RISK FACTORS FOR SURGICAL SITE INFECTION FOLLOWING CAESAREAN SECTION IN NOVA SCOTIAN WOMEN

by

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DEDICATION PAGE

To my parents, Dwain and Colleen. Even when I completely changed my career path and moved to attend graduate school, you supported me every step of the way. Thank you for all your love, support, and encouragement in everything I do.

And to my brother, Edward. Thank you for always being there for me not just as my brother but also as my best and closest friend.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Surgical site infections (SSIs) can be serious complications after Caesarean section. Therefore, we determined among women undergoing a Caesarean section in Nova Scotia: 1) the incidence of SSI to hospital discharge, 2) risk factors associated with the development of a SSI, and 3) risk factors associated with the development of a SSI using a more inclusive SSI definition. Using a perinatal provincial database, we created a retrospective cohort of Nova Scotian women undergoing Caesarean section from 1997-2012 and followed them to hospital discharge. We determined risk factors for SSI using logistic regression with generalized estimating equations. The SSI rate decreased over our study period. The number of Caesarean sections performed per hospital per year; pre-pregnancy weight; hypertension; year of delivery; and anticoagulation therapy, weight gain, and chorioamnionitis during pregnancy were important risk factors for SSI.

LIST OF ABBREVIATIONS USED

aOR	Adjusted odds ratio
ASA	American Society of Anesthesiologists
BMI	Body mass index
CCI	Canadian Classification of Health Interventions
CDC	Centers for Disease Control and Prevention
CI	Confidence interval
GBS	Group B Streptococcus
HAI	Hospital-acquired infection
ICD	International Classification of Diseases
ICD-10-CA	Canadian Enhancement of the International Classification of Diseases, edition 10
NHSN	National Healthcare Safety Network
NNIS	National Nosocomial Infections Surveillance System
NOS	Not otherwise specified
NSAPD	Nova Scotia Atlee Perinatal Database
OR	Odds ratio
RCP	Reproductive Care Program of Nova Scotia
RR	Relative risk
SSI	Surgical site infection
uOR	Unadjusted odds ratio

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CHAPTER 1: INTRODUCTION

Surgical wound infections, called surgical site infections (SSIs), after Caesarean section are serious complications (1). While some SSIs can be managed with oral antibiotics on an ambulatory basis, others are potentially life threatening and can lead to hospitalization of the mother or another surgery, and interrupt the normal mother-infant postpartum period (2). SSIs occurring in the 30 days after surgery are considered nosocomial or hospital-acquired infections (HAIs) (3).

The overall rate of SSI following Caesarean section can vary and has been shown to range from 0.92%-14.70% in studies where women are followed to hospital discharge (4-17). The difference in the range of reported SSI rates can be due to the characteristics of the women in the study and the definition of SSI used (18).

SSI is an important outcome to study as 26% of Nova Scotian births are via Caesarean section (19). While one study has documented the rate of SSI in Nova Scotia from 1988 to 2002 to be 1.50%, this study only examined labouring Caesarean sections (5). There has yet to be a study conducted in Nova Scotia that estimates the incidence of SSI for both non-labouring and labouring Caesarean sections nor one that determines multiple risk factors for developing SSI. Numerous factors have been studied in the literature to determine whether they are risk factors for SSI following Caesarean section. However, due to the differences in study methods and populations, risk factors that are statistically significant in one study may not reach significance in another. As such, it is important to study this outcome on various populations to determine what differences, if any, there are in independent risk factors for SSI.

Our study aimed to determine among women undergoing a Caesarean section in Nova Scotia: 1) the incidence of SSI to discharge in the province as a whole and within each region and Robson Group, 2) risk factors associated with the development of a SSI, and 3) risk factors associated with the development of SSI using additional diagnostic and procedure codes.

Our cohort was created from the Nova Scotia Atlee Perinatal Database (NSAPD) which is administered by the Reproductive Care Program of Nova Scotia (RCP). The retrospective cohort included Nova Scotia women who delivered via Caesarean section from January 1, 1997 to December 31, 2012. We determined relevant exposure and risk factor information from the NSAPD as well as captured any women who presented with a SSI before hospital discharge.

Our population-based study adds to the existing literature on the risk factors for SSI following Caesarean section. It also gives an estimate of the SSI rate in Nova Scotia following both labouring and non-labouring Caesarean sections. Our study gives evidence that independent risk factors for SSI differ depending upon what diagnostic and procedure codes are included in the SSI definition.

This document begins with the background which covers the status of the literature regarding SSIs following Caesarean sections. It begins by discussing the prevalence of Caesarean sections and incidence of SSIs and how each are classified and defined. It also examines how SSIs are detected, the incidence of SSI following obstetric and gynecologic surgeries, length of patient follow-up, the burden of SSIs, and risk factors for SSI that have been studied in the literature. The following section lists the objectives for our study. The next section discusses the methods that we used. It begins

by discussing our study design, study population, sample size, ethical considerations, and the database used. Next the outcome and exploratory variables that were examined are discussed followed by how each of the objectives were analysed. This is followed by the results of each objective and then a discussion of these results. Finally, the study's strengths and limitations, our recommendations, and the study's impact and relevance are discussed.

CHAPTER 2: BACKGROUND

2.1. Caesarean Sections

Most neonates are delivered vaginally. However, some deliveries occur via Caesarean section, a surgical procedure in which a neonate is delivered via an incision in a woman's abdomen. These surgeries can be elective or emergent/urgent. Elective Caesarean sections are performed on non-labouring women if problems are anticipated, such as uterine rupture for a repeat Caesarean section. If a woman is in labour and a problem develops that puts her health and/or the health of the fetus in danger, the delivery team must decide if they can deliver vaginally with instrumentation or perform an emergent/urgent Caesarean section.

2.1.1. Prevalence of Caesarean Sections

The percentage of deliveries that are by Caesarean section rather than vaginally has been increasing. In Canada, the prevalence of Caesarean sections increased from 6% in 1970 to 20% in 1988, 27% in 2006 (19) and 28% in fiscal year 2010-2011 (20). The Caesarean section rate in Nova Scotia is comparable to the national rate with the percentage of births by Caesarean section increasing from 20% in 1988 to 27% in 2006 (19) and remaining at 27% in 2011 (21).

There are many reasons for the increase in this rate which can be categorized into maternal choice (women with previous Caesarean section choosing repeat Caesarean section or having a Caesarean section to avoid pelvic floor disorders), changes in obstetrical practice (decreasing use of forceps-assisted vaginal delivery, data on adverse outcomes associated with vaginal breech delivery), maternal characteristics (older maternal age and higher body mass index [BMI]), and attitudes and beliefs (informed

women should be able to choose whether to give birth vaginally or via Caesarean section) (19).

Given that the number of women having elective/non-labouring and emergency/labouring Caesarean sections has increased in this timeframe, the risk for developing SSI may have also increased. Since women having elective and emergency Caesarean sections are different clinical populations, decreasing the SSI rate would require a different intervention for each group. Due to the higher rate of women undergoing Caesarean sections, research into what factors place women at a higher risk for developing a SSI is important.

2.1.2. Classification of Caesarean Sections

Classifying Caesarean sections can be useful to both clinicians and researchers. A "mutually exclusive and totally inclusive" classification system for Caesarean section has been developed by Robson (22). The Robson classification system has been validated and determined to be the most superior system by a study which compared 27 classification systems for Caesarean sections by analyzing a set of criteria deemed important by multidisciplinary experts (23).

The Robson system consists of 10 classes that group Caesarean sections based on several criteria: having had a previous Caesarean section, parity, gestational age, number of fetuses (singleton or multiples), type of labour (spontaneous, induced, or none), and position of the fetus (cephalic, breech, transverse, or oblique) (22). It is straightforward for clinicians to use as it consists of a logical organization that should not require retroactive reclassification (22).

The purpose of this static classification system is to compare the Caesarean section rate over time and between institutions and groups, such as by examining whether a certain group is contributing more or less to the overall Caesarean section rate than in previous years (22). In addition, a classification system allows care to improve and for all research, whether it be conducted nationally or internationally, to be comparable (22,24). Knowing which groups have a high Caesarean section rate can help clinicians determine which groups require better managing with the goal of lowering the rate of Caesarean section (22).

The Society of Obstetricians and Gynaecologists of Canada developed a modified Robson criteria which further subdivides each Robson group based on type of labour (24). Group 2 and groups 4-10 were modified to include induced and no labour categories and groups 5-10 were modified to include induced, spontaneous, and no labour categories (24).

Kelly et al. classified Caesarean sections performed in five Canadian provinces (British Columbia, Alberta, Ontario, Nova Scotia, and Newfoundland and Labrador) over four years (April 2007 to March 2011) using the Robson criteria and found that the three groups contributing the most to the Caesarean section rate were consistent between all five provinces (the only exception being British Columbia where the rank of the second and third highest contributors were reversed from that of the other provinces) (21). The group contributing the most to the Caesarean section rate was women with one or more previous Caesarean sections and a single fetus at term in cephalic position (Robson's Group 5); this was followed by nulliparous women who were not in labour or whose labour was induced with a single fetus at term in cephalic position (Robson's Group 2)

and then nulliparous women in spontaneous labour with a single fetus at term in cephalic position (Robson's Group 1) (21).

During the fiscal year April 2010 to March 2011, the rate of Caesarean section in Nova Scotia was 27% (21). 78.5% of women in Group 5 had a Caesarean section which contributed 7.8% to the overall rate (21). Of the women in Group 2, 34.4% had a Caesarean section, contributing 5.5% to the overall Caesarean section rate, followed by women in Group 1 who had a Caesarean section rate of 15.3% which contributed 3.7% to the overall rate (21). Another Nova Scotian study of these select maternal groups and adjusted analyses demonstrated an increased risk for Caesarean section over time for three groups: nulliparous women at term who were in labour (spontaneous or induced) with a single cephalic pregnancy, previous delivery via Caesarean section, and multiple gestations (25).

Identifying potentially modifiable risk factors, reassessing indication and methods for inducing labour, having resources available for vaginal birth after Caesarean section, and the use of external cephalic version for breech presentation are important areas to consider managing to safely lower the Caesarean section rate (25). By doing so, it may also lower the number of women developing SSIs.

2.2. Surgical Site Infections

The risk of postpartum infection is five to twenty times higher after a Caesarean section than after a vaginal birth (26). Postpartum infections include urinary tract infections, septicemia, peritonitis, and SSIs (19). SSIs are infections of the surgical wound and develop within 30 days of a Caesarean section (3). They are usually from endogenous bacteria (woman's own bacteria entering the wound) but can also develop

from exogenous bacteria (bacteria from elsewhere entering the wound) (27,28). Since the risk of developing infection is higher after a Caesarean section than after a vaginal birth, more research in this area is needed.

2.2.1. Types of and Definition of Surgical Site Infections

The US Centers for Disease Control and Prevention (CDC) identifies three types of SSIs: superficial incisional, deep incisional, and organ/space (3,29). Superficial incisional SSIs are infections of the skin and subcutaneous tissue, deep incisional SSIs infect the deeper fascial and muscle layers, and organ/space SSIs infect any part of the body that was affected from the surgery that does not meet the requirements of superficial or deep incisional SSIs (3,29). Both superficial and deep incisional SSIs can be further categorized into primary or secondary to distinguish in which incision the SSI has developed (3,29).

A superficial incisional SSI must meet at least one of the following criteria: 1) "purulent drainage", 2) "organisms isolated from an aseptically-obtained culture of fluid or tissue from the superficial incision", 3) has been "deliberately opened by a surgeon" and has at least one of "pain or tenderness; localized swelling; redness; or heat", or 4) diagnosis of superficial incisional SSI (3). The criteria for a deep incisional SSI are at least one of: 1) "purulent drainage", 2) "spontaneously dehisces or is deliberately opened by a surgeon" and has at least one of "fever (>38^0C); localized pain or tenderness", or 3) "abscess or other evidence of infection" (3). In order for an organ/space SSI to be diagnosed, the infection must be in at least one site, such as endometritis, and must meet at least one of the following criteria: 1) "purulent drainage", 2) "organisms isolated from a...culture…", or 3) "abscess or other evidence of infection" (3).

Most Caesarean section SSIs are superficial incisional. In a study conducted by Johnson et al., of the 80 SSIs detected within 30 days, 90% were superficial infections (30). Another study conducted by Wloch et al. found that of the 394 SSIs, 88.3% were superficial whereas only 4.8% were deep incisional and were 6.9% organ/space (31). Similar results were found in a study by Barwolff et al. with 83% of SSIs being superficial (32). A study conducted by Mitt and colleagues found that 63.2% of SSIs were superficial, 10.5% were deep and 26.3% were organ/space [80% of which were endometritis]) (33).

2.2.1.1. Detection of Surgical Site Infections

SSIs can be detected by using a clinical diagnosis, nosocomial infection surveillance system, or administrative data. A clinical diagnosis of a SSI is made by a physician following a patient history and physical examination. This is the most clinically accurate method of detecting SSIs.

There are several considerations that need to be made when surveillance data is used to detect SSIs. The first is that they may capture pre-existing infections, such as endometritis, that are not considered HAIs. This can be avoided by only considering SSIs that were diagnosed after a Caesarean section, as then no pre-existing HAIs would be captured. The second consideration is the source of the surveillance data. Nosocomial surveillance conducted by trained infection prevention and control professionals using national or international definitions is more accurate than using administrative databases. This is because the former uses a more sensitive definition so is more likely to capture a definite SSI. In addition, surveillance data is collected by trained personnel with expertise in the area and therefore is less prone to misclassification than administrative

databases. Third, the purpose of surveillance systems is not to be clinically accurate but rather to be reproducible and to serve as a system in which one can detect changes in infection rates over time. When changes are detected, they can then be investigated.

Administrative data can also be used to detect SSIs. As with surveillance data, these data capture both HAI and non-HAI infections which makes it less accurate than using a clinical diagnosis. However, by using appropriate infection codes, such as SSI after an obstetrical surgery, the risk of capturing non-HAI infections is lowered. Another limitation to administrative data is that these data can be collected, entered, and analyzed incorrectly and therefore could be misclassified.

2.2.1.2. Definitions of SSI using administrative data

The International Classification of Diseases (ICD) provides standardized codes for identifying diagnoses of health conditions and the Canadian Classification of Health Interventions (CCI) provides standardized codes for identifying medical procedures. Both ICD and CCI codes are routinely used for administrative purposes. SSIs following a Caesarean section can be captured using codes for infections specific to obstetrical wounds as well as more general codes for wound infection. The more ICD codes used to define SSI, the more people the definition will capture. While using more ICD codes allows for a more sensitive definition, it is less specific as it may capture people who do not necessarily have a SSI. A sensitivity analysis can be used to compare the incidence of SSI between the more specific and more sensitive definition.

Tsai et al conducted a sensitivity analysis by examining the association between method of anesthesia and SSI within 30 days of surgery using five ICD-9 codes and 81 ICD-9 codes to define SSI (34). When five ICD-9 codes were used, the SSI rate was

0.3% and this increased to 1.5% when 81 codes were used. Compared to spinal anesthesia, when five ICD-9 codes were used general anesthesia had a significant association with SSI when controlled for maternal age, diabetes (unknown type), hypertension (pre-existing, gestational, eclampsia, and pre-eclampsia), fetal distress, indication for Caesarean section (maternal request), previous Caesarean section, and length of hospital stay (adjusted odds ratio [aOR] 3.82; 95% confidence interval [CI] 3.12-4.68) (34). When 81 ICD-9 codes were used in the same analysis, general and epidural anesthesia both significantly increased the risk for SSI (aOR 2.23; 95% CI 1.94-3.00 and aOR 1.36; 95% CI 1.25-1.48, respectively).

2.2.2. Incidence of Surgical Site Infections Following Caesarean Sections Compared to Other Obstetric/Gynecologic Surgeries

Compared to most obstetric/gynecologic surgeries, the risk for developing SSI following Caesarean section is high (3,35,36). The CDC ranked 18 abdominal surgeries in terms of the risk for SSI (3). This ranking included four obstetric/gynecological surgeries: Caesarean section was ranked as number 10 which ranked it as less risky than an abdominal hysterectomy (9^{th}) but riskier than a vaginal hysterectomy (15^{th}) and ovarian surgery (18^{th}) (3). A study from the CDC's National Nosocomial Infections Surveillance System (NNIS) that examined the rate of SSI following numerous types of surgeries performed in the surveyed United States hospitals from 1992-2004 had a similar finding (35). The riskiest obstetric/gynecologic surgery was Caesarean section with an overall SSI rate of 3.15% followed by abdominal hysterectomy at 1.90%, vaginal hysterectomy at 1.31%, and other obstetric surgeries at 0.51% (35).

Findings released for the years 2006-2008 by the National Healthcare Safety Network (NHSN), an evolution of the NNIS, had similar results: Caesarean section was

the riskiest surgery with a SSI rate of 1.84% followed by abdominal hysterectomy (1.65%), vaginal hysterectomy (0.87%) and ovarian surgery (0.56%) (36). Since Caesarean sections are a common obstetric surgery with the highest risk for developing SSI, identifying risk factors for SSI among women undergoing this type of surgery rather than other types of surgery in this field will have the biggest public health impact.

2.3. Impact of Length of Follow-up on Incidence Estimates

The length of time that a patient should be followed to determine if they have developed a SSI varies according to the type of surgery performed. The CDC recommends that women who have undergone a Caesarean section be followed for 30 days after surgery (3) as it can take that long for a SSI to develop.

A report on SSIs following several surgeries using data from a Dutch surveillance system found that approximately 35% of SSIs following Caesarean section were detected within the first week postsurgery and the majority (nearly 80%) were detected within the first two weeks (37). However, in Nova Scotia, based on 1997-2005 data, the average postpartum length of stay following a Caesarean section is not quite four days which means a considerable proportion of SSIs develop postdischarge (19).

When women are followed for at least 30 days postsurgery, the overall SSI rate has been shown to range from 1.44% - 26.6% (18,30,31,33,38-48), the denominator only including subjects followed for the entire 30 days and therefore not lost to follow-up as suggested by Creedy et al. (27). This is higher than in studies that only follow women to discharge where SSI rates have been shown to range from 0.92% - 14.70% (4-17).

However, there is no gold standard for postdischarge surveillance (29) and different methods can result in different SSI rates (18,41). In addition, most hospital-

based infection prevention and control surveillance programs do not perform postdischarge surveillance because of the expense and effort of doing so. Therefore, many studies are unable to follow women postdischarge or may only be able to do so passively through methods such as hospital readmissions (18,31,33,34,42,43,45-47,49-60) and emergency room visits (18,42,46,47,60).

2.4. Burden of Illness

Despite being HAIs, community-based healthcare bears most of the burden of SSIs following Caesarean section (31). Many women will go to a family physician for diagnosis and treatment of SSI and in these cases it is community-based healthcare, not hospitals, that bears the economic costs of SSIs (31). Conversely, in the most severe cases, hospitals bear the economic costs as women with severe SSIs require readmission for treatment.

These economic costs are not the only consequences of SSI. The postpartum period is a critical time and so a SSI is detrimental to both the mother and infant as it can affect the normal mother-infant postpartum period (2) Women who have had a Caesarean section have a more difficult time recovering from their surgery and adjusting to having a baby if they develop a SSI (2). This difficulty could pose a barrier in women being able to effectively care for their infants, such as being unable to breastfeed, which could lead to adverse health consequences (61). Therefore, it is important to identify risk factors for SSI so they can be prevented when possible and their associated burdens can be avoided.

2.5. Risk Factors for Surgical Site Infection Following Caesarean Section

We conducted a literature search using specific keywords to determine which factors are known to increase the risk for SSI and which still need to be explored. Appendix 1 outlines our search strategy and Appendix 3 lists which factors other studies have examined as potential risk factors for SSI following Caesarean section.

2.5.1. Classification of Risk Factors

Risk factors for SSI can be categorized to differentiate between different types of risks. Categories that have been used in the literature include patient, obstetric, and operation factors (47); modifiable and non-modifiable factors (1,28,38); extrinsic and intrinsic factors (1,2,30); and preoperative and postoperative factors (28). If an individual woman's risk can be predicted, it is possible that her modifiable risk factors can be changed thereby reducing or eliminating her increased risk for developing a SSI (1).

2.5.2. Institution-Related Risk Factors

Potential institution-related risk factors that have been studied include the number of deliveries per month and the number of Caesarean sections performed per month.

In a large study of 80 maternity units, Vincent et al. observed a significant association between the development of SSI and the number of deliveries per month (62). Patients who delivered in units with less than 50 deliveries per month were at a significantly higher risk of SSI compared to women delivering in units with at least 103 deliveries per month when adjusted for year of birth, rupture of membranes, maternal age, nulliparity, planned Caesarean section, primary Caesarean section, antibiotic

prophylaxis, and the number of vaginal deliveries and Caesarean sections performed per month (aOR 2.63; 95% CI 1.43-4.84) (62).

Vincent et al. also examined whether the number of Caesarean sections performed per month per maternity unit was a risk factor for SSI. When compared to delivering in a unit with at least 19 Caesarean sections per month, delivering in a unit with 9-13 sections per month increased the risk of SSI when adjusted for the same variables as above as well as the number of deliveries per month (aOR 1.95; 95% CI 1.16-3.28) (62).

2.5.3. Patient-Related Risk Factors

Potential patient-related risk factors that have been studied include area-level risk factors such as rural residence; maternal demographics such as age and BMI; maternal lifestyle factors such as smoking during pregnancy; and maternal medical conditions such as hypertension (pre-existing, gestational, and preeclampsia), diabetes (pre-existing type 1 and 2 and gestational), other health conditions, and anemia during pregnancy.

2.5.3.1. Area-Level

Only one recent study has examined rural residence as a potential risk factor and found living rurally to significantly increase the risk of SSI after controlling for BMI, urgency of surgery, length of time in delivery, number of vaginal examinations, rupture of membranes, and method of anesthesia (aOR 1.73; 95% CI 1.05-2.84) (1).

2.5.3.2. Maternal Demographics

Many previous studies have not shown a significant association between age and development of SSI (1,10,11,18,33,39,47,48,51,52,54,63,64). However, some studies have found younger age to be independently associated with SSI when adjusted for other factors (31,32,65). For example, a multicentre study by Wloch et al. found that relative

to women aged 25-29, women <20 years old had a significantly increased risk of SSI when adjusted for hospital variation, BMI, ethnicity, duration of surgery, and surgeon grade (aOR 1.92; 95% CI 1.08-3.42) (31).

A higher pre-pregnancy or delivery BMI has almost consistently been shown to be associated with the development of SSI (1,6,18,30,40,46,51,52,65,66). For example, Wloch et al. observed a dose-response with the only BMI category (unspecified as to whether pre-pregnancy or delivery) not significantly associated with SSI to be ≤18.5 kg/m^2 relative to 18.5 to 24.9 kg/m^2 when controlled for maternal age, hospital variation, ethnicity, duration of surgery, and surgeon grade (aOR 3.67; 95% CI 2.62-5.16) (31).

2.5.3.3. Maternal Lifestyle Factors

Previous studies have not found smoking to be a significant risk factor for SSI (10,47,48,51,60). Small sample size may have caused insignificant results in some cases (10,51).

