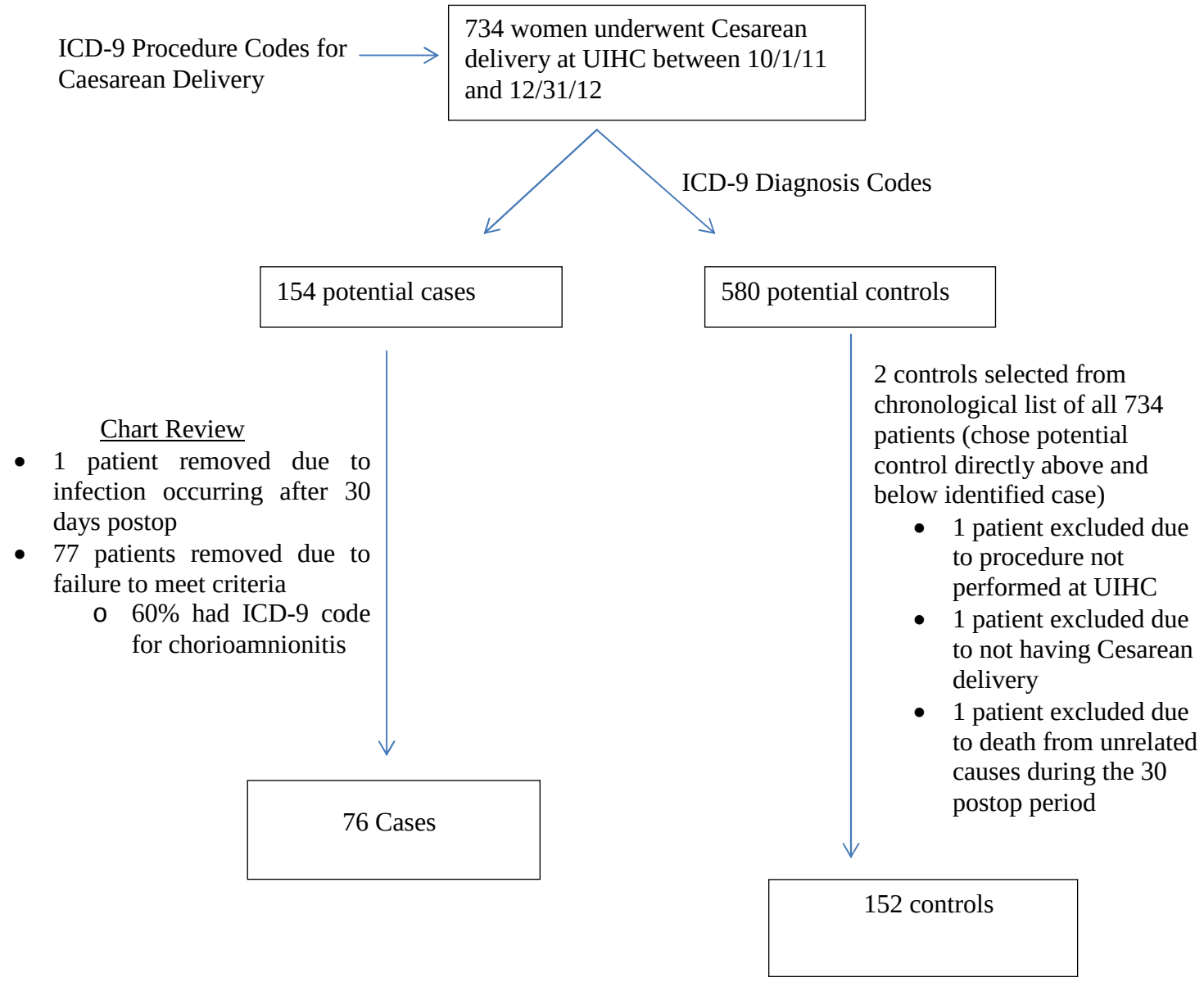
Table A18. Power for Study Sample Size (Control *N* = 152, Wound Complication *N* = 72) to Detect Small, Medium, and Large Cohen's *w* Effect Sizes in Chi Square Tests of Independence

	Chi Square Degrees of Freedom				
Effect Size, *w*	1	2	3	4	5
.40 or larger	>.99	>.99	>.99	>.99	>.99
.30 (medium)	.99	.99	.98	.97	.96
.20	.86	.78	.72	.67	.63
.10 (small)	.33	.25	.22	.19	.17

Table A19. Power for Study Sample Size (Control N = 152, Wound Complication N = 72) to Detect Small, Medium, and Large Cohen's d Effect Sizes in Independent Samples t Tests

Effect Size, *d*	Power
.65 or larger	>.99
.50 (medium)	.94
.40	.81
.30	.57
.20 (small)	.29

Figure A1. Subject Identification Flowchart



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