2.5.3.4. Maternal Medical Conditions

Geubbels et al. examined gestational hypertension and did not find it to be significantly associated with SSI in an unadjusted analysis (67). Schneid-Kofman et al. examined both mild and severe preeclampsia but neither reached significance when adjusted for other factors (68). While one study not specifying the type of hypertension (whether it was pre-existing, gestational, or a combination) did not observe significant results (48), others have (11,39). For example, Merchavy et al. found hypertension was independently associated with SSI when adjusted for previous Caesarean section, polyhydramnios, method of placenta removal, and urgency of surgery (aOR 3.3; 95% CI 2.0-38.5) (11). Similarly, Schneid-Kofman et al. found that pre-existing hypertension

significantly increased the risk for SSI when controlled for fertility treatments, twin pregnancy, severe preeclampsia, gestational diabetes, pre-existing diabetes, premature rupture of membranes, non-reassuring fetal heart rate, Apgar score at one minute of <7, and maternal blood transfusion (aOR 1.7; 95% CI 1.4-2.1) (68).

Many previous studies have not found a significant association between diabetes and SSI (1,10,11,31,33,39,47,48,60,63,64,66,69). This could be due to many studies combining or likely combining gestational and pre-existing diabetes instead of treating them as separate variables (1,11,31,39,47,48,60,64,69). Schneid-Kofman et al. found an association between pre-existing diabetes and SSI which remained significant when adjusted for fertility treatments, twin pregnancy, chronic hypertension, severe preeclampsia, gestational diabetes, premature rupture of membranes, non-reassuring fetal heart rate, Apgar score at one minute of <7, and maternal blood transfusion (aOR 1.4; 95% CI 1.1-1.7) (68). The authors did not find gestational diabetes to be associated with SSI when adjusted for other factors (68).

Only Gong et al. has included pre-existing disease (a composite of heart disease, diabetes, hyperthyroidism, and other pre-existing diseases) as a potential risk factor for the development of SSI (52). When adjusted for BMI, parity, number of vaginal and anal examinations, pre-existing infection, bladder catheterization, antibiotic prophylaxis, premature rupture of membranes, method of anesthesia, length of hospital stay, preoperative hemoglobin, blood loss, and duration of surgery, pre-existing disease was not associated with SSI (52). Anemia has not been found to have a significant association with SSI perhaps due to a low prevalence in most studies (11,33,69).

2.5.4. Obstetric-Related Risk Factors

Potential obstetric-related risk factors that have been studied include pregnancy history such as parity and number of previous Caesarean sections; pregnancy characteristics such as length of antepartum stay, chorioamnionitis, length of postpartum stay, and steroid use; labour risk factors such as cervical dilation, hours of labour, hours from rupture of membranes to delivery, stage of labour, and type of rupture of membranes; delivery risk factors such as indication for Caesarean section, anesthesia type, antibiotic prophylaxis, maternal blood transfusion, and other procedures performed; and fetal or neonatal factors such as malpresentation, infant birth weight, Apgar score at five minutes, number of fetuses, and gestational age.

2.5.4.1. Pregnancy History

When controlled for other variables, some studies have not found parity to be associated with SSI (40,52,62) and most previous studies have not found parity to be associated with SSI even when unadjusted for other factors (1,10,33,39,51,63,64,69). For example, when Vincent et al. controlled for year of birth; rupture of membranes; maternal age; planned Caesarean section; primary Caesarean section; antibiotic prophylaxis; and the number of deliveries, vaginal deliveries and Caesarean sections performed per month, nulliparous women were not at a significantly higher risk for SSI compared to multiparous women (62).

Similarly, studies examining previous Caesarean section have not found it to be associated with SSI when adjusted for other factors (6,11,62) and most studies have not found it to be associated with SSI in an unadjusted analysis (1,4,7,18,31,50,60,64,68). For example, when controlling for age; year of birth; parity; rupture of membranes;

maternal age; planned Caesarean section; primary Caesarean section; antibiotic prophylaxis; and the number of deliveries, vaginal deliveries and Caesarean sections performed per month, Vincent et al. did not observe women having a primary Caesarean section to be at a significantly higher risk of developing SSI than women having a repeat Caesarean section (aOR 1.18; 95% CI 0.97-1.44) (62).

2.5.4.2. Pregnancy Characteristics

Previous studies have not shown a significant association between the length of preoperative hospital stay and SSI (33,48,65,67). In studies that controlled for other variables, length of postoperative hospital stay (40) and total hospital stay (52,63) did not remain significant. This is likely because postoperative hospital stay is not only an indicator of SSI since women with a SSI are more likely to require a longer hospital stay, but also a risk factor for SSI since a longer hospital stay means an increased exposure to potential contaminates.

Most previous studies have not found a significant association between chorioamnionitis and SSI (47,66,69). Conversely, after adjusting for internal fetal monitoring and wound contamination class, Mitt et al. observed that chorioamnionitis was independently associated with SSI (aOR 8.8; 95% CI 1.10-69.60) (33). The large confidence interval could be due to the low prevalence of chorioamnionitis in the sample (1.3%) (33).

Only one study has examined the use of steroids (corticosteroids) but the reason for their use and the timing of administration was not specified (63). There was not an association with SSI in a univariate analysis likely because only 1.10% of subjects had been administered corticosteroids (63).

2.5.4.3. Labour

Many previous studies have not found a significant association between cervical dilation and SSI (59,70,71). For example, Gungorduk et al. studied intraoperative cervical dilation during elective Caesarean section and in an unadjusted analysis showed no difference in rates of SSI (unadjusted RR 1.11; 95% CI 0.44-2.81) or endometritis (unadjusted RR 1.68; 95% CI 0.39-7.14) (70). Allen et al. showed no difference in the SSI rate in low-risk Nova Scotian women having a Caesarean section at full cervical dilation compared to those with less than full dilation when controlled for maternal age, antibiotic prophylaxis, induction or augmentation of labour, regional anesthesia, length of labour, and gestational age (adjusted RR 1.10; 95% CI 0.41 - 3.2), regardless of whether operative-vaginal delivery was attempted before surgery (71). Among women undergoing an elective Caesarean section, Koifman et al. showed no difference in the SSI rate between women with intraoperative cervical dilation compared to those without dilation in an unadjusted analysis (unadjusted odds ratio [uOR] 0.7; 95% CI 0.1 - 3.6); however, this could be due to a limited statistical power due to a low rate of SSI (1.0%) (59).

Only one study examining duration of labour found it to be significantly associated with SSI when controlled for other variables (66). Al Jama et al. categorized labour as no labour, <6 hours of labour, 6-12 hours of labour, and >12 hours of labour and found >12 hours of labour to increase the risk for SSI compared to no labour when adjusted for no prenatal care, BMI >30 kg/m^2, premature rupture of membranes, number of vaginal examinations, operating time, and blood loss (aOR 3.20; 95% CI 1.6-5.44)

(66). Other studies have not found a significant association between duration of labour and SSI (39,47,48) or only found an association in an unadjusted analysis (33,51,66).

Previous studies have not found a significant independent association between SSI and the stage of labour (72), whether labour had begun (5), whether labour was induced (5,68) or whether there was a failed induction (66). For example, Allen et al. did not show an increased risk of SSI in low-risk Nova Scotian women without labour compared to women with a spontaneous onset of labour (unadjusted RR 0.7; 95% CI 0.4-1.4) (73) nor women with an induction of labour compared to women with no labour when controlled for maternal age, type of anesthesia, antibiotic prophylaxis, gestational age, and infant birth weight (adjusted RR 0.89; 95% CI 0.41-1.95) (5). However, these non-significant results could be due to analyses performed in low-risk populations (5,73) or not being adjusted for potentially confounding variables such as rupture of membranes (5).

Most studies have not found rupture of membranes to be associated with SSI while adjusting for other factors (1,30,65,68,74) nor in an unadjusted analysis (11,39,40,51,54,60,63,64,66,69). For example, when adjusted for year of birth; maternal age; nulliparity; planned Caesarean section; primary Caesarean section; antibiotic prophylaxis; and the number of deliveries, vaginal deliveries and Caesarean sections performed per month, rupture of membranes (at least 12 hours at admission) was not associated with SSI despite there being an association in an unadjusted analysis (uOR 1.83; 95% CI 1.29-2.60) (62). Conversely, Gong et al. found women with premature rupture of membranes to have an increased risk of SSI when controlled for BMI, parity, pre-existing disease, number of vaginal and anal examinations, pre-existing infection,

bladder catheterization, antibiotic prophylaxis, method of anesthesia, length of hospital stay, preoperative hemoglobin, blood loss, and duration of surgery (aOR 3.73; 95% CI 1.05-13.21) (52).

2.5.4.4. Delivery

Some previous studies have not shown a significant association between indication for surgery and SSI, possibly due to small sample size (39) or the categories used being too broad (52). Conversely, Geubbels et al. subdivided indication for surgery into five strata: complications in the child, complications in the mother, complications during labour; fetal dystocia; and other (67). When adjusted for American Society of Anesthesiologists (ASA) score, postdischarge surveillance, and gestational hypertension, fetal dystocia was observed to be independently associated with SSI (aOR 3.19; 95% CI 1.11-9.14) as was complications during labour (aOR 4.16; 95% CI 1.44-12.08) when compared to complications in child (67).

While most previous studies have observed a significant association between receiving regional anesthesia and risk of SSI compared to general anesthesia (1,8,63), some do not observe an association when controlled for other variables possibly due to small sample sizes (52,63) or adjusting only for fetal birth weight and cervical dilation and not risk factors such as pre-existing conditions that may confound the association with SSI (8). Conversely, Salim et al. adjusted for place of residence, BMI, urgency of surgery, length of time in delivery ward, number of vaginal examinations, and rupture of membranes and found women who were administered general anesthesia had a higher risk of SSI than women administered regional anesthesia (aOR 2.42; 95% CI 1.01-5.83) (1).

While some previous studies examining both elective and emergency Caesarean sections have not found a significant association between receiving antibiotic prophylaxis and developing SSI, perhaps due to small sample sizes (30,31,33), a high proportion of the population receiving them (62), or antibiotics having been given preoperatively for other reasons such as premature rupture of membranes (30), others have shown a difference (16,47,48,52). For example, in a population of women who were not in labour and were only given antibiotics for prophylaxis, Dinsmoor et al. found that receiving antibiotics significantly decreased the risk of developing both endometritis (aOR 0.40; 95% CI 0.28-0.59) and SSI (aOR 0.49; 95% CI 0.28-0.86) when adjusted for anemia, BMI, diabetes, duration of surgery, gestational age, infections, previous Caesarean section, payer status, race, smoking, and study centre (16).

Only Schneid-Kofman et al. have examined whether maternal blood transfusion is associated with SSI and though they observed an association in an unadjusted analysis, it did not remain a significant risk factor when adjusted for fertility treatments, twin pregnancy, chronic hypertension, severe preeclampsia, gestational diabetes, pre-existing diabetes, premature rupture of membranes, non-reassuring fetal heart rate, and Apgar score at one minute of <7 (68). Previous studies have not shown a significant association between blood loss and the development of SSI (1,31,33,39,40,47,51,54,62,66). For example, Wloch et al. did not show an association with blood losses of 500-599 mL (uOR 1.07; 95% CI 0.86-1.34), 1000-1500 ml (uOR 1.14; 95% CI 0.75-1.73), and at least 1500 mL (uOR 0.62; 95% CI 0.27-1.45) compared to 0-499 mL of blood loss (31). The latter strata had a small sample size which may have led to its protective effect (31). These results may have also been influenced by multiple vaginal examinations and

uterine explorations to assess for retained placental fragments and removal of clots, with the subsequent administration of postpartum antibiotics to reduce the risk of intrauterine infection.

One previous study included other procedures performed during surgery (tubal ligation, abdominal hysterectomy, and repair of bladder laceration) as a potential risk factor and it was not found to be associated with SSI (39). However, the authors noted that the relationship could have been confounded by duration of surgery as most subjects with a surgery lasting longer than the mean of 1.25 hours had another procedure performed (39).

2.5.4.5. Fetal or Neonatal Factors

Only two studies have examined whether malpresentation is a risk factor for the development of SSI and neither showed a significant association (68,69). Previous studies have not found a significant association between infant birth weight and the development of SSI; however, this could be due to small numbers within the strata (8,69). Schneid-Kofman and colleagues have examined whether Apgar score at five minutes is associated with SSI in an unadjusted analysis and compared to an Apgar score of ≥7, a score of <7 was not found to be significantly associated (uOR 1.2; 95% CI 0.6-2.6) (68).

Schneid-Kofman et al. have also studied whether twin pregnancy is associated with SSI and observed that it was no longer associated with SSI when controlled for fertility treatments, pre-existing hypertension, severe preeclampsia, gestational diabetes, pre-existing diabetes, premature rupture of membranes, non-reassuring fetal heart rate, Apgar score at one minute of <7, and maternal blood transfusion (68).

Previous studies have not shown a significant association between gestational age and SSI (8,18,31,39,48,52,69). However, there is evidence from Wloch et al. that a younger gestational age (< 37 weeks) decreases the risk of SSI and a gestational age >40 weeks increases the risk (31).

2.5.5. Risk Index for Surgical Site Infections

There are several existing models for the prediction of risk for SSI following any surgery. The NNIS developed a validated risk index that combines wound class (contaminated or dirty-infected), ASA score (score of 3, 4, or 5) and the duration of surgery (above the 75th percentile of more than one hour) (35,75). The goal of the risk index is to stratify patients based on their risk for developing a SSI (76). In a NHSN report of American hospitals surveyed from 2006-2008, women undergoing Caesarean section who were in the lowest risk category had a 1.46% risk of developing SSI, women in the second lowest category had a risk of 2.43%, and women in the two highest categories had a risk of 3.82% (36).

Though the NNIS risk index can be useful to predict development of SSI after certain surgeries (67), it does not apply well to Caesarean section for several reasons (17,76). First, most Caesarean section wounds are considered clean contaminated (2). Second, most women undergoing Caesarean section are healthy (18) and therefore have a low ASA score (77). Third, the duration of surgery is fairly consistent for Caesarean section with most surgeries taking no more than one hour; this was the case in a study by Johnson and colleagues where only 4.8% of subjects had an operating time of over one hour (30). A similar result was found by Salim et al. (1). As such, most women undergoing a Caesarean section are classified in the lowest NNIS risk category. Finally,

this risk index does not include risk factors specific to Caesarean section such as parity or rupture of membranes (67).

A Caesarean section risk model should substratify the lowest risk group and include Caesarean section-specific risk factors. In addition, since this index does not involve the application of relative weights for each factor according to its relative contribution to the risk, it assumes all three risk factors contribute an equal amount to an increased risk for SSI (67) which is not necessarily the case. More research is needed to determine the risk factors that would contribute to such a model.

2.6. Contribution of the Study

Our study is the first to examine multiple risk factors for SSI following Caesarean section in Nova Scotian women and to estimate the rate of SSI in Nova Scotia following both labouring and non-labouring Caesarean sections. It is also the first to estimate the incidence of SSI within each Nova Scotian region and each Robson group.

To our knowledge, our study is the second largest study, following a study of a French surveillance network, examining multiple risk factors for SSI following Caesarean section (62). Similar to Tsai et al., we conducted a sensitivity analysis using different SSI codes (34) and did so using multiple risk factors which will add valuable information to the literature regarding how risk factors for SSI can differ depending on how SSI is defined. We examined novel risk factors such as quintile of neighbourhood-level income, SSI after previous Caesarean section, and anticoagulation therapy during pregnancy. Our study will contribute to an improved risk index as it includes risk factors that could be considered in this index.

CHAPTER 3: OBJECTIVES

Our study aimed to identify risk factors for SSI following Caesarean section. The objectives of our study were to determine among women undergoing a Caesarean section in Nova Scotia:

1. The incidence of SSI after Caesarean section to hospital discharge in the province as a whole, within each region, and within each Robson Group.
2. Risk factors associated with the development of a SSI.
3. Risk factors associated with the development of a SSI according to a more inclusive definition that included additional diagnostic and procedure codes.

We hypothesized that Nova Scotian women with risk factors for SSI following Caesarean section are more likely to develop a SSI than women without risk factors. We expected women with multiple risk factors to be at a higher risk for developing a SSI than women with fewer risk factors. Finally, we expected that using additional diagnostic and procedure codes to define SSI would result in different independent risk factors for SSI than when the primary SSI definition was used.

CHAPTER 4: METHODS

4.1. Study Design

We created a retrospective cohort of women who gave birth via Caesarean section and followed them to hospital discharge to determine if they presented with SSI. We identified risk factors for SSI and conducted a logistic regression using generalized estimating equations to determine which risk factors were independently associated with SSI.

4.2. Study Population

Our study included Nova Scotian women who delivered via Caesarean section during a 16-year period from January 1, 1997 to December 31, 2012. Women were excluded from the study if they delivered a baby that weighed <500 g or was <20 weeks gestational age.

4.3. Sample Size

We estimated a total of 34,000 Caesarean sections over the study period. In 2011, 8,860 births occurred in Nova Scotia with 26.6% via Caesarean section (78). Based on this, we conservatively estimated a Caesarean section rate of 25% and 8,500 births per year for our study period. We used the low-risk SSI rate of 1.46% from a large, multicenter NHSN study as an estimate of risk (30). We estimated the smallest odds ratio that we could detect (Objective 2) for risk factors with low, moderate, and high prevalence (5%, 25%, and 50%, respectively). With a power of 80% and a statistical significance of 5%, we estimated we would have enough power to detect odds ratios of 1.70, 1.32, and 1.30 or greater for risk factors with low, moderate, and high prevalence, respectively.

4.4. Ethics

The database used in this study is an ongoing perinatal database. Since these data are collected for healthcare and planning purposes rather than research purposes, it was necessary to obtain ethical approval. As per the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*, we did not require consent from each individual in the study because our large sample size made it impracticable to do so and our study posed minimal risk to participants (79).

The main risk to study participants was inadvertent identification and therefore steps were taken to ensure the privacy of data. The dataset did not include information such as names of participants, dates of birth and dates of delivery. The age of study participants at time of delivery was rounded to one decimal place and year, month, and day of week of delivery were provided instead of the exact day of delivery. Infant birth weight was rounded to 100 g. Only the study researchers had access to the dataset and electronic documents pertaining to the study. They were kept in a folder on the Izaak Walton Killam Health Centre server and accessible only to the research team who accessed the folder from password-protected computers. Before any data were printed, they were checked to ensure there were no small cell sizes (< 5 observations). Printouts were kept in a locked room.

Study approval was required and obtained from RCP's Joint Data Access Committee on April 21, 2015 (approval number: JDAC 71). Ethical approval was required from Izaak Walton Killam Health Centre's Research Ethics Board and given on May 11, 2015 (approval number: 1019575).

4.5. Nova Scotia Atlee Perinatal Database

The NSAPD is managed by the RCP whose mandate with the Nova Scotia Department of Health and Wellness concerns perinatal surveillance across the province of Nova Scotia. The purpose of this database is to improve reproductive health outcomes across Nova Scotia.

The NSAPD has documented every delivery in Nova Scotia hospitals since 1988 that resulted in an infant weighing over 500 g or was at least 20 weeks' gestational age. This database contains relevant maternal demographic and pregnancy information as well as maternal and perinatal diagnoses and procedures at the time of admission and during and after labour and delivery. This information is collected through the use of standardized provincial prenatal and hospital forms that are completed by healthcare professionals and chart documentation from inpatient admissions (71,80). Data are periodically checked for accuracy and the database has shown to be reliable (80).

Our cohort was identified from the NSAPD and contained all women meeting the eligibility criteria from January 1, 1997 to December 31, 2012. Following a literature search to determine which factors are known to increase the risk for SSI and which still need to be explored, the NSAPD was examined to determine which variables would be suitable clinical risk factors for SSI (see Appendix 2 for code list). The NSAPD has its own diagnostic and procedure codes which we used to capture risk factors and the outcome of SSI. From 2003 onward, ICD-10-CA diagnostic (Canadian enhancement of ICD-10) and CCI procedure codes were available through the NSAPD. Therefore, from 2003-2012 we used all three types of codes, all of which we obtained directly from the NSAPD.

4.6. Outcomes

The overall objective of our study was to determine risk factors for SSI following Caesarean section. Since our dataset only followed women to hospital discharge rather than to 30 days postdischarge, there are women who present with SSI following discharge that are not captured in our study. We used both a more specific, restrictive SSI definition and a more sensitive, inclusive definition.

The main outcome of our study was a specific, restrictive definition for SSI (Table 2). Women were coded as having a SSI if they were diagnosed with an infection of an obstetrical wound, endometritis, or inflammation of the uterus. These diagnostic codes included both NSAPD (before 2003) and ICD-10-CA codes (2003 and later). They were used as the primary SSI definition as they are diagnoses thought to define SSIs quite specifically.

We also conducted a sub-analysis using a more sensitive, inclusive SSI definition (Table 2) for 2003-2012. This more inclusive SSI definition included the primary definition as well as additional diagnostic codes and procedure codes (most only available in the NSAPD after 2003) that are indicative of a possible SSI or SSI-related complications. These codes include disruption of the wound, sepsis and puerperal infection, hematoma and drainage of hematoma, hemorrhage, inflammation of pelvic/abdominal organs, drainage of uterus, drainage of skin, drainage of abdomen, excision and debridement, and aspiration and curettage. This SSI definition closely corresponds to and is supported by the definition used in an Ontario validation study which used hospital, physician, and emergency room administrative databases to

determine SSI rates (42). Table 2 and Appendix 2 outline the specific codes used to define the primary and more inclusive SSI definitions.

4.7. Explanatory Variables

4.7.1. Potential Institution-Related Risk Factors

Potential institution-related risk factors were the number of Caesarean sections in the year at the institution where the delivery took place. This potential risk factor was categorized into quartiles at <130, 130-949, 950-1249, and ≥1250.

4.7.2. Potential Patient-Related Risk Factors

We grouped patient-related risk factors into the categories of area-level, maternal demographics, maternal lifestyle factors, and maternal medical conditions.

4.7.2.1. Area-Level

Area-level risk factors that were considered included region of maternal residence, rural residence, and quintile of neighbourhood-level income.

Region of maternal residence was a coded variable representing the four regions of Nova Scotia: western, eastern, northern, and southern. This variable was coded in order to preserve the anonymity of hospitals and surgeons, especially those in smaller regions where inadvertent identification is more likely than in larger regions. Rural residence was a dichotomous variable (urban, rural). Women were determined as living in a rural area if there was a '0' for the second digit of their residential postal code; all others were categorized as living in an urban area. We used Statistics Canada's quintile of neighbourhood-level income as a proxy for socioeconomic status. This variable represents the median pre-tax household income of each census metropolitan, census agglomeration, or rural area divided into quintiles (81).

4.7.2.2. Maternal Demographics

Maternal demographics considered as potential risk factors were age at delivery, marital status, and pre-pregnancy weight.

Some studies have set 20-years-old and 45-years-old as the cut-offs for younger and older age, respectively (31,32); however, this would have resulted in small sample sizes for those strata. As such, age at delivery was categorized as younger age (<25 years), intermediate age (25-34 years), and older age (≥35 years). Marital status was dichotomized as married/common-law or single/divorced/separated/widowed and was used as a proxy for social support.

Pre-pregnancy weight was categorized to approximate standard BMI categories from cut points previously determined using Receiver Operating Characteristics curves. This was done as height was only available from 2003 onwards and therefore we were unable to determine BMI. Pre-pregnancy weight was categorized as underweight (<53 kg), normal weight (53-66.9 kg), overweight (67-76.9 kg), obese class I (77-86.9 kg), obese class II (87-97.9 kg), obese class III (≥98 kg), and missing. For comparison purposes, we ran the final models for 2003-2012 using pre-pregnancy BMI, calculated as pre-pregnancy weight (kg) divided by height (m^2). For this variable, we used the standard BMI categories of underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), obese class I (30.0-34.9 kg/m^2), obese class II (35.0-39.9 kg/m^2), and obese class III (≥40.0 kg/m^2). We did not examine delivery weight but rather investigated weight gain during pregnancy (described later).

4.7.2.3. Maternal Lifestyle Factors

Maternal lifestyle factors were smoking and alcohol or drug abuse during pregnancy.

Smoking can be recorded at the first prenatal visit, 20 weeks, or delivery. If any of these smoking variables were coded as a 'yes', women were included in the 'smoking' category. Like smoking, alcohol or drug abuse during pregnancy was dichotomized as no, yes.

4.7.2.4. Maternal Medical Conditions

Maternal medical conditions were hypertension, diabetes, depression during pregnancy, other non-obstetric pre-existing health conditions affecting pregnancy, anemia during pregnancy, absence of influenza immunization, and anticoagulation therapy during pregnancy.

Hypertension was categorized as no hypertension, pre-existing, gestational, preeclampsia, and unspecified. Diabetes was categorized as no diabetes, pre-existing (type I or type II), and gestational. Non-obstetrical pre-existing health conditions affecting pregnancy was dichotomized (no, yes) and included gastrointestinal, psychiatric, neurological, heart, endocrine, renal, and pulmonary conditions as well as neoplasms and blood dyscrasias. Anemia, anticoagulation, and depression during pregnancy were dichotomized (no, yes) as was influenza immunization (yes, no).

4.7.3. Potential Obstetric-Related Risk Factors

We grouped potential obstetric-related risk factors into the categories of pregnancy history, pregnancy characteristics, labour, delivery, and fetal or neonatal factors.

4.7.3.1. Pregnancy History

Pregnancy history factors included parity, mode of delivery of last pregnancy, number of previous Caesarean sections, and SSI after previous Caesarean section.

Parity was dichotomized as primiparous or multiparous. Mode of delivery of last pregnancy was categorized as not applicable (if there were no previous pregnancies) or unknown, vaginal, or Caesarean section. Number of previous Caesarean sections was categorized as 0, 1, or 2+. SSI after previous Caesarean section was dichotomous (no, yes) and only captured SSIs that presented before discharge or upon readmission.

4.7.3.2. Pregnancy Characteristics

Pregnancy characteristics were chorioamnionitis during pregnancy, diagnostic and/or therapeutic procedure(s) performed on mother, weight gain during pregnancy, and steroid use ≥48 hours before delivery for fetal lung maturity.

Chorioamnionitis during pregnancy, maternal diagnostic and/or therapeutic procedures (at least one of forceps; manual or vacuum rotation; removal or insertion of device; and external or internal version) and steroid use ≥48 hours before delivery for fetal lung maturity were dichotomized (no, yes). Weight gain during pregnancy was categorized as <10 kg, 10-29.9 kg, ≥30 kg and missing.

4.7.3.3. Labour

Labour characteristics were the extent of cervical dilation at the last examination before Caesarean section, hours from onset of rupture of membranes to delivery, stage of labour before Caesarean section, and type of rupture of membranes.

Cervical dilation was categorized as no dilation, 1-3 cm, and 4-10 cm. Stage of labour before Caesarean section was categorized as no labour, first stage, and second

stage. Hours from onset of rupture of membranes to delivery of the last baby was categorized as ≤1 hour before delivery, 2-11 hours before delivery, and at least 12 hours before delivery. Type of rupture of membranes was dichotomized (artificial, spontaneous).

4.7.3.4. Delivery

Delivery characteristics were length of antepartum stay, year of delivery, month of delivery, day of week of delivery, primary indication for Caesarean section, mode of Caesarean section, use of instrumentation at time of Caesarean section, general anesthesia during labour and/or delivery, regional anesthesia during labour and/or delivery, absence of antibiotic prophylaxis, maternal blood transfusion, and other procedures performed during Caesarean section.

Length of antepartum stay was categorized as <24 hours, 24 to 49 hours, and ≥50 hours. Year of delivery was categorized into groups of four years each: 1997-2000, 2001-2004, 2005-2008, and 2009-2012. Month of delivery was categorized into seasons: summer (June, July, August), autumn (September, October, November), winter (December, January, February), and spring (March, April, May). Day of week of delivery was collapsed by weekday and weekend.

The primary indication for Caesarean section was categorized as breech, dystocia, fetal distress, previous Caesarean section, and other (advanced maternal age, abruption placenta, diseases of the cervix, diabetes, fetal growth restriction, failed induction, human immunodeficiency virus, herpes simplex infection, hypertension, isoimmunisation, maternal choice, malpresentation, multiple pregnancy, prolapsed cord, placenta previa, prolonged rupture of membranes, suspected fetal anomaly, suspected or imminent uterine

rupture, transverse lie, previous uterine surgery, other fetal conditions, and other obstetrical conditions) as per Feldman et al. (80). Mode of Caesarean section was categorized as low segment transverse Caesarean section or other type of Caesarean section. Use of instrumentation at time of Caesarean section (forceps or vacuum) was dichotomized (no instrumentation, instrumentation). Regional anesthesia and general anesthesia during labour and/or delivery were both dichotomized (no, yes).

We dichotomized absence of antibiotic prophylaxis (yes, no). Starting in 2010, the NSAPD used a code specifically for Group B Streptococcus (GBS) antibiotics which are only given to women who have screened positive for GBS. For all analyses we combined GBS and non-GBS antibiotic prophylaxis into a single variable. Maternal blood transfusion and other procedures performed during Caesarean section (excision of uterus, ovaries, or fallopian tubes; occlusion of fallopian tubes; and repair of obstetrical lacerations) were dichotomized as no, yes.

4.7.3.5. Fetal or Neonatal Factors

Fetal or neonatal factors were presentation at delivery, infant birth weight, Apgar score at five minutes, number of fetuses, gestational age, breastfeeding at discharge, and diagnostic and/or therapeutic procedure(s) performed on fetus.

Presentation at delivery was categorized as vertex, other (brow, compound, face, frank breech, footling breech, occiput posterior, shoulder presentation, transverse lie, and breech/other/unspecified), and missing. We dichotomized number of fetuses (singleton, multiples) and breastfeeding at discharge (yes, no). Diagnostic and/or therapeutic procedure(s) performed on fetus (at least one of amniocentesis, amnioreduction, amnioninfusion, chorionic villus sampling, cordocentesis, fetal blood transfusion, fetal

drainage, fetal reduction, feto/placental laser, and placement of a fetal stent) was dichotomized as no, yes.

Infant birth weight was rounded to the nearest 100 g in our dataset and categorized as <2,500 g, 2,500-3,900 g and ≥4,000 g. Apgar score at five minutes, a measure of an infant's health five minutes after birth, was measured as a categorical variable as 0-6 and 7-10 where a lower score indicates a lower state of health. The best overall estimate of gestational age was used to determine gestational age. This variable is based on the last menstrual period unless there was an ultrasound that suggested a discrepancy of more than seven days. If there was neither an estimate from the last menstrual period nor from an ultrasound, the clinical estimate of gestational age was used. Gestational age was measured as a categorical variable (<37 weeks, 37-39.9 weeks, 40-42 weeks).

4.8. Analysis

All analyses were conducted using STATA SE 14 (StataCorp LP, College Station, Texas) with a statistical significance set at $p<0.05$. Explanatory variables were exposures and risk factors for SSI. Referent categories were the standard referent category used (such as an approximation of normal weight for pre-pregnancy weight), the lowest category for ordinal variables and the category with the highest frequency for nominal variables. All continuous variables were categorized as ordinal variables.

4.8.1. Outcome Variable

The dependent variable used in all analyses was SSI (no, yes).

4.8.2. Data Management

All variables were tabulated to determine their prevalence in the study population, the proportion of missing values, and, for continuous variables, whether there were any outliers. We did not analyse meconium aspiration, placenta previa, procedures for postpartum hemorrhage, maternal steroid use <48 hours before delivery for fetal lung maturity, or manual removal of placenta as these variables had a very low prevalence in the study population and their use could lead to inadvertent identification of these individuals and factors. We did not analyse number of hours from labour to rupture of membranes, number of hours from labour to full cervical dilation, or number of hours from full cervical dilation to delivery as these variables were only applicable to no more than half the population since not all women had labour, membrane rupture, and/or cervical dilation. We did not include the potential risk factor 'mode of Caesarean section in last pregnancy' due to a low prevalence of Caesarean section types other than low transverse. We did not analyse driving time to hospital due to a high proportion of missing values which were significant with the outcome despite the non-missing values not being significant. ASA class, secondary indication for Caesarean section, amount of blood loss, time from administration of antibiotic prophylaxis to delivery to the labour-delivery room and time from administration of antibiotic prophylaxis to delivery were not analysed due to being infrequently coded in the NSAPD during some years of the study period and therefore being coded as missing in the dataset.

Infant birth weight was used rather than infant weight for age as the former had fewer missing values. Stage of labour was used instead of hours from onset of labour to delivery as hours from onset of labour to delivery is a variable that overlaps with hours

from rupture of membranes to delivery. In addition, there was a small discrepancy between the proportion of women without labour between this variable and stage of labour.

Length of postpartum stay was not analysed since women with a longer hospital stay are more likely to have a SSI and to have a SSI diagnosed due to being under a physician's care for a longer time than those women who were discharged sooner, thereby confounding the association with SSI. Attendance in prenatal classes for first pregnancy was not analysed due to being collinear with parity and indication for Caesarean section. Number of births per hospital per year was not analysed due to collinearity with number of Caesarean sections per hospital per year. Due to the low prevalence of some Robson groups, groups 6, 7, and 9 were combined as a group comprised of singletons not in cephalic position (Table 1). For the same reason, we were unable to use the modified Robson criteria and subdivide by labour type. For multiple gestations, we only kept the data for the first baby delivered.

Any women with a postal code for which Statistics Canada does not include a quintile of neighbourhood-level income were recoded from '9' to missing. For pre-pregnancy BMI, used for comparison purposes during 2003-2012, we combined underweight and normal weight due to a low prevalence of the former. Women coded as taking antihypertensives but without a hypertension code were categorized as having unspecified hypertension. Due to a low prevalence of pre-existing and unspecified hypertension in 2003-2012, these levels were combined in the analyses for those years. Women coded as taking insulin but who were not coded as having diabetes and women with an unspecified type of diabetes were assumed to have gestational diabetes since

most women with gestational diabetes take insulin and unspecified diabetes is more likely to be gestational than pre-existing. Pre-existing type 1 and type 2 diabetes were collapsed into a single category due to a low prevalence of each. Depression during pregnancy was coded as a yes if there was a diagnostic code for depression and/or a code for having been on antidepressants during pregnancy.

Number of previous Caesarean sections was based on what was recorded on the patient's chart, which included Caesarean sections in non-Nova Scotian hospitals. In some cases, the number of previous Caesarean sections was missing from the chart and so the number of previous Caesarean sections recorded in the NSAPD was used. Weight gain during pregnancy was calculated by subtracting pre-pregnancy weight from delivery weight. Steroid use ≥48 hours before delivery for fetal lung maturity included women with an unknown time of steroid administration.

Due to a low prevalence, suspected rupture of membranes was combined with spontaneous rupture of membranes. For mode of Caesarean section, 'other' included abdominal, combined transverse and vertical incision, hysterectomy, classical/vertical incision, low vertical incision, and unknown type as most Caesarean sections were low transverse. Women with an attempted vaginal birth with instrumentation followed by a Caesarean section without instrumentation were coded as having had instrumentation.

Regional anesthesia included epidural, spinal, double needle, pudendal, or any other type of regional anesthetic. Maternal blood transfusion was a composite of NSAPD and CCI codes. We chose not to include the number of procedures performed due to a low prevalence of more than one procedure performed.

4.8.2.1. Outliers

Summary statistics and box plots were used to determine if there were any outliers. Negative values observed for variables in which negative values did not make logical sense (e.g. length of antepartum stay) were assumed to be outliers. A gestational age of <20 weeks and >42 weeks and an antepartum length of stay of >3,000 hours were also assumed to be outliers. All values determined to be outliers were changed to missing values so that they would not skew any potential association with the outcome.

4.8.2.2. Missing Values

A missing category was created for variables with ≥ 5% of observations missing. Since we had a large sample size, all other missing values for variables with <5% missing observations remained as missing. Therefore, multiple regressions were conducted as complete case analyses.

4.8.2.3. Continuous Variables

Lowess plots, which graph the smoothed mean of the independent and dependent variables, were used to graph the association between continuous variables and SSI to determine if it was appropriate to keep them as continuous. All continuous variables had irregularly shaped associations with SSI such as J-shaped curves and therefore were categorized using standard cut points or where it made logical sense based on their association with SSI or the quartiles of each variable.

4.8.3. Objective 1

Prevalence is the number of cases of disease within the study population at a certain point in time whereas incidence is the number of new cases of disease within the study population over a specific period of time. Since our study considered the

development of SSI in the period between delivery and hospital discharge, we used the term incidence. Descriptive statistics were used to estimate the incidence by region of maternal residence, year of delivery, and Robson Group according to each SSI definition.

4.8.4. Objective 2

The incidence of SSI by each risk factor was determined using frequencies. All variables were categorical and described using frequency and percentage. Univariate and multivariable analysis were used to determine risk factors for SSI. Chi-square or Fisher's exact test were conducted to determine which risk factors were significantly associated with SSI in a univariate analysis. Risk factors that were significant or approaching significance in the univariate analysis with $p<0.10$ were selected for inclusion in a logistic regression to determine which were independent risk factors. We used generalized estimating equations to account for potential correlation among repeated Caesarean sections to the same woman.

The final model was a complete case analysis determined using backward stepwise selection where the variable with the largest p-value was removed from the model at each step. Variables were not removed if any of their strata had a $p<0.05$ for its association with the odds of SSI. Variables were removed from the model until all remaining variables had at least one stratum with $p<0.05$. Eliminated variables were added back into this final model one at a time to determine if they should be included in the final model. Any variables that had at least one stratum with $p<0.05$ upon being reintroduced to the final model remained in it.

Since information contained in the NSAPD became more specific in 2003, two analyses were conducted. The main analysis was for 1997-2012 and included all

variables that were available during all years. We also conducted an analysis for 2003-2012 which included risk factors independently associated with SSI in the main analysis. For comparison purposes, we ran the 2003-2012 model using BMI instead of pre-pregnancy weight to determine the results with our pre-pregnancy weight categories approximated those observed with BMI.

4.8.5. Objective 3

We analysed risk factors independently associated with the more inclusive SSI definition. A preliminary analysis calculated the percentage of women with additional diagnostic codes who were diagnosed with SSI according to the primary SSI definition in order to determine which of these variables were most indicative of a possible SSI. We were unable to do this analysis using inflammation of other pelvic/abdominal organs and procedure codes due to a low prevalence of these in our sample. A multivariable analysis was conducted using the more inclusive definition of SSI for 2003-2012 in the same manner as in Objective 2. We did not conduct analyses on the more inclusive SSI definition for 1997-2012 as more procedure codes were only available from 2003 onward.

4.9. Tables

Table 1: Robson Group characteristics

Robson Group	Characteristics
1	Nulliparous Singleton Cephalic pregnancy ≥ 37 weeks gestational age Spontaneous labour
2	Nulliparous Singleton Cephalic pregnancy ≥ 37 weeks gestational age Induced labour or Caesarean section with no labour
3	Multiparous No previous Caesarean section Singleton Cephalic pregnancy ≥ 37 weeks gestational age Spontaneous labour
4	Multiparous No previous Caesarean section Singleton Cephalic pregnancy ≥ 37 weeks gestational age Induced labour or Caesarean section
5	Multiparous Previous Caesarean section(s) Singleton Cephalic pregnancy ≥ 37 weeks gestational age
6, 7, 9	Singleton Non-cephalic pregnancy
8	Multiples With or without previous Caesarean section(s)
10	Singleton Cephalic pregnancy ≤36 weeks gestational age With or without previous Caesarean section(s)
11	Unknown Robson Group

Note: adapted from Robson, 2001

Table 2: Definitions used for primary and more inclusive SSI outcome variables

Surgical site infection variable	Definition
Primary	• Wound infection (NSAPD) • Endometritis (NSAPD) • Acute inflammatory disease of uterus (ICD-10-CA) • Inflammatory disease of the uterus NOS (ICD-10-CA) • Infection of obstetrical surgical wound (ICD-10-CA)
More inclusive	• Any of the above, plus: • Extended diagnostic codes o Disruption of Caesarean section wound (ICD-10-CA) and wound dehiscence (NSAPD) o Puerperal infection; sepsis (NSAPD and ICD-10-CA) o Hematoma (NSAPD) including haemorrhage (ICD-10-CA) o Inflammation of other pelvic/abdominal organs (ICD-10-CA) including peritonitis (NSAPD) • Extended procedure codes o Drainage of hematoma (ICD-10-CA) and evacuation of hematoma (NSAPD) o Drainage of uterus (ICD-10-CA) o Skin drainage (ICD-10-CA) o Abdominal drainage (ICD-10-CA) o Excision and debridement (ICD-10-CA) o Aspiration and curettage (ICD-10-CA)

See Appendix 2 for specific codes within each category

CHAPTER 5: RESULTS

5.1. Objective 1: Incidence of SSI

5.1.1. Primary SSI Definition

5.1.1.1. Incidence of SSI within Nova Scotia

Over the 16-year study period, 26,293 women had 35,586 Caesarean sections in Nova Scotia. Of these women, 396 (1.11%) presented with a SSI according to the primary definition. Figure 1 and Table 3 compare the SSI rates among the four regions of Nova Scotia. Region A of maternal residence accounted for 16,773 Caesarean sections (47.13%) with a SSI rate of 1.08% over the study period. Region B of maternal residence had the highest SSI rate at 1.69% (95% CI 1.37-2.00) and Region D of maternal residence had the lowest at 0.76% (95% CI 0.54-0.98).

5.1.1.2. SSI Rate by Year

The number of Caesarean sections generally increased from 1997-2008 with 2,420 Caesarean sections in 2008 (6.8% of the sample). From 2008 to 2012, the number of Caesarean sections performed each year began to decrease. Conversely, the SSI rate decreased over time. Figure 2 and Table 4 show the proportion of SSIs that occurred each year. The year 2000 had the highest rate of SSI at 2.70% (95% CI 1.99-3.40). The year 2011 had the lowest rate of SSI at 0.30% (95% CI 0.08-0.52).

5.1.1.3. SSI Rate by Robson group

Figure 3 and Table 5 outline the proportion of Caesarean sections and the SSI rate within each Robson group. Robson Group 5 (multiparous women having a repeat Caesarean section delivering a singleton at term in cephalic position) had the highest number of Caesarean sections and one of the lowest rates of SSI at 0.91% (95% CI 0.73-

1.10). Multiparous women without a previous Caesarean section delivering a singleton in cephalic position at term (Group 3) had the lowest number of Caesarean sections (884) and the lowest SSI rate at 0.79% (95% CI 0.21-1.38). There were 5,505 Caesarean sections that were classified as singletons in a non-cephalic position (Groups 6, 7, and 9); this group had a SSI rate of 0.80% (95% CI 0.56-1.03). Only 1,224 (3.4%) Caesarean sections were classified as Group 8 (multiples); however, this group had the highest rate of SSI of 2.37% (95% CI 1.52-3.22).

5.1.2. More Inclusive SSI Definition

5.1.2.1. Incidence of SSI within Nova Scotia

We combined additional diagnostic and procedure codes with the primary SSI definition to create a SSI definition that is more inclusive and more sensitive than the primary SSI definition. When the more inclusive definition of SSI was used, the number of women with a SSI increased from 396 (1.11%) to 865 (2.43%). Figure 4 and Table 6 compare the SSI rate according to this inclusive definition between the four regions of Nova Scotia. The region of maternal residence with the highest SSI rate was Region B at 3.03% (95% CI 2.61-3.46). Region C had the lowest rate of SSI at 1.75% (95% CI 1.43-2.06).

5.1.2.2. SSI Rate by Year

Figure 5 and Table 7 show the proportion of SSIs that occurred each year according to the more inclusive definition. The year 1997 had the highest SSI rate at 4.24% (95% CI 3.33-5.15) and the year 2011 had the lowest SSI rate at 1.21% (95% CI 0.76-1.65).

5.1.2.3. SSI Rate by Robson Group

Figure 6 and Table 8 show the SSI rate in each Robson Group according to the more inclusive definition. Women who delivered singletons in positions other than cephalic (Groups 6, 7, and 9) had the lowest SSI rate of 1.87% (95% CI 1.51-2.23). Women with multiple gestations (Group 8) had the highest SSI rate at 4.58% (95% CI 3.40-5.75).

5.2. Objective 2: Risk Factors for SSI (Primary Definition)

5.2.1. Description of Cohort

Among the population in which we determined potential risk factors for SSI, there were 26,293 Nova Scotian women who had 35,586 Caesarean sections in Nova Scotia hospitals from January 1, 1997 to December 31, 2012. Tables 9-18 show the characteristics of the sample. Nearly half of the women (47.1%) were from Region A. Over three-fifths (61.5%) were between the ages of 25-34 years old. Nearly one-third (29.40) of women had a pre-pregnancy weight between 53-66.9 kg. Most women (76.7%) were married or in a common-law relationship.

Nearly one-fifth (19.9%) of women had a non-obstetric pre-existing health condition affecting pregnancy. The most prevalent types of hypertension and diabetes were gestational rather than pre-existing. Approximately half the sample was primiparous (49.6%) and 22,483 (63.2%) had no previous Caesarean section. Most women (55.3%) gained between 10-29.9 kg during pregnancy.

Approximately half the sample did not have a dilated cervix during the last examination before Caesarean section and nearly half were not in labour. Most membrane ruptures were artificial (72.1%) and occurred less than one hour before delivery (50.1%). Most women (83.5%) had an antepartum stay that was less than 24

hours. The most common indications for Caesarean section were previous Caesarean section (29.2%) and dystocia (26.1%).

Over the entire study period, 22,415 (63.0%) women received antibiotic prophylaxis. From 1997-2000, only 46.7% received antibiotic prophylaxis and this increased to 73.4% in the era 2009-2012. Almost three-quarters of neonates had a birth weight between 2500-3900 g. Over half of neonates (57.8%) had a gestational age between 37 and 40 weeks.

5.2.2. 1997-2012

5.2.2.1. Univariate Analysis

We performed a univariate analysis to estimate unadjusted odds ratios for the associations between potential risk factors for SSI during the years 1997-2012 (Tables 9-18). Twenty-four risk factors were significantly associated with presenting with SSI according to the primary definition.

Delivering in a hospital with 130-1,249 Caesarean sections per year; Region B of maternal residence; the lowest quintile of neighbourhood-level income; pre-pregnancy weight of at least 87 kg; being single, divorced, separated, or widowed; non-obstetrical pre-existing health conditions affecting pregnancy; gestational, preeclampsia, and unspecified hypertension; pre-existing and gestational diabetes; anticoagulation therapy during pregnancy; weight gain of at least 30 kg during pregnancy; chorioamnionitis during pregnancy; steroid use at least 48 hours before delivery for fetal lung maturity; a cervical dilation of at least 4 cm at the last examination before Caesarean section; at least 12 hours from rupture of membranes to delivery; being in labour before Caesarean section; an antepartum stay of at least 24 hours; year of delivery; a primary indication for

Caesarean of dystocia; absence of antibiotic prophylaxis; maternal blood transfusion; infant birth weight of less than 2,500 g; Apgar score at five minutes of 0-6; multiples; gestational age of less than 37 weeks; and no breastfeeding at discharge significantly increased the risk of SSI without controlling for other factors. Other procedures performed during Caesarean section was observed to decrease the risk for SSI when unadjusted for other factors.

5.2.2.2. Multivariable Analysis

Table 19 shows the factors associated with SSI using the primary SSI definition when adjusted for all other factors in the model. The final model included 25,339 women who had 33,813 Caesarean sections. There were fifteen independent risk factors for SSI. Delivering in a hospital with ≥130 Caesarean sections per year significantly increased the risk of SSI relative to delivering in a hospital with <130 Caesarean sections per year when controlled for other factors. As the number of Caesarean sections per hospital per year increased, the strength of the association with SSI decreased.

Women who weighed ≥87 kg had a significantly increased risk for SSI compared to women who weighed 53-66.9 kg. A pre-pregnancy weight of <53 kg or 67-76.9 kg did not increase the risk for SSI compared to weights of 53-66.9 kg. Though it had a weak association which just made significance, being single, divorced, separated or widowed had a higher risk for SSI than being married or in a common-law relationship.

Women with non-obstetrical pre-existing health conditions affecting pregnancy had a significantly higher risk of SSI than women without non-obstetrical pre-existing health conditions affecting pregnancy. An unspecified type of hypertension (either gestational, preeclampsia, or pre-existing) was strongly associated with SSI and

significantly increased the risk for SSI compared to no hypertension. Both gestational and pre-existing diabetes showed an increased risk for SSI compared to no diabetes with pre-existing diabetes having a stronger association with SSI than gestational diabetes.

Anticoagulation therapy and chorioamnionitis during pregnancy both significantly increased the risk for SSI. A weight gain of ≥30 kg during pregnancy significantly increased the risk for SSI compared to a weight gain of 10-29.9 kg. Steroid use ≥48 hours before delivery for fetal lung maturity was shown to be a significant risk factor for SSI compared to not taking steroids ≥48 hours before delivery.

Women who were in the second stage of labour before Caesarean section had a significantly higher risk of SSI compared to women not in labour. Relative to delivering during the years 2009-2012, women who delivered between the years 1997-2008 had a significantly higher risk of SSI. The farther back during the study period, the stronger the association with SSI with the years 1997-2000 having the strongest association. Women who were administered antibiotic prophylaxis had a significantly lower risk of SSI than women who did not receive antibiotic prophylaxis. Maternal blood transfusion was shown to increase the risk of SSI compared to not having a blood transfusion. Women who delivered multiples had a significantly higher risk of SSI than women who delivered singletons.

5.2.3. 2003-2012

All risk factors that were independently associated with SSI in the 1997-2012 analysis were included in a multivariable analysis for 2003-2012 to determine if they were associated with SSI when adjusted for other factors. The final model (Table 20)

included 18,221 women who had 23,334 Caesarean sections. There were eight independent risk factors for SSI using the primary definition for 2003-2012.

The number of Caesarean sections per hospital per year had a stronger association with SSI than in the main analysis. Similar to the main analysis, a pre-pregnancy weight of ≥87 kg was associated with SSI. We observed a stronger association in the 2003-2012 analysis than in the main analysis. When we used pre-pregnancy BMI in the model instead of pre-pregnancy weight, obese class I, II and III were independent risk factors for SSI whereas when we used pre-pregnancy weight, only weights of ≥87 kg (approximately obese classes II and III) were associated. For the obese classes, the strength of the association with SSI was higher when BMI was used, particularly for obese class III, than when pre-pregnancy weight was used. Other factors included in the final model had a similar association with SSI when BMI was used.

Women with at least one non-obstetric pre-existing health condition affecting pregnancy had a significantly higher risk of SSI. This factor was more strongly associated with SSI in the 2003-2012 analysis than the main analysis. Gestational hypertension and preeclampsia were not associated with SSI in the main analysis though they were in the 2003-2012 analysis. Anticoagulation therapy during pregnancy had a considerably stronger association with SSI in the 2003-2012 analysis.

We observed a weight gain during pregnancy of ≥30 kg to be associated with SSI but with a weaker association than in the main analysis. Chorioamnionitis during pregnancy had a considerably stronger association with SSI than in the 1997-2012 analysis. Year of delivery had a similar association with SSI in both analyses. Unlike in the main analysis, marital status, diabetes, steroid use ≥48 hours before delivery for fetal

lung maturity, stage of labour before Caesarean section, antibiotic prophylaxis, maternal blood transfusion, and number of fetuses were not observed to be associated with SSI.

5.3. Objective 3: Risk Factors for SSI (More Inclusive Definition)

Tables 21-23 show the relationship between SSI according to the primary definition and women diagnosed with the additional diagnosis included in the more inclusive definition: disruption of Caesarean section wound, sepsis or puerperal infection, and hematoma or hemorrhage. Of the women with disruption of Caesarean section wound, 13.4% also had a SSI according to the primary definition. There were 8.8% of women with hematoma or hemorrhage of obstetric wound who also had SSI according to the primary definition. Over one-third (33.8%) of women with sepsis or puerperal infection also had SSI according to the primary definition.

5.3.1. Multivariable Analysis

Table 24 shows the final adjusted model for the 2003-2012 analysis examining risk factors for SSI using the more inclusive definition. The final model included 18,221 women who had 23,334 Caesarean sections. There were nine independent risk factors for SSI when we used the more inclusive SSI definition.

Delivering in a hospital with ≥ 130 Caesarean sections per hospital per year was associated with SSI but had a weaker association than in the 2003-2012 analysis using the primary SSI definition. A pre-pregnancy weight of ≥98 kg (approximately obese class III) was associated with SSI with a weaker association than in the 2003-2012 analysis using the primary SSI definition. When we ran the model using pre-pregnancy BMI as a comparison for pre-pregnancy weight, obese class I and III were both associated with SSI. The strength of the association with SSI was similar for all categories of BMI and

pre-pregnancy weight except for obese class II (approximated at 87-97.9 kg) in which pre-pregnancy weight had a stronger association. Other factors included in the final model had a similar association with SSI when BMI was used. Other procedures performed during Caesarean section was not associated with SSI when pre-pregnancy weight was used; however, it was observed to be weakly associated when we used BMI.

Pre-existing or unspecified hypertension, gestational hypertension, and preeclampsia were all associated with SSI with weaker associations than in the 2003-2012 analysis using the primary definition. Both anticoagulation therapy and chorioamnionitis during pregnancy were associated with SSI but had weaker associations than when the primary SSI definition was used.

Women who had anemia during pregnancy, one previous Caesarean section, a blood transfusion, and multiples had an increased risk of SSI. This was not observed in the 2003-2012 analysis using the primary SSI definition. Though non-obstetric pre-existing health conditions affecting pregnancy, weight gain during pregnancy, and year of delivery were associated with SSI in the 2003-2012 analysis using the primary definition, they were not associated with the more inclusive SSI definition.

5.4. Figures

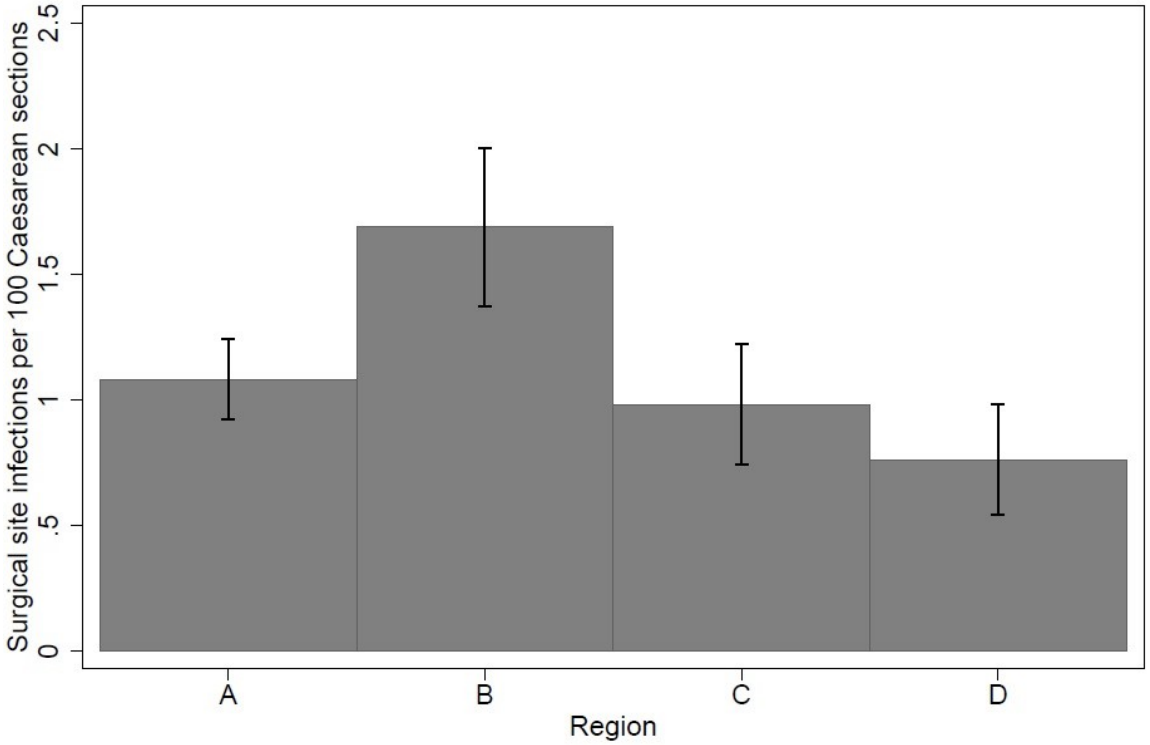

Figure 1: Rate of surgical site infection (primary definition) among women undergoing Caesarean section, by region, Nova Scotia, 1997-2012

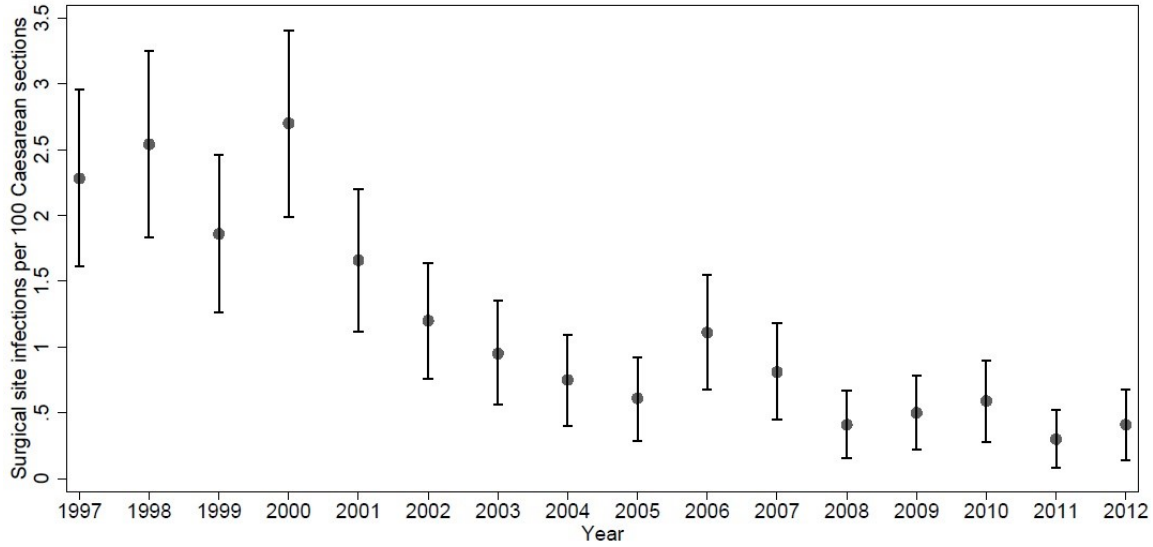

Figure 2: Rate of surgical site infection (primary definition) among women undergoing Caesarean section, by year, Nova Scotia, 1997-2012

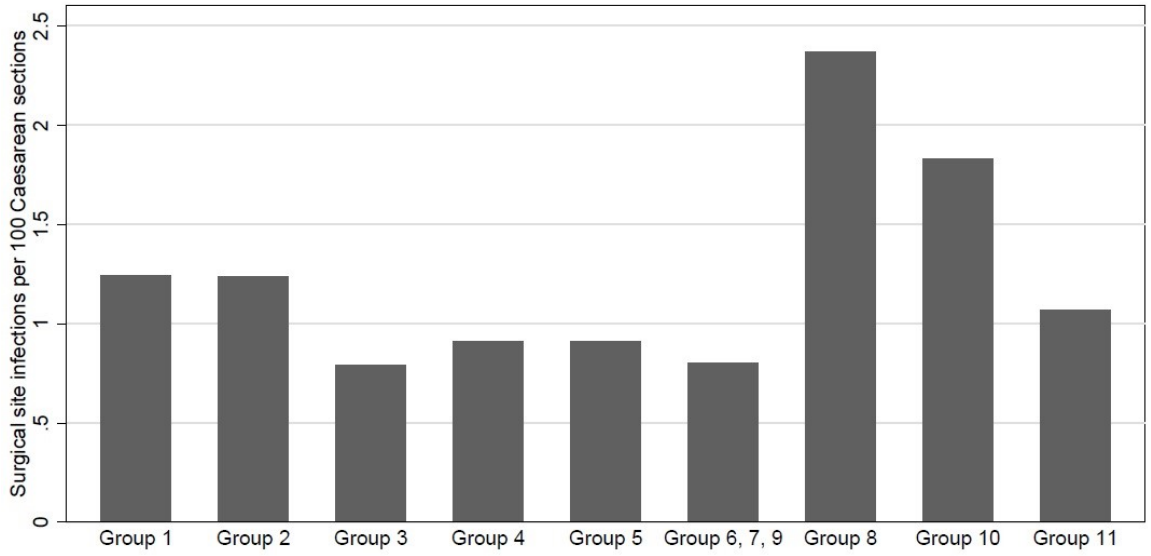

Figure 3: Rate of surgical site infection (primary definition) among women undergoing Caesarean section, by Robson Group, Nova Scotia, 1997-2012

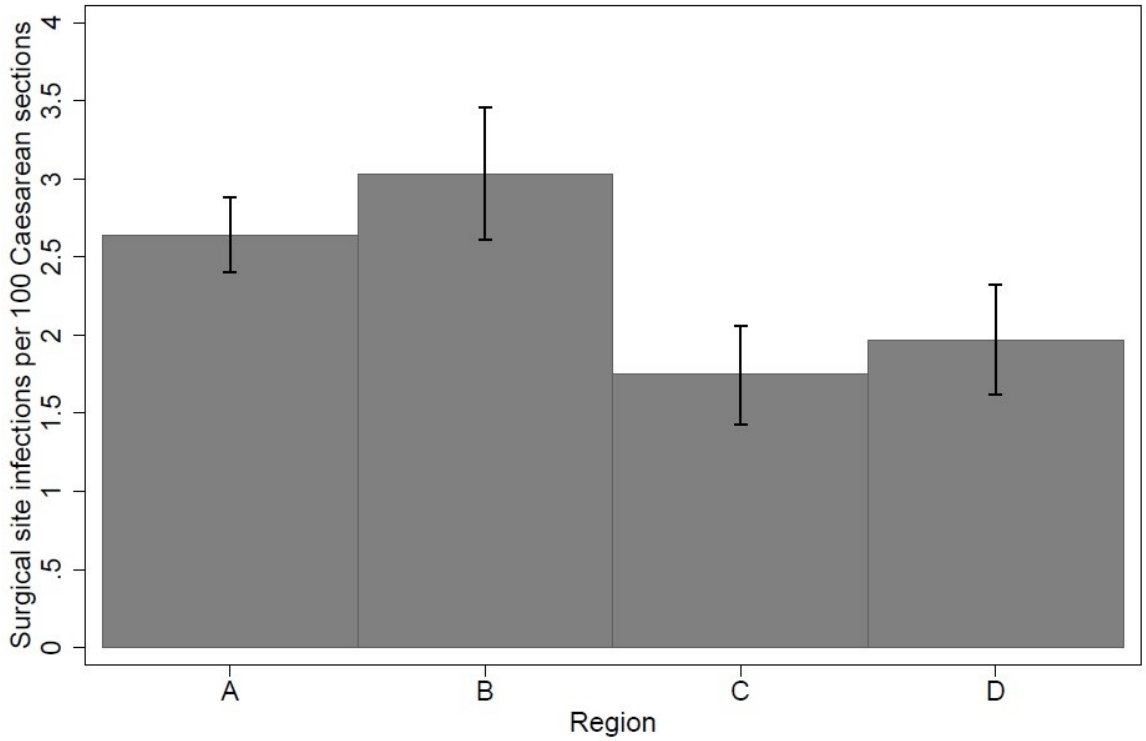

Figure 4: Rate of surgical site infection (more inclusive definition) among women undergoing Caesarean section, by region, Nova Scotia, 1997-2012

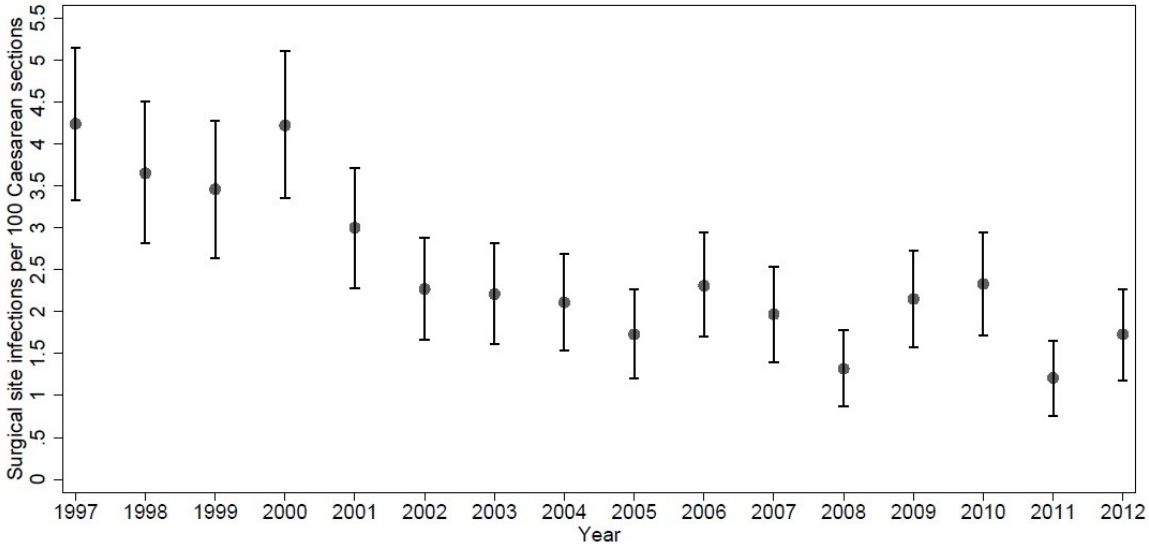

Figure 5: Rate of surgical site infection (more inclusive definition) among women undergoing Caesarean section, by year, Nova Scotia, 1997-2012

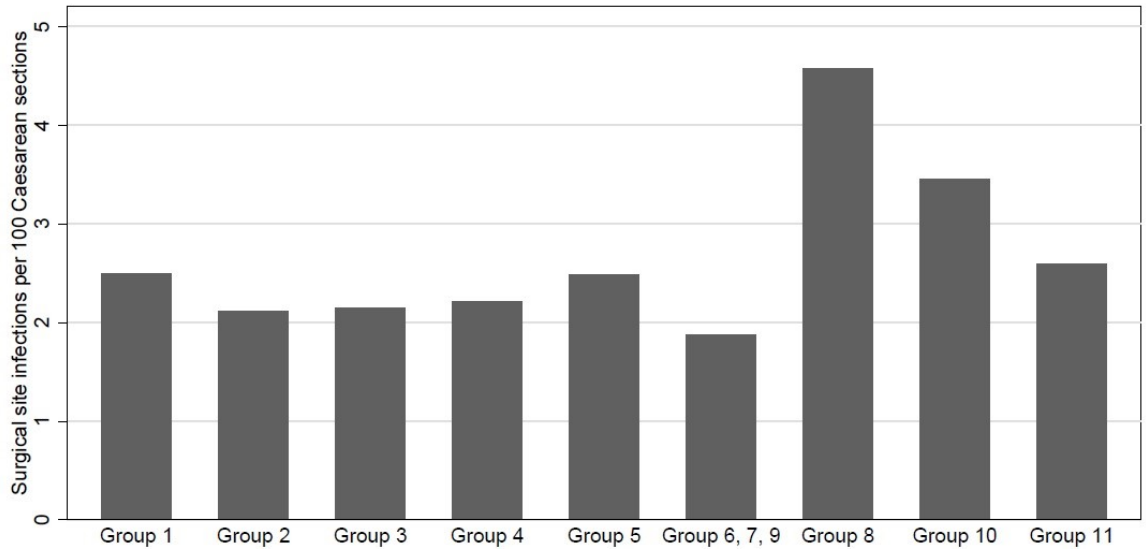

Figure 6: Rate of surgical site infection (more inclusive definition) among women undergoing Caesarean section, by Robson Group, Nova Scotia, 1997-2012

5.5. Tables

Table 3: Surgical site infection rate by region using the primary surgical site infection definition, Nova Scotia, 1997-2012

Region	Number of Caesarean sections	Number of SSIs	% (95% CI)
A	16,773	181	1.08 (0.92-1.24)
B	6,231	105	1.69 (1.37-2.00)
C	6,528	64	0.98 (0.74-1.22)
D	6,054	46	0.76 (0.54-0.98)

CI – confidence interval; SSI – surgical site infection

Table 4: Surgical site infection rate by year using the primary surgical site infection definition, Nova Scotia, 1997-2012

Year	Number of Caesarean sections	Number of SSIs	% (95% CI)
1997	1,885	43	2.28 (1.61-2.96)
1998	1,889	48	2.54 (1.83-3.25)
1999	1,937	36	1.86 (1.26-2.46)
2000	2,038	55	2.70 (1.99-3.40)
2001	2,169	36	1.66 (1.12-2.20)
2002	2,334	28	1.20 (0.76-1.64)
2003	2,305	22	0.95 (0.56-1.35)
2004	2,414	18	0.75 (0.40-1.09)
2005	2,308	14	0.61 (0.29-0.92)
2006	2,248	25	1.11 (0.68-1.55)
2007	2,340	19	0.81 (0.45-1.18)
2008	2,420	10	0.41 (0.16-0.67)
2009	2,417	12	0.50 (0.22-0.78)
2010	2,358	14	0.59 (0.28-0.90)
2011	2,323	7	0.30 (0.08-0.52)
2012	2,201	9	0.41 (0.14-0.68)

CI – confidence interval; SSI – surgical site infection

Table 5: Surgical site infection rate by Robson group using the primary surgical site infection definition, Nova Scotia, 1997-2012

Robson group	Number of Caesarean sections	Number of SSIs	% (95% CI)
1	5,080	63	1.24 (0.94-1.54)
2	7,124	88	1.24 (0.98-1.49)
3	884	7	0.79 (0.21-1.38)
4	1,540	14	0.91 (0.43-1.38)
5	10,299	94	0.91 (0.73-1.10)

Table 5: Surgical site infection rate by Robson group using the primary surgical site infection definition, Nova Scotia, 1997-2012, continued			
Robson group	**Number of Caesarean sections**	**Number of SSIs**	**% (95% CI)**
6, 7, 9	5,505	44	0.80 (0.56-1.03)
8	1,224	29	2.37 (1.52-3.22)
10	1,967	36	1.83 (1.24-2.42)
11	1,963	21	1.07 (0.61-1.53)

CI – confidence interval; SSI – surgical site infection

Table 6: Surgical site infection rate by region using the more inclusive surgical site infection definition, Nova Scotia, 1997-2012

Region	**Number of Caesarean sections**	**Number of SSIs**	**% (95% CI)**
A	16,773	443	2.64 (2.40-2.88)
B	6,231	189	3.03 (2.61-3.46)
C	6,528	114	1.75 (1.43-2.06)
D	6,054	119	1.97 (1.62-2.32)

CI – confidence interval; SSI – surgical site infection

Table 7: Surgical site infection rate by year using the more inclusive surgical site infection definition, Nova Scotia, 1997-2012

Year	**Number of Caesarean sections**	**Number of SSIs**	**% (95% CI)**
1997	1,885	80	4.24 (3.33-5.15)
1998	1,889	69	3.65 (2.81-4.50)
1999	1,937	67	3.46 (2.64-4.27)
2000	2,038	86	4.22 (3.35-5.10)
2001	2,169	65	3.00 (2.28-3.71)
2002	2,334	53	2.27 (1.67-2.88)
2003	2,305	51	2.21 (1.61-2.81)
2004	2,414	51	2.11 (1.54-2.69)
2005	2,308	40	1.73 (1.20-2.27)
2006	2,248	52	2.31 (1.70-2.94)
2007	2,340	46	1.97 (1.40-2.53)
2008	2,420	32	1.32 (0.87-1.78)
2009	2,417	52	2.15 (1.57-2.73)
2010	2,358	55	2.33 (1.72-2.94)
2011	2,323	28	1.21 (0.76-1.65)
2012	2,201	38	1.73 (1.18-2.27)

CI – confidence interval; SSI – surgical site infection

Table 8: Surgical site infection rate by Robson Group using the more inclusive surgical site infection definition, Nova Scotia, 1997-2012

Robson group	Number of Caesarean sections	Number of SSIs	% (95% CI)
1	5,080	127	2.50 (2.07-2.93)
2	7,124	151	2.12 (1.79-2.45)
3	884	19	2.15 (1.19-3.11)
4	1,540	34	2.21 (1.47-2.94)
5	10,299	256	2.49 (2.18-2.79)
6, 7, 9	5,505	103	1.87 (1.51-2.23)
8	1,224	56	4.58 (3.40-5.75)
10	1,967	68	3.46 (2.65-4.27)
11	1,963	51	2.60 (1.89-3.30)

CI – confidence interval; SSI – surgical site infection

Table 9: Institution-related cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	N (col %)	SSI (%)	uOR (95% CI)
Number of Caesarean sections per hospital per year*			
<130	9,073 (25.5)	56 (0.6)	1.00 (ref)
130-949	7,558 (21.2)	126 (1.7)	2.73 (1.99-3.76)
950-1249	9,985 (28.1)	153 (1.5)	2.50 (1.84-3.41)
≥1250	8,970 (25.2)	61 (0.7)	1.10 (0.77-1.59)

CI – confidence interval; SSI – surgical site infection; uOR – unadjusted odds ratio
*p-value <0.05

Table 10: Patient-related (area-level) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	N (col %)	SSI (%)	uOR (95% CI)
Region of maternal residence*			
A	16,773 (47.1)	181 (1.1)	1.00 (ref)
B	6,231 (17.5)	105 (1.7)	1.57 (1.23-2.01)
C	6,528 (18.3)	64 (1.0)	0.90 (0.68-1.21)
D	6,054 (17.0)	46 (0.8)	0.70 (0.51-0.98)
Rural residence			
Urban	24,736 (69.6)	289 (1.2)	1.00 (ref)
Rural	10,828 (30.5)	106 (1.0)	0.84 (0.67-1.05)
Missing	22		

Table 10: Patient-related (area-level) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012, continued			
Variable	**N (col %)**	**SSI (%)**	**uOR (95% CI)**
Quintile of neighbourhood-level income			
1 (lowest)	7,037 (20.2)	97 (1.4)	1.39 (1.01-1.89)
2	6,338 (18.2)	74 (1.2)	1.17 (0.84-1.63)
3	6,964 (20.0)	65 (0.9)	0.93 (0.66-1.32)
4	7,638 (22.0)	88 (1.2)	1.16 (0.84-1.59)
5 (highest)	6,819 (19.6)	68 (1.0)	1.00 (ref)
Missing	790		

CI – confidence interval; SSI – surgical site infection; uOR – unadjusted odds ratio
*p-value <0.05

Table 11: Patient-related (maternal demographics) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	**N (col %)**	**SSI (%)**	**uOR (95% CI)**
Age, years			
<25	6,599 (18.5)	82 (1.2)	1.22 (0.94-1.57)
25-34	21,901 (61.5)	224 (1.0)	1.00 (ref)
≥35	7,086 (19.9)	90 (1.3)	1.24 (0.97-1.59)
Pre-pregnancy weight, kg*			
<53	2,855 (8.0)	28 (1.0)	1.06 (0.70-1.62)
≥53-66.9	10,464 (29.4)	97 (0.9)	1.00 (ref)
≥67-76.9	5,964 (16.8)	51 (0.9)	0.92 (0.66-1.30)
≥77-86.9	4,252 (12.0)	48 (1.1)	1.22 (0.86-1.73)
≥87-97.9	2,744 (7.7)	39 (1.4)	1.54 (1.06-2.24)
≥98	3,340 (9.4)	74 (2.2)	2.41 (1.78-3.28)
Missing	5,967 (16.8)	59 (1.0)	1.07 (0.77-1.48)
Marital status*			
Married/common-law	25,936 (76.7)	269 (1.0)	1.00 (ref)
Single/divorced/separated/ widowed	7,878 (23.3)	111 (1.4)	1.36 (1.09-1.71)
Missing	1,772		

CI – confidence interval; SSI – surgical site infection; uOR – unadjusted odds ratio
*p-value <0.05

Table 12: Patient-related (maternal demographics) Cohort Characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	**N (col %)**	**SSI (%)**	**uOR (95% CI)**
Smoking during pregnancy			
No	27,712 (78.5)	294 (1.1)	1.00 (ref)
Yes	7,573 (21.5)	100 (1.3)	1.25 (0.99-1.57)
Missing	301		

Table 12: Patient-related (maternal demographics) Cohort Characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012			
Variable	**N (col %)**	**SSI (%)**	**uOR (95% CI)**
Alcohol or drug abuse during pregnancy			
No	35,092 (98.6)	387 (1.1)	1.00 (ref)
Yes	494 (1.4)	9 (1.8)	1.67 (0.86-3.26)

CI – confidence interval; SSI – surgical site infection; uOR – unadjusted odds ratio

Table 13: Patient-related (maternal medical conditions) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	**N (col %)**	**SSI (%)**	**uOR (95% CI)**
Non-obstetric pre-existing health conditions affecting pregnancy*			
No	28,690 (80.6)	376 (1.1)	1.00 (ref)
Yes	6,896 (19.4)	20 (1.3)	1.50 (1.20-1.88)
Hypertension*			
No	30,836 (86.7)	314 (1.0)	1.00 (ref)
Pre-existing	511 (1.4)	7 (1.4)	1.36 (0.64-2.88)
Gestational	2,744 (7.7)	42 (1.5)	1.52 (1.10-2.10)
Preeclampsia	1,357 (3.8)	28 (2.1)	2.05 (1.39-3.03)
Unspecified	138 (0.4)	5 (3.6)	3.68 (1.50-9.03)
Diabetes*			
No	33,263 (93.5)	351 (1.1)	1.00 (ref)
Pre-existing	220 (0.6)	6 (2.7)	2.62 (1.15-5.95)
Gestational	2,103 (5.9)	39 (1.9)	1.77 (1.27-2.48)
Anemia during pregnancy			
No	32,859 (92.3)	365 (1.1)	1.00 (ref)
Yes	2,727 (7.7)	31 (1.1)	1.03 (0.71-1.49)
Depression during pregnancy			
No	33,987 (95.5)	376 (1.1)	1.00 (ref)
Yes	1,599 (4.5)	20 (1.3)	1.13 (0.72-1.78)
Influenza immunization			
Yes	1,038 (2.9)	6 (0.6)	1.00 (ref)
No	34,548 (97.1)	390 (1.1)	1.95 (0.87-4.38)
Anticoagulation therapy during pregnancy*			
No	35,247 (99.1)	384 (1.1)	1.00 (ref)
Yes	339 (1.0)	12 (3.5)	3.31 (1.84-6.00)

CI – confidence interval; SSI – surgical site infection; uOR – unadjusted odds ratio
*p-value <0.05

Table 14: Obstetric-related (pregnancy history) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	N (col %)	SSI (%)	uOR (95% CI)
Parity*			
Primiparous	17,637 (49.6)	215 (1.2)	1.00 (ref)
Multiparous	17,949 (50.4)	181 (1.0)	0.82 (0.67-1.00)
Mode of delivery of last pregnancy			
Not applicable/unknown	19,821 (55.7)	233 (1.2)	1.00 (ref)
Vaginal	4,491 (12.6)	52 (1.2)	0.98 (0.73-1.33)
Caesarean section	11,274 (31.7)	111 (1.0)	0.83 (0.66-1.04)
Number of previous Caesarean sections			
0	22,483 (63.2)	268 (1.2)	1.00 (ref)
1	10,309 (29.0)	99 (1.0)	0.80 (0.63-1.01)
2+	2,794 (7.9)	29 (1.0)	0.86 (0.58-1.26)
SSI after previous Caesarean section			
No	35,221 (99.0)	389 (1.1)	1.00 (ref)
Yes	365 (1.0)	7 (1.9)	0.76 (0.25-2.35)

CI – confidence interval; SSI – surgical site infection; uOR – unadjusted odds ratio
*p-value <0.05

Table 15: Obstetric-related (pregnancy characteristics) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	N (col %)	SSI (%)	uOR (95% CI)
Weight gain during pregnancy, kg*			
<10	5,879 (16.5)	65 (1.1)	1.04 (0.79-1.38)
10-29.9	19,669 (55.3)	208 (1.1)	1.00 (ref)
≥30	681 (1.9)	18 (2.6)	2.52 (1.55-4.11)
Missing	9,357 (26.3)	105 (1.1)	1.06 (0.84-1.34)
Chorioamnionitis during pregnancy*			
No	34,972 (98.3)	381 (1.1)	1.00 (ref)
Yes	614 (1.7)	15 (2.4)	2.29 (1.36-3.85)
Diagnostic and/or therapeutic procedure(s) performed on mother			
No	34,543 (97.1)	382 (1.1)	1.00 (ref)
Yes	1,043 (2.9)	14 (1.3)	1.21 (0.71-2.07)
Steroid use ≥48 hrs before delivery for fetal lung maturity*			
No	34,211 (96.1)	363 (1.1)	1.00 (ref)
Yes	1,375 (3.9)	33 (2.4)	2.28 (1.59-3.28)

CI – confidence interval; SSI – surgical site infection; uOR – unadjusted odds ratio
*p-value <0.05

Table 16: Obstetric-related (labour) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	N (col %)	SSI (%)	uOR (95% CI)
Cervical dilation at the last examination before Caesarean section, cm*			
No dilation	17,961 (51.8)	172 (1.0)	1.00 (ref)
1-3	3,623 (10.4)	41 (1.1)	1.19 (0.84-1.67)
4-10	13,106 (37.8)	171 (1.3)	1.37 (1.11-1.70)
Missing	896		
Hours from rupture of membranes to delivery			
≤1	17,647 (50.1)	178 (1.0)	1.00 (ref)
2-11	8,653 (24.5)	103 (1.2)	1.19 (0.93-1.52)
≥12	8,962 (25.4)	114 (1.3)	1.27 (1.00-1.61)
Missing	324		
Stage of labour before Caesarean section*			
None	17,409 (48.9)	165 (1.0)	1.00 (ref)
First	11,295 (31.7)	139 (1.2)	1.30 (1.04-1.64)
Second	6,881 (19.3)	92 (1.3)	1.42 (1.10-1.84)
Missing	1		
Type of rupture of membranes			
Spontaneous	9,836 (27.9)	122 (1.2)	1.00 (ref)
Artificial	25,389 (72.1)	272 (1.1)	0.86 (0.69-1.07)
Missing	361		

CI – confidence interval; SSI – surgical site infection; uOR – unadjusted odds ratio
*p-value <0.05

Table 17: Patient-related (delivery) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	N (col %)	SSI (%)	uOR (95% CI)
Length of antepartum stay, hours*			
<24	29,690 (83.5)	295 (1.0)	1.00 (ref)
24-49	3,263 (9.2)	46 (1.4)	1.43 (1.04-1.95)
≥50	2,605 (7.3)	55 (2.1)	2.14 (1.60-2.87)
Missing	28		
Year of delivery*			
1997-2000	7,749 (21.8)	182 (2.4)	5.30 (3.78-7.43)
2001-2004	9,222 (25.9)	104 (1.1)	2.52 (1.76-3.61)
2005-2008	9,316 (26.2)	68 (0.7)	1.62 (1.10-2.38)
2009-2012	9,299 (26.1)	42 (0.5)	1.00 (ref)
Season of delivery			
Summer	9,270 (26.1)	100 (1.1)	1.00 (ref)
Winter	8,100 (22.8)	91 (1.1)	1.04 (0.78-1.38)
Spring	9,121 (25.6)	100 (1.1)	1.02 (0.77-1.34)
Autumn	9,095 (25.6)	105 (1.2)	1.07 (0.81-1.41)

Table 17: Patient-related (delivery) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012, continued			
Variable	**N (col %)**	**SSI (%)**	**uOR (95% CI)**
Day of week of delivery			
Weekday	29,432 (82.7)	319 (1.1)	1.00 (ref)
Weekend	6,154 (17.3)	77 (1.3)	1.16 (0.90-1.48)
Primary indication for Caesarean section*			
Previous Caesarean section	10,374 (29.2)	98 (0.9)	1.00 (ref)
Breech	4,810 (13.5)	46 (1.0)	1.02 (0.72-1.45)
Dystocia	9,295 (26.1)	130 (1.4)	1.50 (1.15-1.95)
Fetal distress	5,464 (15.4)	63 (1.2)	1.23 (0.89-1.69)
Other	5,643 (15.9)	59 (1.1)	1.11 (0.80-1.54)
Mode of Caesarean section			
Low segment transverse	34,805 (97.8)	385 (1.1)	1.00 (ref)
Other	781 (2.2)	11 (1.4)	1.28 (0.70-2.34)
Use of instrumentation at time of Caesarean section			
No	32,824 (92.2)	359 (1.1)	1.00 (ref)
Yes	2,762 (7.8)	37 (1.3)	1.22 (0.87-1.72)
General anesthesia during labour and/or delivery			
No	32,601 (91.6)	355 (1.1)	1.00 (ref)
Yes	2,985 (8.4)	41 (1.4)	1.26 (0.91-1.75)
Regional anesthesia during labour and/or delivery			
No	2,260 (6.4)	33 (1.5)	1.00 (ref)
Yes	33,326 (93.7)	363 (1.1)	0.74 (0.52-1.07)
Antibiotic prophylaxis*			
Yes	22,415 (63.0)	194 (0.9)	1.00 (ref)
No	13,171 (37.0)	202 (1.5)	1.78 (1.46-2.18)
Maternal blood transfusion*			
No	35,216 (99.0)	386 (1.1)	1.00 (ref)
Yes	370 (1.0)	10 (2.7)	2.50 (1.32-4.73)
Other procedures performed during Caesarean section*			
No	31,071 (87.3)	360 (1.2)	1.00 (ref)
Yes	4,515 (12.7)	36 (0.8)	0.68 (0.48-0.96)

CI – confidence interval; SSI – surgical site infection; uOR – unadjusted odds ratio
*p-value <0.05

Table 18: Obstetric-related (fetal or neonatal factors) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	**N (col %)**	**SSI (%)**	**uOR (95% CI)**
Presentation at delivery			
Vertex	23,883 (67.1)	274 (1.2)	1.00 (ref)
Other	9,636 (27.1)	97 (1.0)	0.88 (0.69-1.11)
Missing	2,067 (5.8)	25 (1.2)	1.06 (0.70-1.59)

Table 18: Obstetric-related (fetal or neonatal factors) cohort characteristics using the primary surgical site infection definition, Nova Scotia, 1997-2012, continued			
Variable	**N (col %)**	**SSI (%)**	**uOR (95% CI)**
Infant birth weight, g*			
<2500	2,524 (7.1)	44 (1.7)	1.73 (1.25-2.38)
2500-3900	25,415 (71.5)	258 (1.0)	1.00 (ref)
≥4000	7,619 (21.4)	94 (1.2)	1.21 (0.95-1.54)
Missing	28		
Apgar score at 5 minutes*			
0-6	715 (2.0)	15 (2.1)	1.93 (1.14-3.25)
7-10	34,663 (98.0)	380 (1.1)	1.00 (ref)
Missing	208		
Number of fetuses*			
Singleton	34,362 (96.6)	367 (1.1)	1.00 (ref)
Multiples	1,224 (3.4)	29 (2.4)	2.25 (1.53-3.29)
Gestational age, weeks*			
<37	3,602 (10.3)	68 (1.9)	1.91 (1.45-2.52)
37-39.9	20,154 (57.8)	201 (1.0)	1.00 (ref)
≥40	11,125 (31.9)	117 (1.1)	1.07 (0.86-1.34)
Missing	705		
Breastfeeding at discharge*			
Yes	24,912 (70.7)	250 (1.0)	1.00 (ref)
No	10,337 (29.3)	142 (1.4)	1.37 (1.11-1.69)
Missing	337		
Diagnostic and/or therapeutic procedure(s) performed on fetus			
No	34,068 (95.7)	377 (1.1)	1.00 (ref)
Yes	1,518 (4.3)	19 (1.3)	1.13 (0.71-1.80)

CI – confidence interval; SSI – surgical site infection; uOR – unadjusted odds ratio
*p-value <0.05

Table 19: Risk factors for surgical site infection following Caesarean section using the primary surgical site infection definition, Nova Scotia, 1997-2012

Variable	**SSI**	**No SSI**	**aOR (95% CI)**
Number of Caesarean sections per hospital per year			
<130	55	8,536	1.00 (ref)
130-949	114	6,338	2.93 (2.10-4.10)
950-1249	152	9,757	2.52 (1.80-3.53)
≥1250	59	8,802	1.70 (1.13-2.56)

Table 19: Risk factors for surgical site infection following Caesarean section using the primary surgical site infection definition, Nova Scotia, 1997-2012, continued			
Variable	**SSI**	**No SSI**	**aOR (95% CI)**
Pre-pregnancy weight, kg			
<53	27	2,683	1.01 (0.65-1.55)
≥53-66.9	95	9,914	1.00 (ref)
≥67-76.9	51	5,600	0.99 (0.70-1.39)
≥77-86.9	45	3,990	1.21 (0.84-1.74)
≥87-97.9	36	2,553	1.50 (1.01-2.23)
≥98	70	3,061	2.68 (1.91-3.76)
Missing	56	5,632	1.09 (0.70-1.70)
Marital status			
Married/common-law	269	25,667	1.00 (ref)
Single/divorced/separated/ widowed	111	7,766	1.29 (1.02-1.62)
Non-obstetric pre-existing health conditions affecting pregnancy			
No	281	6,966	1.00 (ref)
Yes	99	6,467	1.35 (1.06-1.72)
Hypertension			
No	302	28,966	1.00 (ref)
Pre-existing	7	477	0.91 (0.42-1.95)
Gestational	41	2,603	1.12 (0.79-1.57)
Preeclampsia	25	1,271	1.31 (0.85-2.01)
Unspecified	5	116	4.31 (1.70-10.92)
Diabetes			
No	337	31,285	1.00 (ref)
Pre-existing	6	198	2.51 (1.08-5.83)
Gestational	37	1,950	1.59 (1.11-2.27)
Anticoagulation therapy during pregnancy			
No	370	33,121	1.00 (ref)
Yes	10	312	2.73 (1.40-5.33)
Weight gain during pregnancy, kg			
<10	63	5,495	0.81 (0.60-1.09)
10-29.9	202	18,537	1.00 (ref)
≥30	17	617	2.56 (1.53-4.29)
Missing	98	8,784	1.23 (0.87-1.74)
Chorioamnionitis during pregnancy			
No	365	32,876	1.00 (ref)
Yes	15	557	3.13 (1.81-5.41)
Steroid use ≥48 hrs before delivery for fetal lung maturity			
No	348	32,132	1.00 (ref)
Yes	32	1,301	1.56 (1.04-2.35)

Table 19: Risk factors for surgical site infection following Caesarean section using the primary surgical site infection definition, Nova Scotia, 1997-2012, continued			
Variable	**SSI**	**No SSI**	**aOR (95% CI)**
Stage of labour before Caesarean section			
None	159	16,430	1.00 (ref)
First	132	10,453	1.06 (0.84-1.35)
Second	89	6,550	1.37 (1.05-1.80)
Year of delivery			
1997-2000	180	7,526	5.80 (3.95-8.50)
2001-2004	101	9,007	3.05 (2.06-4.52)
2005-2008	63	8,312	1.83 (1.21-2.78)
2009-2012	36	8,588	1.00 (ref)
Antibiotic prophylaxis			
Yes	195	12,159	1.00 (ref)
No	185	21,274	1.55 (1.23-1.95)
Maternal blood transfusion			
No	371	33,105	1.00 (ref)
Yes	9	328	2.43 (1.22-4.84)
Number of fetuses			
Singleton	352	32,282	1.00 (ref)
Multiples	28	1,151	1.88 (1.24-2.86)

aOR – adjusted odds ratio; CI – confidence interval; SSI – surgical site infection
Model adjusted for all factors in this table.

Table 20: Risk factors for surgical site infection following Caesarean section using the primary surgical site infection definition, Nova Scotia, 2003-2012

Variable	**SSI**	**No SSI**	**aOR (95% CI)**
Number of Caesarean sections per hospital per year			
<130	12	5,525	1.00 (ref)
130-949	55	5,159	5.28 (2.79-9.97)
950-1249	28	4,839	3.15 (1.57-6.32)
≥1250	55	7,661	3.07 (1.62-5.80)
Pre-pregnancy weight, kg			
<53	7	1,773	0.78 (0.34-1.77)
≥53-66.9	32	6,496	1.00 (ref)
≥67-76.9	14	3,848	0.70 (0.38-1.32)
≥77-86.9	22	2,758	1.52 (0.87-2.63)
≥87-97.9	19	1,806	2.06 (1.15-3.70)
≥98	36	2,311	2.74 (1.63-4.59)
Missing	20	4,192	0.70 (0.35-1.41)
Non-obstetric pre-existing health conditions affecting pregnancy			
No	108	18,744	1.00 (ref)
Yes	42	4,440	1.68 (1.14-2.46)

Table 20: Risk factors for surgical site infection following Caesarean section using the primary surgical site infection definition, Nova Scotia, 2003-2012, continued			
Variable	**SSI**	**No SSI**	**aOR (95% CI)**
Hypertension			
No	106	20,179	1.00 (ref)
Pre-existing or unspecified*	8	442	2.05 (0.97-4.33)
Gestational	24	1,686	1.93 (1.22-3.08)
Preeclampsia	12	877	1.97 (1.06-3.66)
Anticoagulation therapy during pregnancy			
No	139	22,890	1.00 (ref)
Yes	11	294	4.11 (2.12-7.95)
Weight gain during pregnancy, kg			
<10	24	3,799	0.67 (0.42-1.09)
10-29.9	77	12,414	1.00 (ref)
≥30	8	481	2.32 (1.10-4.90)
Missing	41	6,490	1.40 (0.86-2.30)
Chorioamnionitis during pregnancy			
No	142	22,789	1.00 (ref)
Yes	8	395	4.95 (2.35-10.40)
Year of delivery			
2003-2004	40	4,679	2.49 (1.53-4.03)
2005-2008	68	9,248	1.88 (1.27-2.78)
2009-2012	42	9,257	1.00 (ref)

aOR – adjusted odds ratio; CI – confidence interval; SSI – surgical site infection
Model adjusted for all factors in this table.
*Pre-existing and unspecified hypertension were combined due to a low prevalence of each.

Table 21: Relationship between disruption of Caesarean section wound and surgical site infection according to the primary definition, Nova Scotia, 1997-2012

		SSI according to Primary Definition	
		Yes	*No*
Disruption of Caesarean section wound	*Yes*	9	58
	No	387	35,132

SSI – surgical site infection

Table 22: Relationship between sepsis or puerperal infection and surgical site infection according to the primary definition, Nova Scotia, 1997-2012

		SSI according to Primary Definition	
		Yes	*No*
Sepsis or puerperal infection	*Yes*	48	94
	No	348	35,096

SSI – surgical site infection

Table 23: Relationship between hematoma of obstetric wound and surgical site infection according to the primary definition, Nova Scotia, 1997-2012

		SSI according to Primary Definition	
		Yes	*No*
Hematoma or hemorrhage of obstetric wound	*Yes*	21	219
	No	375	34,971

SSI – surgical site infection

Table 24: Risk factors for surgical site infection following Caesarean section using the more inclusive surgical site infection definition, Nova Scotia, 2003-2012

Variable	SSI	No SSI	aOR (95% CI)
Number of Caesarean sections per hospital per year			
<130	58	5,479	1.00 (ref)
130-949	117	5,097	2.04 (1.47-2.82)
950-1249	87	4,780	1.86 (1.32-2.62)
≥1250	183	7,533	2.45 (1.80-3.33)
Pre-pregnancy weight, kg			
<53	36	1,744	1.05 (0.71-1.54)
≥53-66.9	119	6,409	1.00 (ref)
≥67-76.9	61	3,801	0.86 (0.63-1.17)
≥77-86.9	48	2,732	0.91 (0.65-1.29)
≥87-97.9	42	1,783	1.21 (0.84-1.74)
≥98	71	2,276	1.44 (1.05-1.97)
Missing	68	4,144	0.81 (0.60-1.10)
Hypertension			
No	349	19,936	1.00 (ref)
Pre-existing or unspecified*	17	433	1.87 (1.12-3.12)
Gestational	46	1,664	1.46 (1.06-2.03)
Preeclampsia	33	856	1.82 (1.24-2.67)
Anemia during pregnancy			
No	364	20,750	1.00 (ref)
Yes	81	2,139	1.59 (1.19-2.13)

Table 24: Risk factors for surgical site infection following Caesarean section using the more inclusive surgical site infection definition, Nova Scotia, 2003-2012, continued			
Variable	**SSI**	**No SSI**	**aOR (95% CI)**
Anticoagulation therapy during pregnancy			
No	423	22,606	1.00 (ref)
Yes	22	283	2.84 (1.78-4.53)
Number of previous Caesarean sections			
0	251	14,091	1.00 (ref)
1	157	6,909	1.48 (1.21-1.83)
2+	37	1,889	1.27 (0.88-1.81)
Chorioamnionitis during pregnancy			
No	431	22,500	1.00 (ref)
Yes	14	389	2.19 (1.25-3.84)
Maternal blood transfusion			
No	405	22,644	1.00 (ref)
Yes	40	245	6.74 (4.54-10.00)
Number of fetuses			
Singleton	414	22,071	1.00 (ref)
Multiples	31	818	1.80 (1.23-2.64)

aOR – adjusted odds ratio; CI – confidence interval; SSI – surgical site infection
Variables considered for inclusion in the multivariable model were number of Caesarean sections per hospital per year, region of maternal residence, rural residence, quintile of neighbourhood-level income, maternal age, pre-pregnancy weight, non-obstetric pre-existing health conditions affecting pregnancy, hypertension, diabetes, anemia during pregnancy, anticoagulation therapy during pregnancy, parity, number of previous Caesarean sections, chorioamnionitis during pregnancy, steroid use ≥48 hours before delivery for fetal lung maturity, cervical dilation at the last examination before Caesarean section, stage of labour before Caesarean section, length of antepartum stay, use of instrumentation at time of Caesarean section, maternal blood transfusion, other procedures performed during Caesarean section, infant birth weight, Apgar score at five minutes, number of fetuses, and gestational age.
Model adjusted for all factors in this table.
*Pre-existing and unspecified hypertension were combined due to a low prevalence of each.

CHAPTER 6: DISCUSSION

6.1. Objective 1 Findings

We estimated the incidence of SSI after Caesarean section to hospital discharge within Nova Scotia by year, region of maternal residence, and Robson Group. For the primary SSI definition we used codes for obstetrical-specific and more general SSIs. For the more inclusive SSI definition we used additional diagnostic and procedure codes that could indicate a SSI.

Over our 16 year study period, the SSI rate was 1.11% using the primary definition and 2.43% using the more inclusive definition. These findings are lower than most other studies following women to hospital discharge (4-17). This could be due to population differences in previous studies such as only examining Caesarean sections performed under general anesthetic (4), women with at least two previous Caesarean sections (7), singleton gestations (9), and elective (14,16) or emergency (15) Caesarean sections. Another potential reason for this difference is that the number of Caesarean sections performed per year increased during our study period while the SSI rate decreased. Finally, there were clinical practice changes over our study period that effectively decreased infection rates, including SSI.

Our SSI rate was 2.43% when we used the more inclusive SSI definition which equals a 119% increase from the primary definition. Similarly, Tsai et al. observed a considerable increase of 200% from 0.3% to 0.9% when they used 81 rather than 5 diagnostic codes (34). Our rate of 2.43% is comparable to the reported SSI rate of 2.20% when a hospital database and similar diagnostic and procedure codes were used in a validation study conducted by Daneman et al. (42). The additional codes used in the

more inclusive SSI definition allow for a more sensitive outcome than using solely the primary SSI definition. However, these additional codes are less specific than the primary SSI definition as they are not necessarily indicative of a true SSI.

Our study showed differences in the SSI rate between the four regions in Nova Scotia when using both the primary and more inclusive SSI definitions. These findings may be indicative that regions differ in their infection prevention practices or their case mix profiles; however, women may not necessarily deliver in the region they reside in so this conclusion must be interpreted cautiously. The association between region of residence and SSI after controlling for other variables is discussed below.

We observed a decrease in the SSI rate over our study period. There are a number of possible reasons why this was observed. First, antibiotic prophylaxis usage increased following several clinical practice guidelines (82-84). Second, there may have been other changes in clinical practice during this time period such as improved infection prevention measures or changes in operating technique. Third, the mean length of postpartum stay decreased during the study period from an average of 93 hours in 1997-2000 to an average of 77 hours in 2009-2012. Finally, there may have been changes in the recording or coding of SSIs in the NSAPD which may have affected how SSIs are captured.

Significant differences in the SSI rate were observed among Robson groups. Multiple gestations (Group 8) had the second lowest number of Caesarean sections over the study period but the highest SSI rate using both definitions. This suggests that the variables used to classify Caesarean sections by Robson Group may be important risk factors for SSI, particularly the number of fetuses. The association between number of fetuses and SSI after controlling for other variables is discussed below.

6.2. Objective 2 Findings

Using the primary SSI definition, we conducted a multivariable analysis to determine independent risk factors for SSI from 1997-2012. We then conducted an analysis for 2003-2012.

For both our main and 2003-2012 analysis, we found that the number of Caesarean sections per hospital per year was a significant risk factor for SSI. Smaller hospitals with <130 Caesarean sections per year had the lowest SSI risk whereas an inverse relationship was observed for other hospital sizes. The differences we observed would not be due to the differences between hospitals, such as pre-existing conditions and pregnancy complications in patients, as that was controlled for. However, it could be due to other differences. Hospitals may have different policies in operating procedures or infection prevention. For example, hospitals may use different methods of wound closure, some of which may be an independent risk factor for SSI. Women who delivered in hospitals with <130 Caesarean sections per year had the lowest SSI risk perhaps due to these hospitals having fewer resources. As such, compared to larger hospitals, these hospitals would perform the surgery only when the surgery team was available, thereby increasing the chance of the Caesarean sections being performed sooner.

Vincent et al. also observed that a hospital volume-related risk factor, maternity units with a lower number of Caesarean sections per month (9-13 or 108-156 per year), increased the risk of SSI compared to units with ≥20 per month (240 per year) (62). However, Vincent and colleagues observed a much weaker association with SSI than we did possibly because the maternity units in their study were all part of the same

surveillance network which may make them more likely to have similar infection prevention practices (62).

We observed an association between SSI and pre-pregnancy weight for weights of ≥87 kg (approximately obese classes II and III) in both analyses. Most studies examining pre-pregnancy BMI have shown that a higher BMI increases the risk of SSI (1,6,18,31). When we used pre-pregnancy BMI rather than pre-pregnancy weight to determine if our pre-pregnancy weight categories approximated BMI, the results suggested there is some non-differential misclassification. That being said, the strength of the association between SSI and the other factors in the model was similar which suggests the weight categories are an overall fairly accurate approximation of BMI.

Women who gained ≥30 kg during pregnancy had a significantly higher risk for SSI than women who gained 10-29.9 kg. Unlike pre-pregnancy or delivery weight, weight gain is more easily modifiable than pre-pregnancy weight. However, previous studies have examined delivery BMI rather than weight gain and found that a higher BMI increases the odds of developing SSI (46,47,52,66). Studies have noted that a higher BMI, and therefore a larger weight, could increase the risk of SSI due to there being a longer surgical wound with more area to potentially become contaminated (31,47,52) and requiring longer to heal (6,31) compared to normal BMI. In addition, a longer surgical wound could increase the risk of wound dehiscence and therefore the risk of SSI.

Relationship status was a risk factor for SSI in the 1997-2012 analysis. When controlled for other factors, women who are single, divorced, separated or widowed had approximately a 30% higher risk of SSI than women who are married or common-law. That being said, marital status was weakly associated with SSI.

We found that non-obstetric pre-existing health conditions affecting pregnancy was associated with SSI in both analyses when controlled for other variables. Conversely, Gong et al. examined pre-existing disease and it did not remain associated with SSI when adjusted for other factors (52). This difference could lie in what pre-existing conditions were considered. While we considered a large number of pre-existing conditions, Gong et al. only examined heart disease, diabetes, hyperthyroidism, and other pre-existing diseases (52). In addition, a large proportion of our population (19%) had pre-existing conditions whereas the prevalence was much lower in the study by Gong et al. (8.5%) (52).

In the main analysis, unspecified hypertension was a significant risk factor for SSI. Two studies examining hypertension without subdividing it by type also found that it was related to a higher SSI risk (11,39). However, when pre-existing hypertension and unspecified hypertension were combined in the 2003-2012 analysis they were not associated with SSI. This could be because there was a low prevalence in the population or pre-existing hypertension nullified the association between unspecified hypertension and SSI. Both preeclampsia and gestational hypertension were independent risk factors for SSI but only in the 2003-2012 analysis. Our conflicting results could be due to other factors existing in the 2003-2012 era, such as changes in clinical practice, which confounded the association between hypertension and SSI. It could also be because, unlike in the 2003-2012 analysis, our main analysis controlled for diabetes. These results also conflict with the literature as Schneid-Kofman et al. did not find mild nor severe preeclampsia to be associated with SSI when adjusted for other factors (68). Likewise,

Geubbels et al. did not find gestational hypertension to be a risk factor for SSI, even in an unadjusted analysis (67).

We found pre-existing and gestational diabetes to be risk factors for SSI in the main analysis. Schneid-Kofman et al. also found pre-existing diabetes to be a significant risk factor for SSI when controlled for other factors (68). Most other previous studies have observed it to be non-significant (63,67,85), in most cases likely due to its low prevalence in the sample (63,67). The literature suggests that gestational diabetes is not associated with SSI (10,66,67). One study even observed that women with gestational diabetes had a lower risk of developing SSI than women without gestational diabetes, though the authors noted this may have been confounded by surgeons deciding to perform elective surgeries for diabetic gestations (85). The difference in our observed association between SSI and gestational diabetes with the literature could be explained by there not being enough power to detect an association in previous studies (10,66,67).

Anticoagulation therapy during pregnancy was a risk factor for SSI in our study. Compared to women who did not receive anticoagulants during pregnancy, women who did were over two and a half times as likely to develop a SSI in the main analysis and over four times as likely in the 2003-2012 analysis. Anticoagulation therapy may have had a weaker association with SSI in the main analysis because, unlike the 2003-2012 analysis, this analysis controlled for maternal blood transfusion which may have explained part of this factor's association with SSI.

Chorioamnionitis during pregnancy was observed to significantly increase the odds of SSI when controlled for other factors. As only 1.73% of our sample was diagnosed with chorioamnionitis during pregnancy, the large confidence interval

observed in the 2003-2012 analysis is likely due to the low prevalence of chorioamnionitis during pregnancy in the population during that time period. Our result is similar to the association found by Mitt et al. who also found chorioamnionitis to be independently associated with SSI (33). However, most previous studies examining chorioamnionitis have not found it to be associated with SSI (47,66,69) which could be due to differences in study population (obese women only) (69), or not having enough power to detect an association (47).

Steroid use ≥48 hours before delivery for fetal lung maturity only increased the risk for SSI in the main analysis. This finding is contradictory to a previous study that examined corticosteroid use and did not find it to be associated with SSI in an unadjusted analysis (63). This difference could be because the prevalence of steroid usage in our study was considerably higher at 3.86% and therefore we were able to detect an association.

We found that being in the second stage of labour was associated with SSI in the main analysis when controlling for other variables. Pergialiotis et al. conducted a systematic review and meta-analysis and, from the seven studies examining stage of labour as a proxy for a fully dilated cervix, did not find their adjusted pooled association with SSI to be significant (72). Other previous studies examining cervical dilation have not found an association either (59,70,71). However, these differences are likely explained by the populations studied. Two studies examined elective Caesarean sections and randomized women into an intraoperative cervical dilation group and no intraoperative cervical dilation group (59,70). Given that these women would have had a dilated cervix for a shorter period of time than the nearly 20% of women who had a fully

dilated cervix (and therefore were in the second stage of labour) in our study, there would have been fewer opportunities for bacteria to be introduced. Allen et al. had different eligibility criteria (singleton, nulliparous pregnancies at 37-40 weeks with labour) than our study which may explain the differences between our results (71). We did not observe cervical dilation at the last examination before Caesarean section to have an association with SSI in an adjusted analysis likely because our model included stage of labour before Caesarean section which explained most of its association with SSI.

We found year of delivery to be strongly associated with SSI. This association is likely explained by confounders for which we did not have information such as changes in operation technique and infection prevention over the 16-year study period.

We observed an increase in antibiotic prophylaxis usage rates over time which coincided with publications recommending changes in clinical practice. There was an increase from 1998-1999 after the CDC published guidelines on SSI prevention (82), an increase from 2002-2003 following a publication from the American College of Obstetricians and Gynecologists which recommended antibiotic prophylaxis for all women undergoing Caesarean section (83), and from 2009-2010 when the Society of Obstetricians and Gynaecologists of Canada recommended the same (84).

Absence of antibiotic prophylaxis was observed to significantly increase the risk of SSI in the main analysis. In general, previous studies have also found antibiotic prophylaxis to be an independent risk factor for SSI when adjusted for other factors (16,47,48,52). Antibiotic prophylaxis was not observed to be a risk factor for SSI when controlled for other variables in the 2003-2012 analysis. We may not have detected an association because most women received antibiotic prophylaxis during this time period.

Maternal blood transfusion was associated with SSI in the main analysis. A previous study conducted by Schneid-Kofman et al. did not find maternal blood transfusion to be associated with SSI after adjustment for other factors such as obesity, hypertension, premature rupture of membranes, diabetes, and emergency Caesarean section (68). This could be because it was partially explained by emergency Caesarean section, which was adjusted for in the final model.

We observed that multiple gestations increased the risk for SSI in the main analysis. Multiple gestations could be a risk factor for SSI due to the Caesarean section taking longer to perform than with singletons and therefore there being more opportunities for wound contamination. Schneid-Kofman et al. did not find twin gestations to be associated with SSI when adjusted for other factors (68). As in our study, they did not control for length of operation; however, they did control for urgency of Caesarean section which may explain some of its association with SSI since twin pregnancies are more likely to be delivered via an elective rather than emergency Caesarean section (68).

We did not find rural residence to be associated with SSI in either adjusted model. This could be because its association with SSI was partly explained by number of Caesarean sections per hospital per year as hospitals performing fewer sections are more likely to be located in rural areas. Conversely, Salim et al. did find that rural residence was associated with SSI perhaps due to a difference in study populations (the study took place in Israel) (1).

Like most previous studies, we did not find an association between maternal age (1,10,11,18,33,39,47,48,51,52,54,63,64), smoking during pregnancy (10,47,48,51,60),

anemia during pregnancy (11,33,69), parity (1,10,33,39,51,63,64,69), number of previous Caesarean sections (1,4,7,18,31,50,60,64,68), length and type of rupture of membranes (11,39,40,51,54,60,63,64,66,69), indication for Caesarean section (39,52), and presentation at delivery (68,69) in either analysis.

As with previous studies examining length of antepartum stay (40,52,63), we did not find it to be a significant risk factor for SSI when adjusted for other factors despite a length of antepartum stay of ≥50 hours having a strong association with SSI in an unadjusted analysis. This is likely because the other variables in the adjusted model explained most of its association with SSI. Year of delivery could have confounded its association as the length of antepartum stay decreased during the study period.

We did not observe an association between other procedures performed during Caesarean section and SSI which is what was observed in a previous study examining this factor (39). This could be because it was associated with antibiotic prophylaxis as women who had other procedures performed during their Caesarean section were more likely to receive antibiotic prophylaxis than women who did not do undergo additional procedures.

Though a low infant birth weight (<2,500 grams) was associated with SSI in an unadjusted analysis, it did not remain significant after controlling for other factors such as maternal weight and weight gain. Previous studies have also not found an association between infant birth weight and SSI (8,69). Apgar score at five minutes did not remain significant when controlled for other factors. This could be because it was confounded by gestational age, which was not adjusted for in the final model. Another possible explanation for this non-association is that women who delivered an infant with a low

Apgar score (0-6) at five minutes were more likely to receive antibiotic prophylaxis than women with infants who had a higher Apgar score (6-10). Schneid-Kofman et al. also did not observe Apgar score at five minutes to be independently associated with SSI (68).

Though a gestational age of less than 37 weeks was associated with SSI in the unadjusted analysis, it did not remain significant when adjusted for other factors. This could be because gestational age was associated with number of Caesarean sections per hospital per year as hospitals that performed fewer (<950) Caesarean sections per year were less likely to deliver neonates less than 37 weeks old than hospitals with at least 950 Caesarean sections per year. Other studies have also not found gestational age to be associated with SSI (8,18,31,39,48,52,69).

We did not observe region of maternal residence to be associated with SSI. This could be because most of its association was explained by number of Caesarean sections per hospital per year in the adjusted analysis. We did not observe an association between SSI and quintile of neighbourhood-level income, season of delivery, or day of week of delivery possibly because there was not enough of a clinical difference between these populations. We observed breastfeeding at discharge to no longer be associated with SSI when adjusted for other factors. This could be because most of its association with SSI was explained by relationship status as a considerably higher proportion of women without a partner were not breastfeeding at discharge compared to women with a partner.

We did not observe an association between SSI and alcohol or drug abuse, depression during pregnancy, influenza immunization, mode of delivery of last pregnancy, SSI after previous Caesarean section, use of instrumentation at time of

Caesarean section, or type of anesthesia during labour and/or delivery possibly due to there being no underlying association with SSI.

We did not find diagnostic and/or therapeutic procedure(s) performed on the fetus or mother to be associated with SSI. This could be due to these factors being a compilation of various diagnoses and procedures which may cause those diagnoses and procedures with a non-association to pull the overall association toward the null. We found that mode of Caesarean section was not associated with SSI likely due to most women having a low segment transverse Caesarean section and there being a low prevalence of other types of Caesarean sections.

6.3. Objective 3 Findings

Using the more inclusive SSI definition, we determined independent risk factors for SSI for the years 2003-2012.

Number of Caesarean sections per hospital per year was a significant risk factor in both the 2003-2012 analysis using the primary SSI definition and the 2003-2012 sub-analysis using the more inclusive definition though with a weaker association in the latter. This could be because women with pre-existing conditions that may cause them to be at a higher risk for the SSI-related complications included in the more inclusive SSI definition could be more likely to deliver in a larger hospital as these hospitals would have more resources to manage such complications.

Unlike when the primary SSI definition was used, when adjusted for other factors, a pre-pregnancy weight between 87-97.9 kg was not associated with SSI in the sub-analysis. This could be because of a threshold effect between pre-pregnancy weight and SSI-related complications where there is no effect until a weight of ≥98 kg. When we ran

the final model using pre-pregnancy BMI as a comparison, the results suggested that there may be some misclassification when using weight categories. That being said, the association between SSI and the other factors in the model was similar which suggests that pre-pregnancy weight was an overall fairly accurate approximation of BMI.

Unlike in the 2003-2012 analysis using the primary SSI definition, we observed an association between SSI and pre-existing or unspecified hypertension when adjusted for other factors. This is likely because there was more power to detect an association in the sub-analysis.

The observed association between anticoagulation therapy during pregnancy and SSI was stronger when the primary SSI definition was used than in the sub-analysis. This could be because maternal blood transfusion, which was controlled for in the sub-analysis but not the 2003-2012 analysis using the primary definition, explained some of the association between SSI and anticoagulation therapy and therefore weakened the strength of its association. We also observed chorioamnionitis during pregnancy to have a stronger association with SSI in the sub-analysis. This could be because chorioamnionitis during pregnancy is more likely to be associated with a definite SSI than with SSI-related complications.

Though they were associated with SSI when the primary definition was used, non-obstetric pre-existing health conditions affecting pregnancy, weight gain during pregnancy and year of delivery were not associated when we used the more inclusive definition. This could be due to these factors increasing the risk for a definite SSI rather than SSI-related complications. Year of delivery may not have been associated as the clinical practice changes that occurred over the study period may be more likely to

decrease the risk of a definite SSI than the SSI-related complications included in the more inclusive definition.

We observed anemia to be associated with SSI contrary to the primary SSI definition and the literature (11,33,69). A possible explanation could be that women with anemia are more likely to develop complications, including SSI-related complications that are not actually diagnosed as SSIs, than women without anemia. Women with one previous Caesarean section were at a higher risk for SSI than women without a previous Caesarean section. However, this was not observed when the primary SSI definition was used nor has it been observed in most previous studies (1,4,7,18,31,50,60,64,68). We may have observed this association because the more inclusive definition includes wound dehiscence, a complication women with a previous Caesarean section would be at a higher risk for, compared to women without a previous Caesarean section.

Compared to no maternal blood transfusion, the odds of SSI were nearly seven times higher for women with at least one blood transfusion. This factor was not associated with the primary SSI definition. This could be because the sub-analysis using the more inclusive definition included women who had SSI-related complications (such as a hematoma or hemorrhage) that are more likely to require a blood transfusion than women who did not have such complications. We observed that multiple gestations were associated with SSI in the sub-analysis but not when we used the primary SSI definition from 2003-2012. We may have been able to detect an association in the sub-analysis because we had more power to tighten the confidence interval.

We observed a number of differences in risk factors for SSI between the 2003-2012 analyses using the primary SSI definition and the more inclusive SSI definition.

We also observed that some SSI-related complications are considerably more indicative of a possible SSI than others. This suggests the way a SSI is defined can have a considerable impact on the risk factors shown to be associated with SSI. Furthermore, this also suggests that the definition of SSI may impact the comparability between studies.

6.4. Strengths and Limitations

6.4.1. Strengths

A major strength of this study is that it is population-based and therefore representative of the Nova Scotian population, which allows our study findings to be generalizable to all Nova Scotia women who have a Caesarean section. We examined this population over a large study period of 16 years and conducted our analyses using a sensitive SSI definition over the entire study period as well as for the years 2003-2012 to determine if there were differences over time. We also conducted an analysis for 2003-2012 using a more specific SSI definition which included additional diagnoses and procedures indicative of a possible SSI to determine if there were differences with the SSI definition used. Our study has a large sample of over 35,000 Caesarean sections which is larger than most studies examining risk factors for SSI following Caesarean section. We examined novel risk factors such as breastfeeding at discharge and anticoagulation therapy during pregnancy as well as understudied risk factors such as maternal blood transfusion and number of fetuses which will add valuable information to the literature.

6.4.2. Limitations

Our SSI rate is likely underestimated as we only followed women to hospital discharge rather than to 30 days postdischarge. Linking the NSAPD to databases which record hospital admissions and/or physician visits for SSI and following the cohort for 30 days would provide a more accurate estimate of the SSI rate. Since our study was retrospective, we were reliant on secondary data (a perinatal database) to obtain information on women who presented with a SSI.

There are several ways in which women may have been misclassified in this database. A physician may not have put a SSI diagnosis in the patient's chart which would lower our estimated SSI rate. Minor SSIs may be less likely than severe SSIs to be diagnosed and recorded on the patient's chart which would also underestimate our SSI rate and bias it toward more severe SSIs. Women with more risk factors for SSI may have a lower risk of misclassification than women with fewer risk factors since these women may have been more carefully monitored for complications after surgery. As such, the odds of detecting a SSI may be higher in women with more risk factors than in women with fewer risk factors. This would bias our results by increasing the prevalence of risk factors in our study and making them more likely to be identified as associated with SSI. Women may have also been misclassified if the data from patient charts were entered into the database incorrectly. This could either under- or overestimate our SSI rate.

Since diagnostic codes do not specify what layer of tissue is infected, we were not able to determine whether SSIs were superficial incisional, deep incisional, or organ/space and whether risk factors differ between each type. Some risk factors in the

NSAPD are inconsistently used during our study period. For example, smoking variables, such as smoking at the delivery admission, have a high percentage of missing values due to inconsistent use. Therefore, we used a compilation of all smoking variables to determine if there was any smoking during pregnancy.

Since height was not used until 2003 and it was not always recorded when it was used, we approximated BMI using weight categories. In order to be consistent throughout the study, we did this even during years when height was available. When we used BMI instead of weight categories as a comparison, there was some misclassification but we found that the weight categories were an overall fairly accurate approximation of BMI. Finally, some procedure-specific factors, such as experience of the obstetrician performing the Caesarean section and duration of surgery, are not available in the NSAPD and therefore could not be included as potential risk factors in our study.

6.5. Recommendations

According to at least one of our analyses, many of the risk factors for SSI that we observed are likely known well before delivery including pre-pregnancy weight, marital status, non-obstetric pre-existing health conditions affecting pregnancy, hypertension, diabetes, anemia during pregnancy, anticoagulation therapy during pregnancy, number of previous Caesarean sections, chorioamnionitis during pregnancy, and number of fetuses. Given that these risk factors are known in advance, precautions can be taken to decrease the risk of SSI.

Modifiable risk factors observed in at least one of our analyses were weight gain during pregnancy and antibiotic prophylaxis. Healthcare providers should advise women during the first prenatal visit what a healthy weight gain is for their pregnancy. In

addition, women should be informed that gaining ≥30 kg will place them at a higher risk for SSI. All women undergoing Caesarean section should receive antibiotic prophylaxis to decrease the risk of SSI. While there may not be enough time to administer antibiotic prophylaxis in an emergency situation, it should be administered for all elective surgeries.

Since a Caesarean section can be either an elective or an emergent/urgent surgery, different interventions are required to decrease the risk of SSI in these two groups. There may not be enough time to take infection prevention measures for an emergent/urgent surgery. However, women undergoing an elective Caesarean section may have risk factors for SSI known before delivery which may make it easier to take infection prevention measures to decrease the SSI risk. If existing risk factors are modifiable, such as weight gain, steps can and should be taken to reduce the associated odds of SSI.

Number of Caesarean sections per hospital per year was observed to be a risk factor in each model. More research is needed to investigate which surgical factors, such as sutures versus staples for wound closure, and infection prevention factors, such as the type of antiseptic used, are independently associated with SSI. If a specific factor is seen to increase the risk of SSI, an intervention could be conducted with the intent of decreasing the SSI rate.

Non-obstetric pre-existing health conditions affecting pregnancy was observed to be a risk factor for both analyses using the primary SSI definition. A large number of various health conditions were included and it is unknown whether there are a few conditions that have a stronger association with SSI than others. More research is necessary to determine which health conditions are driving our observed association. Anticoagulation therapy, used to treat heart defects and thromboembolic conditions, was

observed to be a strong, independent risk factor for SSI in all analyses when given during pregnancy. Since anticoagulants prevent blood from clotting which may increase the risk of wound contamination, it is likely that it is the anticoagulation therapy itself, rather than the condition it is used for, that is associated with SSI. Further research should examine whether this association is observed in different populations.

There were differences in independent risk factors for SSI between the analyses using the primary SSI definition and the more inclusive SSI definition. Given this, it is recommended that future studies examining risk factors for SSI following Caesarean section choose their SSI definition with caution and with the knowledge that the independent risk factors for SSI may differ depending upon how SSI is defined.

Our study showed that the Robson Group at the highest risk for presenting with SSI was multiple gestations (Group 8). Multiples was also a significant risk factor for the main analysis and the sub-analysis and likely would have been in the 2003-2012 using the primary definition had there been enough power to detect an association. It is known which women are pregnant with multiples early in pregnancy, which allows for early identification of their higher risk for SSI. Therefore, special precautions can and should be taken for women with multiple gestations such as by attempting a trial of labour in order to lower the Caesarean section rate for this group, and/or managing modifiable risk factors to decrease the risk of developing a SSI following Caesarean section.

CHAPTER 7: CONCLUSION

Our study is the first to estimate the incidence of SSI in Nova Scotian women following both labouring and non-labouring Caesarean sections. It is the first study to estimate the incidence of SSI within each Nova Scotian region of maternal residence. The rate of SSI in Nova Scotia can be compared to the rate in other provinces across Canada.

This study is the first to determine multiple risk factors for SSI following Caesarean section in a Nova Scotian population. Our study will help future research develop a risk index for Caesarean sections as it identified novel risk factors for SSI, such as anticoagulation therapy and weight gain during pregnancy, which could be considered for inclusion. We observed that many of the independent risk factors for SSI, such as pre-pregnancy weight and number of fetuses, are known before delivery and therefore, in many cases, a woman's potential increased risk for SSI is also known before delivery.

Knowing which women are at a higher risk for SSI before surgery or, if possible, preconception, can allow for a targeted infection prevention and clinical approach by focusing on reducing or eliminating the adverse effects of modifiable risk factors (1,31). This can assist healthcare professionals in predicting if their patient is at an increased risk for developing SSI which could lead to a decrease in the rate of SSI following Caesarean section. By doing so, the rate of SSI following Caesarean section in Nova Scotia could decrease. This decrease will be beneficial to both hospitals and the community as it could lead to a lower burden associated with these infections.

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APPENDIX 1 - SEARCH STRATEGY

Both MEDLINE via Pubmed and Embase were searched for articles published in English within the last 10 years. A second literature search was conducted before analysis began. Relevant articles were identified first based on review of title then abstract. Articles with relevant abstracts were reviewed further. Reference lists of relevant articles were reviewed for additional articles. When possible, Web of Science was used to search forward in time for articles citing the relevant articles.

Search terms were Caesarean delivery AND surgical site infection AND (age OR obesity OR diabetes OR urgency of surgery OR antibiotic prophylaxis OR ASA score OR membrane rupture OR anesthesia OR residency OR trial of labour OR parity OR gestational age OR previous Caesarean section OR wound contamination class OR hypertension OR risk index OR meconium staining OR smoking OR risk factor). Exact terms used for each part of the search differed based on each database's mapping strategies (see below).

PubMed Search Strategy:

(((((((((c-section) OR cesarean delivery) OR cesarean section) OR caesarean) OR cesarean) OR caesarean delivery) OR caesarean section)) AND ((((((surgical site infection) OR postoperative infection) OR post-operative infection) OR wound infection) OR post Caesarean infection) OR post caesarean infection)) AND ((((((((((((((((((((age) OR maternal age)) OR (((((obese) OR obesity) OR overweight) OR body mass index) OR BMI)) OR ((((diabetes) OR diabetes mellitus) OR gestational diabetes) OR diabetic)) OR (((emergency) OR elective) OR urgen*)) OR ((prophylaxis) OR antibiotic proph*)) OR ASA score) OR ((((membrane rupture*) OR PROM) OR premature membrane*) OR premature ruptur*)) OR ((anesthesia) OR anaesthesia)) OR (((residency) OR rural) OR urban)) OR trial of labo*) OR (((parity) OR nulipar*) OR multipar*)) OR gestational age) OR ((previous ces*) OR previous caes*)) OR wound contaminat*) OR (((((hyperten*) OR high blood pressu*) OR gestational hypertens*) OR pre-eclamps*) OR preeclamps*)) OR risk index) OR ((meconium) OR meconium stain*)) OR smoking) OR risk factor*)

PubMed Results:

Results: 1250 articles
Filter: humans --> 1160 articles
Filter: 2004-2014 --> 440 articles
Filter: English --> 394 articles
Result: 53 relevant articles

Embase Search Strategy:

'cesarean section' AND ('surgical infection' OR 'postoperative infection' OR 'wound infection') AND (('age' OR 'maternal age') OR ('obese' OR 'obesity' OR 'body mass' OR 'bmi') OR ('diabetes mellitus' OR 'pregnancy diabetes mellitus' OR ('emergency' OR 'elective surgery' OR 'urgency') OR ('prophylaxis' OR 'antibiotic prophylaxis') OR ('american society of anesthesiologists score' OR 'american society of anesthesiologists classification' OR 'american society of anesthesiologist score' OR 'american society of anesthesiology score') OR ('membrane rupture' OR 'premature fetus membrane rupture') OR 'anesthesia' OR 'residence' OR 'trial of labor' OR ('parity' OR 'nullipara' OR 'multipara') OR 'gestational age' OR 'wound assessment' OR ('hypertension' OR 'maternal hypertension' OR 'preeclampsia') OR 'risk index' OR ('meconium' OR 'meconium stained amniotic fluid') OR 'smoking' OR 'risk factor')

Embase Search Results:

Results: 1113
Filter: humans → 1055
Filter: 2004-2015 → 689
Filter: English → 659
Filter: Embase (not Medline) → 621
Filter: articles and reviews → 451
Result: 19 (52 relevant articles less 33 duplicates with Pubmed)

APPENDIX 2 - RISK FACTORS AND OUTCOMES

Institution-Level Variables

Name	RCP, CCI, or ICD code		Derivation for analysis
Total number of Caesarean sections by year per institution			Derived by RCP
Total number of births by year per institution			Derived by RCP

Area-Level

Name	RCP, CCI, or ICD code		Derivation for analysis
Region	dlresreg	Mother's region of residence (western, northern, eastern, and central)	Derived by RCP
Postal code		Second digit of postal code (rural indicator)	Second digit only
Quintile of neighbourhood-level income	qaippe	Neighbourhood-level income	

Maternal Demographics

Name	RCP, CCI, or ICD code		Derivation for analysis
Study-specific mother ID			Derived by RCP; required to adjust for potentially having >1 observation per women
Age	momage_r1	Maternal age	To one decimal place
	momage_int	Maternal age	To one year
Height	dlheight	Maternal height	
Weight	dlweight	Weight just prior to delivery	
Weight	dlprepwt	Pre-pregnancy weight	
Driving time to hospital			Derived by RCP

Name	RCP, CCI, or ICD code		Derivation for analysis
Marital status	dlmrstat	Marital status (proxy for social support)	All codes

Maternal Lifestyle Factors

Name	RCP, CCI, or ICD code		Derivation for analysis
Smoking	dlpresmk	Pre-pregnancy smoking	
Smoking	dlvs1smk	Smoking at first prenatal visit	
Smoking	smoke_20	Smoking at 20 weeks	
Smoking	admitsmk	Smoking at time of admission	
Alcohol and drug abuse	R005	Maternal drug and chemical abuse during pregnancy	All codes
	mabusc	Chemical abuse	All codes

Maternal Medical Conditions

Name	RCP, CCI, or ICD code		Derivation for analysis
Non-obstetric GI disorders affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions)	R015	GI Disease	
	mgids	Gastro-intestinal disease	
	K80^	Cholelithiasis	
	K51^	Ulcerative colitis	
	K52^	Other noninfective gastroenteritis and colitis	
	K50^	Crohn's disease [regional enteritis]	
	K58^	Irritable bowel syndrome	
	K85^	Acute pancreatitis	
	K86^	Other diseases of pancreas	
	K20^ to K31^	Diseases of oesophagus, stomach and duodenum	
Non-obstetric psychiatric conditions affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions)	R016	Psychiatric illness; code if conditions is or was present during the pregnancy	All codes except 200
	mpsil	Psychiatric illness	
	mpsilc	Psychiatric illness	All codes except DEP
	O993^	Mental disorders and diseases of the nervous system complicating pregnancy, childbirth and the puerperium	

Name	RCP, CCI, or ICD code		Derivation for analysis
Non-obstetric psychiatric conditions affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions), continued	F20^ to F29^	Schizophrenia, schizotypal and delusional disorders	
	F31^	Bipolar affective disorder	
	F34^	Persistent mood [affective] disorders	
	F38^	Other mood [affective] disorders	
	F39^	Unspecified mood [affective] disorder	
	F40^ to F48^	Neurotic, stress-related and somatoform disorders	
	F50^ to F59^	Behavioural syndromes associated with physiological disturbances and physical factors	
	F60^ to F69^	Disorders of adult personality and behaviour	
Non-obstetric neurologic conditions affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions)	R017	Neurologic illness	All codes
	R004	Maternal drug therapy during pregnancy/ postpartum period	Code 300
	mnril	Neurologic illness	
	G70^	Myasthenia gravis and other myoneural disorders	
	G510	Bell's palsy	
	G80	Cerebral palsy	
	G40^	Epilepsy	
	G710	Muscular dystrophy	
	G35	Multiple sclerosis	
	G540	Brachial plexus disorders	
Non-obstetric heart conditions affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions)	R018	Heart disease	
	mhrtd	Heart disease	
	mthed	Thromboembolic disease – antepartum	
	I05^ to I09^	Chronic rheumatic heart diseases	
	I10^ to I15^	Hypertensive diseases	
	I20^ to I25^	Ischaemic heart diseases	
	I30^ to I52^	Other forms of heart disease	
	Q20^ to Q28^	Congenital malformations of the circulatory system	
	Z867	Personal history of diseases of the circulatory system	

Name	RCP, CCI, or ICD code		Derivation for analysis
Non-obstetric endocrine disorders affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions)	R019	Endocrine	
	mcrin	Endocrine	
	E00^ to E07^	Disorders of thyroid gland	
	E20^ to E35^	Disorders of other endocrine glands	
Non-obstetric renal disorders affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions)	R020	Renal disease	
	mrenl	Renal disease	
	N00^ to N08	Glomerular diseases	
	N10^ to N16^	Renal tubulo-interstitial diseases	
	N20^ to N23^	Urolithiasis	
	N25^ to N29^	Other disorders of kidney and ureter	
	Q60^ to Q64^	Congenital malformations of the urinary system	
Non-obstetric cancers affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions)	R021	Neoplasms including malignancies	
	mmlig	Neoplasms including malignancies	
	C15^ to C26^	Malignant neoplasms of digestive organs	
	C50^	Malignant neoplasm of breast	
	C51^ to C58^	Malignant neoplasms of female genital organs	
	C73^ to C75^	Malignant neoplasms of thyroid and other endocrine glands	
	C76^ to C80^	Malignant neoplasms of ill-defined, secondary and unspecified sites	
	C81^ to C96^	Malignant neoplasms of lymphoid, haematopoietic and related tissue	

Name	RCP, CCI, or ICD code		Derivation for analysis
Non-obstetric blood dyscrasias affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions)	R022	Blood dyscracias	
	R001	Maternal antibody conditions during pregnancy	Code 2100
	mthrm	Thrombocytopenia	
	mbdys	Blood dyscrasias	
	D696	Thrombocytopenia unspecified	
	D59^	Acquired haemolytic anaemia	
	D682	Hereditary deficiency other clotting factors	
	D67	Hereditary factor IX deficiency	
	D550	Anaemia due to glucose-6-phosphate dehydrogenase [G6PD] deficiency	
	D693	Idiopathic thrombocytopenia purpura	
	D57^	Sickle-cell disorders	
	D56^	Thalassaemia	
	D680	Von Willebrand's disease	
	M311	Thrombotic microangiopathy	
Non-obstetric pulmonary disorders affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions)	R023	Pulmonary disease	
	mpuld	Pulmonary disease	
	J45^	Asthma	
	J80^ to J84^	Other respiratory diseases principally affecting the interstitium	
	J95^ to J99^	Other diseases of the respiratory system	
	E84^	Cystic fibrosis	
	J10^ to J18^	Influenza and pneumonia	
Other not elsewhere classifiable non-obstetric disorders affecting pregnancy (composite dichotomous variable with all non-obstetric health conditions)	R024	Other non-obstetrical condition affecting pregnancy – NEC	
	mothr	Other non-obstetrical disease, not elsewhere classifiable	

Name	RCP, CCI, or ICD code		Derivation for analysis
Pre-existing hypertension	R014	Other obstetrical conditions affecting pregnancy	Codes 700, 800
	mchtd	Chronic hypertensive disorder	
	O11^	Pre-existing hypertensive disorder with superimposed proteinuria	
	O10^	Pre-existing hypertension complicating pregnancy, childbirth and the puerperium	
Gestational hypertension without sign proteinuria	R014	Other obstetrical conditions affecting pregnancy	Code 500
	mpihtc	Pregnancy-induced hypertension	Code NSV
	O13^	Gestational [pregnancy-induced] hypertension without significant Proteinuria	
Gestational hypertension with proteinuria	R014	Other obstetrical conditions affecting pregnancy	Code 600
	mpihtc	Pregnancy-induced hypertension	Codes HLP, SEV
	meclp	Eclampsia	
	O14^	Gestational [pregnancy-induced] hypertension with significant proteinuria	
	O15^	Eclampsia	
Pre-existing hypertension with superimposed protein	R014	Other obstetrical conditions affecting pregnancy	Code 800
	mpihtc	Pregnancy-induced hypertension	Codes HLP, SEV
	meclp	Eclampsia	
	O11^	Pre-existing hypertensive disorder with superimposed proteinuria	
Unspecified hypertension	R014	Other obstetrical conditions affecting pregnancy	Code 550
	O16^	Unspecified maternal hypertension	
	P000	Fetus and newborn affected by maternal conditions that may be unrelated to present pregnancy	
Antihypertensive use in pregnancy	R004	Maternal drug therapy during pregnancy/ postpartum period	Code 400
	mdrugc	Maternal drug use during present pregnancy and/or environmental exposure	Code C03
Pre-existing type 1 diabetes	R014	Other obstetrical conditions affecting pregnancy	Code 900

Name	RCP, CCI, or ICD code		Derivation for analysis
Pre-existing type 1 diabetes, continued	iikdmc	Infant of diabetic mother	Codes CLC, CLD, CLF, CLR
	O24501	Pre-existing type 1 diabetes mellitus in pregnancy delivered, with or without mention of antepartum condition	
	O24504	Pre-existing type 1 diabetes mellitus in pregnancy postpartum condition or complication	
	O240	Pre-existing diabetes mellitus, Type 1	
	E10^	Type 1 diabetes mellitus	
Pre-existing type 2 diabetes	R014	Other obstetrical conditions affecting pregnancy	Code 1000
	iikdmc	Infant of diabetic mother	Code CLB
	O24601	Pre-existing type 2 diabetes mellitus in pregnancy delivered, with or without mention of antepartum condition	
	O24602	Pre-existing type 2 diabetes mellitus in pregnancy delivered, with mention of postpartum complication	
	O24604	Pre-existing type 2 diabetes mellitus in pregnancy postpartum condition or complication	
	O241	Pre-existing diabetes mellitus, Type 2	
	E11^	Type 2 diabetes mellitus	
Gestational diabetes	R014	Other obstetrical conditions affecting pregnancy	Codes 1300, 1400
	iikdmc	Infant of diabetic mother	Codes CLA, CLT, CLU
	O24801	Diabetes mellitus arising in pregnancy (gestational) delivered, with or without mention of antepartum condition	
	O24802	Diabetes mellitus arising in pregnancy (gestational) delivered, with mention of postpartum complication	
	O24804	Diabetes mellitus arising in pregnancy (gestational) postpartum condition or complication	

Name	RCP, CCI, or ICD code		Derivation for analysis
Gestational diabetes, continued	O244	Diabetes mellitus arising in pregnancy	
	O249	Diabetes mellitus arising in pregnancy, unspecified	
	P700	Syndrome of infant of mother with gestational diabetes	
Insulin	R004	Maternal drug therapy during pregnancy/ postpartum period	Code 1100
	minslc	Diabetic therapy	Code INS
Anemia in pregnancy	R014	Other obstetrical conditions affecting pregnancy	Code 500
	Manemc	Anemia	
	O990^	Anaemia complicating pregnancy, childbirth and the puerperium	
	D50^ to D53^	Nutritional anemias	
	D55^ to D59^	Hemolytic anemias	
	D60^ to D64^	Aplastic and other anemias	
Depression	R016	Psychiatric illness; code if conditions is or was present during the pregnancy	Code 200
	mpsilc	Psychiatric illness	Code DEP
Antidepressant use in pregnancy	R004	Maternal drug therapy during pregnancy/ postpartum period	Code 200
	mdrugc	Maternal drug use during present pregnancy and/or environmental exposure	Code C04
Influenza immunization	R028	Immunizations	Code 100
Anticoagulation	R004	Maternal drug therapy during pregnancy/ postpartum period	Code 100
	mdrugc	Maternal drug use during present pregnancy and/or environmental exposure	Code C06

Pregnancy History

Name	RCP, CCI, or ICD code	Derivation for analysis
Parity	dlpara Parity	
Mode of delivery of last pregnancy		Derived by RCP
Previous Caesarean section	dlprevcs # of previous c-sections	
SSI after previous c-section		Derived by RCP; infection of obstetric surgical site or abdominal incision in any previous pregnancy

Pregnancy Characteristics

Name	RCP, CCI, or ICD code		Derivation for analysis
Prenatal classes	dlpnclas	Attendance at prenatal classes or received any prenatal education	
Chorioamnionitis	R051	Placental or cord anomalies	Code 200
	ichor	Chorioamnionitis, marked or severe	
	O411^	Infection of amniotic sac and membranes	
	P027	Fetus and newborn affected by chorioamnionitis	
Procedures performed on mother	R006	Maternal/fetal diagnostic and therapeutic procedures	Codes 1300, 1400, 1500, 1600, 1700, 1800, 1900
	mrsut	Removal of cervical suture	All codes
	mcsut	Cervical encerclage	All codes
	rotation	Rotation method	Codes F, M
	5AC80^^	Suturing of internal cervical os	
	5AC80GU	Suture of internal cervical os vag app	
Steroid use <24 hours before delivery for fetal lung maturity	R068	Maternal systemic steroid therapy	Codes 600, 100, 1100

Name	RCP, CCI, or ICD code		Derivation for analysis
Steroid use 24-47 hours before delivery for fetal lung maturity	R068	Maternal systemic steroid therapy	Codes 200, 700, 1200
Steroid use 48 hours to 1 week before delivery for fetal lung maturity	R068	Maternal systemic steroid therapy	Codes 800, 300, 1300
Steroid use >1 week before delivery for fetal lung maturity	R068	Maternal systemic steroid therapy	Codes 900, 400, 1400
Steroid use unknown time of administration for fetal lung maturity	R068	Maternal systemic steroid therapy	Codes 500, 1000, 1500

Labour

Name	RCP, CCI, or ICD code		Derivation for analysis
Cervical dilation	cdilcs	Cervical dilation during last exam prior to c-section	
Hours from onset of labour to full dilation	dist1st2		Derived by RCP
Hours from onset of labour to rupture of membranes	dist1rom		Derived by RCP
Rupture of Membranes (length)	dmromdel	Hours from rupture of membranes to delivery (longest)	Derived by RCP
Rupture of membranes (type)	ruptmb	Type of rupture of membranes	All codes
Type of labour	R009	Induction of labour	
	dmlabour	Labour status	All codes
	minduct	Reason for induction (first)	All codes
	O61^	Failed induction of labour	
Stage of labour	dmcsstag	Stage of labour before c-section (most serious)	

Name	RCP, CCI, or ICD code	Derivation for analysis
Hours from onset of labour to birth	dist1bth	Derived by RCP
Hours from full dilation to birth	dist2bth	Derived by RCP
Robson criteria		Derived by RCP

Delivery

Name	RCP, CCI, or ICD code		Derivation for analysis
Maternal length of antepartum stay			Derived by RCP
Year of delivery			Derived by RCP
Month of delivery			Derived by RCP
Day of week of delivery (Sunday, etc.)			Derived by RCP
Indication for c-section	dmindcs	Primary indication for c-section (most serious)	
Indication for c-section	indiccs1	Primary indication for c-section	
Indication for c-section	indiccs2	Secondary indication for c-section	
ASA Score	asaclass	ASA score	
Type of c-section	modedel	Mode of delivery	
low segment transverse	5MD60AA	Cesarean section, without instrumentation lower segment transverse incision	
	5MD60CF	Cesarean section, with use of both vacuum and forceps low segment transverse incision	
	5MD60JW	Cesarean section, with use of forceps lower segment transverse incision	
	5MD60JX	Cesarean section, with use of vacuum lower segment transverse incision	

Name	RCP, CCI, or ICD code		Derivation for analysis
cesarean hysterectomy	5MD60CB	Cesarean section, with use of both vacuum and forceps cesarean hysterectomy	
	5MD60KE	Cesarean hysterectomy without instrumentation	
	5MD60RC	Cesarean hysterectomy with use of forceps	
	5MD60RD	Cesarean hysterectomy with use of vacuum	
vertical incision	5MD60CC	Cesarean section, with use of both vacuum and forceps classical section [vertical incision in upper segment]	
	5MD60JY	Cesarean section, without instrumentation classical section [vertical incision in upper segment]	
	5MD60JZ	Cesarean section, with use of forceps classical section [vertical incision in upper segment]	
	5MD60KA	Cesarean section, with use of vacuum classical section [vertical incision in upper segment]	
	5MD60CE	Cesarean section, with use of both vacuum and forceps inverted T incision	
	5MD60KG	Cesarean section, without instrumentation inverted T incision	
	5MD60RA	Cesarean section, with use of forceps inverted 'T' incision	
	5MD60RB	Cesarean section, with use of vacuum inverted T incision	
extraperitoneal section	5MD60CD	Cesarean section, with use of both vacuum and forceps extraperitoneal section	
	5MD60KB	Cesarean section, without instrumentation extraperitoneal section	
	5MD60KC	Cesarean section, with use of forceps extraperitoneal section	
	5MD60KD	Cesarean section, with use of vacuum extraperitoneal section	

Name	RCP, CCI, or ICD code		Derivation for analysis
other type of cesarean section	5MD60CG	Cesarean section, with use of both vacuum and forceps other type of cesarean section NEC	
	5MD60KF	Cesarean laparotomy (for abdominal pregnancy) without instrumentation	
	5MD60RE	Cesarean laparotomy (for abdominal pregnancy) with use of forceps	
	5MD60RF	Cesarean laparotomy (for abdominal pregnancy) with use of vacuum	
	5MD60KT	Cesarean section, without instrumentation other type of Cesarean section NEC	
	5MD60RG	Cesarean section, with use of forceps other type of Cesarean section NEC	
	5MD60RH	Cesarean section, with use of vacuum other type of Cesarean section NEC	
Method of delivery	dmmethod	Method of delivery	C-section codes only
Cesarean section, without instrumentation	5MD60AA	Cesarean section, without instrumentation lower segment transverse incision	
	5MD60JY	Cesarean section, without instrumentation classical section [vertical incision in upper segment]	
	5MD60KB	Cesarean section, without instrumentation extraperitoneal section	
	5MD60KE	Cesarean hysterectomy without instrumentation	
	5MD60KF	Cesarean laparotomy (for abdominal pregnancy) without instrumentation	
	5MD60KG	Cesarean section, without instrumentation inverted T incision	
	5MD60KT	Cesarean section, without instrumentation other type of Cesarean section NEC	

Name	RCP, CCI, or ICD code		Derivation for analysis
Cesarean section, with instrumentation	5MD60CB	Cesarean section, with use of both vacuum and forceps cesarean hysterectomy	
	5MD60CC	Cesarean section, with use of both vacuum and forceps classical section [vertical incision in upper segment]	
	5MD60CD	Cesarean section, with use of both vacuum and forceps extraperitoneal section	
	5MD60CE	Cesarean section, with use of both vacuum and forceps inverted T incision	
	5MD60CF	Cesarean section, with use of both vacuum and forceps low segment transverse incision	
	5MD60CG	Cesarean section, with use of both vacuum and forceps other type of cesarean section NEC	
	5MD60JW	Cesarean section, with use of forceps lower segment transverse incision	
	5MD60JX	Cesarean section, with use of vacuum lower segment transverse incision	
	5MD60JZ	Cesarean section, with use of forceps classical section [vertical incision in upper segment]	
	5MD60KA	Cesarean section, with use of vacuum classical section [vertical incision in upper segment]	
	5MD60KC	Cesarean section, with use of forceps extraperitoneal section	
	5MD60KD	Cesarean section, with use of vacuum extraperitoneal section	
	5MD60RA	Cesarean section, with use of forceps inverted 'T' incision	
	5MD60RB	Cesarean section, with use of vacuum inverted T incision	
	5MD60RC	Cesarean hysterectomy with use of forceps	
	5MD60RD	Cesarean hysterectomy with use of vacuum	

Name	RCP, CCI, or ICD code		Derivation for analysis
Cesarean section, with instrumentation, continued	5MD60RE	Cesarean laparotomy (for abdominal pregnancy) with use of forceps	
	5MD60RF	Cesarean laparotomy (for abdominal pregnancy) with use of vacuum	
	5MD60RG	Cesarean section, with use of forceps other type of Cesarean section NEC	
	5MD60RH	Cesarean section, with use of vacuum other type of Cesarean section NEC	
Method of anesthesia, regional	R010	Anesthesia during labour and delivery	Codes 100, 200, 300, 400, 500
	R011	Anesthesia during labour only	Codes 100, 200, 300, 400, 500
	R012	Anesthesia during delivery only	Codes 100, 200, 300, 400, 500
	mepis	Epidural – single administration	
	mepic	Epidural – continuous catheter with intermittent drug administration	
	mifus	Epidural, continuous infusion of drug (CIEA)	
	mpcea	Patient controlled epidural analgesia	
	msedn	Spinal/epidural double needle	
	mpudl	Pudendal	
Method of anesthesia, general	R010	Anesthesia during labour and delivery	Code 600
	R011	Anesthesia during labour only	Code 600
	R012	Anesthesia during delivery only	Code 600
Antibiotic prophylaxis	R007	Antibiotic therapy administered during intrapartum period (not for GBS)	Code 200
Antibiotic prophylaxis	R007	Antibiotic therapy administered during intrapartum period (for GBS)	Code 400

Name	RCP, CCI, or ICD code		Derivation for analysis
Antibiotic prophylaxis, any	R007	Antibiotic therapy administered during intrapartum period (for GBS)	Codes 200, 400
	mantbc	Antibiotics	Code INT
Number of blood transfusions	R026	Maternal transfusions, blood, and other products	Codes 100-1100 (blood only
Blood loss	mcshmc	Blood loss during Cesarean section	All codes
Placenta previa	mplpr	Placenta previa	
	O44^	Placenta praevia	
	P020	Fetus and newborn affected by placenta praevia	
	O44001	Placenta praevia specified as without haemorrhage, delivered, with or without mention of antepartum condition	
	O44003	Placenta praevia specified as without haemorrhage, antepartum condition or complication	
	O44009	Placenta praevia specified as without haemorrhage, unspecified as to episode of care, or not applicable	
	O44101	Placenta praevia with haemorrhage, delivered, with or without mention of antepartum condition	
	O44103	Placenta praevia with haemorrhage, antepartum condition or complication	
	O44109	Placenta praevia with haemorrhage, unspecified as to episode of care, or not applicable	
Procedures for hemorrhage	R029	Procedures for postpartum hemorrhage	Codes 100, 200, 300, 400
	5PC91LA	Suture uterus post delivery	
	5PC91HU	Manual compress/massage uterus post delivery	
	5PC91HV	Compression using intrauterine balloon	

Name	RCP, CCI, or ICD code		Derivation for analysis
Procedures for hemorrhage, continued	1RM13GQC2	Control of bleeding, uterus and surrounding structures using percutaneous transluminal (transarterial) approach and antihemorrhagic agent	
	1RM13GQW0	Control of bleeding, uterus and surrounding structures using percutaneous (transarterial) approach and synthetic agent	
	1KT51^^	Occlusion, vessels of the pelvis, perineum and gluteal region	
Manual removal of placenta	mmrpl	Manual removal of placenta	
	5PC91HN	Interventions to uterus (following delivery or abortion), manual removal of placenta from uterus (e.g. Brandt Andrews maneuver)	
Excision, partial uterus and surrounding structures	1RM87LAGX	Excision partial, uterus and surrounding structures open approach using device NEC	
Excision radical, uterus and surrounding structures	mhyst	Hysterectomy	
	1RM91LA	Excision radical, uterus and surrounding structures using abdominal approach (e.g. Wertheim operation)	
Excision, ovary	1RB89LA	Excision total, ovary using open approach	
	1RB87DA	Excision partial, ovary using endoscopic (laparoscopic) approach	
	1RB87LA	Excision partial, ovary using open approach	
Excision, fallopian tube	1RF87DA	Excision partial, fallopian tube using endoscopic (laparoscopic) approach	
	1RF87LA	Excision partial, fallopian tube using open approach	
	1RF87RA	Excision partial, fallopian tube using open vaginal approach	
	1RF89LA	Excision total, fallopian tube using open approach	
	1RF89RA	Excision total, fallopian tube using open vaginal approach	

Name	RCP, CCI, or ICD code		Derivation for analysis
Excision total, ovary with fallopian tube	mooph	Salpingo-oophorectomy	
	1RD89DA	Excision total, ovary with fallopian tube using endoscopic [laparoscopic] approach	
	1RD89LA	Excision total, ovary with fallopian tube using open approach	
Occlusion, fallopian tube	1RF51DAFF	Occlusion, fallopian tube endoscopic [laparoscopic] approach using clips [e.g. plastic]	
	1RF51DALV	Occlusion, fallopian tube endoscopic [laparoscopic] approach using ligature (and transection or resection)	
	1RF51FJFF	Occlusion, fallopian tube endoscopic vaginal [culdoscopy, hysteroscopy] approach using clips (e.g. plastic)	
	1RF51FJLV	Occlusion, fallopian tube endoscopic vaginal [culdoscopy, hysteroscopy] approach using ligature (and transection or resection)	
	1RF51LAAL	Occlusion, fallopian tube open approach using bipolar electrode	
	1RF51LAFF	Occlusion, fallopian tube open approach using clips (e.g. plastic)	
	1RF51LALV	Occlusion, fallopian tube open approach using ligature (and transection or resection)	
Surgical repair of obstetric laceration	5PC80JH	Surgical repair, postpartum, of obstetric laceration of corpus uteri [body of uterus]	
	5PC80JK	Surgical repair, postpartum, of current obstetric laceration of cervix occurring at Cesarean section or during surgical termination of pregnancy	
	5PC80JL	Surgical repair, postpartum, of current obstetric laceration of broad ligament(s) of uterus	
	5PC80JM	Surgical repair, postpartum, secondary to uterine incision	

Name	RCP, CCI, or ICD code		Derivation for analysis
Surgical repair of obstetric laceration, continued	5PC80JU	Surgical repair, postpartum of current obstetric high vaginal laceration	
	5PC80JN	Surgical repair, postpartum, secondary (to episiotomy)	
	5PC80JP	Surgical repair, postpartum, of current obstetric laceration of pelvic floor, perineum, lower vagina or vulva	
	5PC80JQ	Surgical repair, postpartum, of current obstetric laceration of rectum and sphincter ani	
	5PC80JR	Surgical repair, postpartum, of current obstetric laceration of bladder and urethra	
Number of surgical repairs of obstetric lacerations			Derived by RCP; sum of surgical repair of obstetric laceration
Maternal length of postpartum stay			Derived by RCP

Fetal or Neonatal Factors

Name	RCP, CCI, or ICD code		Derivation for analysis
Position	posatdel	Presentation at delivery	
Infant birth weight	brthwt	Birth weight	Derived by RCP; rounded to nearest 100 g
Apgar score at 1 minute	apgar1		
Apgar score at 5 minutes	apgar5		
Meconium aspiration	R058	Persistent fetal circulation/persistent pulmonary hypertension of the newborn	Code 400
	IPFCSC	Persistent fetal circulation syndrome	Code MEC
	P240	Neonatal aspiration of meconium	
Number of fetuses	dlnumfet	Number of fetuses	

Name	RCP, CCI, or ICD code		Derivation for analysis
Gestational age	ga_best	Best overall estimate of gestational age	
Gestational age	ga_us	Ultrasound-based gestational age	
Breastfeeding at discharge	bfeeding		
Procedures performed on fetus	R006	Maternal/fetal diagnostic and therapeutic procedures	Codes 100 to 1200
	mamni	Amniocentesis	
	mpolyc	Polyhydramnios	Codes AMN, MUL
	mamnf	Amnioinfusion	
	mchvs	Chorionic villi sampling	
	mchdo	Cordocentesis	
	mfett	Fetal theoracentesis	
	mfettx	Fetal theoracentesis	

Outcomes

Name	RCP, CCI, or ICD code		Derivation for analysis
Infection of obstetrical surgical wound	mwinfc	Wound infection	Code CSN
	mendm	Endometritis	
	N710	Acute inflammatory disease of uterus	
	N719	Inflammatory disease of uterus, unspecified	
	N730	Acute parametritis and pelvic cellulitis	
	O86002	Infection of obstetric surgical wound, delivered, with mention of postpartum complication	
	O86004	Infection of obstetric surgical wound, postpartum condition or complication	
	O86009	Infection of obstetric surgical wound, unspecified as to episode of care, or not applicable	
Disruption of Caesarean section wound	dhis	Wound dehiscence	
	O90002	Disruption of caesarean section wound, delivered, with mention of postpartum complication	
	O90004	Disruption of caesarean section wound, postpartum condition or complication	

Name	RCP, CCI, or ICD code		Derivation for analysis
Disruption of Caesarean section wound, continued	O90009	Disruption of caesarean section wound, unspecified as to episode of care, or not applicable	
	T813	Disruption of operation wound, not elsewhere classified	
Puerperal infection; sepsis	msept	Septicemia	
	mpuer	Puerperal morbidity	
	O85002	Puerperal sepsis, delivered, with mention of postpartum complication	
	O85004	Puerperal sepsis, postpartum condition or complication	
	O85009	Puerperal sepsis, unspecified as to episode of care, or not applicable	
	O86802	Other specified puerperal infections, delivered, with mention of postpartum complication	
	O86804	Other specified puerperal infections, postpartum condition or complication	
	O86809	Other specified puerperal infections, unspecified as to episode of care, or not applicable	
Hematoma (including hemorrhage)	mhemtc	Hematoma	Codes WND, PEL
	O90202	Haematoma of obstetric wound, delivered, with mention of postpartum complication	
	O90204	Haematoma of obstetric wound, postpartum condition or complication	
	O90209	Haematoma of obstetric wound, unspecified as to episode of care, or not applicable	
Inflammation of other pelvic/abdominal organs	mpert	Peritonitis	
	N151	Renal and perinephric abscess	
	L0331	Cellulitis of abdominal wall	
Drainage of hematoma	mevac	Evacuation of hematoma	
	5PC73^^	Drainage postpartum	
Drainage of uterus	1RM52LA	Drainage, uterus and surrounding structures using open approach	

Name	RCP, CCI, or ICD code		Derivation for analysis
Skin drainage	1YS52^^	Drainage, skin of abdomen and trunk	
	1YZ52^^	Drainage, skin NEC	
Abdominal drainage	1OT52HA	Drainage, abdominal cavity using percutaneous (needle) approach	
	1OT52HATS	Drainage, abdominal cavity using percutaneous (needle) approach and leaving drainage tube in situ	
	1OT52LA	Drainage, abdominal cavity using open approach	
	1OT52LATS	Drainage, abdominal cavity using open (incisional) approach and leaving drainage tube in situ	
Excision and debridement	1.SZ.59.^^	Destruction, soft tissue of the chest and abdomen	
	1.YS.59.^^	Destruction, skin of abdomen and trunk	
	1.YS.80.^^	Repair, skin of abdomen and trunk	
	1.YS.87.^^	Excision partial, skin of abdomen and trunk	
Aspiration and curettage	5PC91GC	Interventions to uterus (following delivery or abortion), aspiration and curettage	

APPENDIX 3 - RISK FACTORS STUDIED IN THE LITERATURE

There have been many factors examined in the literature to determine if they increase the risk of SSI. Risk factors listed here were examined in studies that separated their outcome of SSI from other potential outcomes and directly analyzed whether the factor increased the risk of developing SSI after Caesarean section.

Patient-Level Risk Factors

Abortions (recurrent)	Schneid-Kofman (2005) (68)
Age	Salim et al (2012) (1), Amer-Alshiek et al (2013) (6), Menderes et al (2012) (10), Merchavy et al (2007) (11), Corcoran et al (2013) (18), Johnson et al (2006) (30), Wloch et al (2012) (31), Barwolff et al (2006) (32), Mitt et al (2005) (33), Cardoso Del Monte et al (2010) (39), Opoien et al (2007) (40), Olsen et al (2008) (47), Farret et al (2014) (48), Ghuman et al (2011) (51), Gong et al (2012) (52), Henman et al (2012) (54), Vincent et al (2008) (62), Ziogos et al (2010) (63), Esmer et al (2014) (64), Ward et al (2008) (65), Geubbels et al (2006) (67)
Altered immunity	Menderes et al (2012) (10)
Anal exams (number)	Gong et al (2012) (52)
Anemia	Merchavy et al (2007) (11), Mitt et al (2005) (33), Thornburg et al (2012) (69)
Anesthesia method	Salim et al (2012) (1), Hager et al (2004) (8), Merchavy et al (2007) (11), Johnson et al (2006) (30), Wloch et al (2012) (31), Tsai et al (2011) (34), Cardoso Del Monte et al (2010) (39), Gong et al (2012) (52), Vincent et al (2008) (62), Ziogos et al (2010) (63), Thornburg et al (2012) (69)
Anticoagulation during surgery (method)	Wloch et al (2012) (31)
Antibiotic prophylaxis (type)	Amer-Alshiek et al (2013) (6), Alfirevic et al (2010) (86)

Antibiotic prophylaxis (yes or no)	Dinsmoor et al (2009) (16), Smaill et al (2010) (26), Johnson et al (2006) (30), Wloch et al (2012) (31), Mitt et al (2005) (33), Opoien et al (2007) (40), Olsen et al (2008) (47), Farret et al (2014) (48), Gong et al (2012) (52), Brown et al (2013) (60), Vincent et al (2008) (62), Ward et al (2008) (65)
Antibiotic prophylaxis (compliance)	Cardoso Del Monte et al (2010) (39)
Antibiotic prophylaxis (timing)	Owens et al (2009) (12), Thurman et al (2010) (13), Kalaranjini et al (2013) (14), Francis et al (2013) (45), Henman et al (2012) (54), Young et al (2012) (57), Brown et al (2013) (60), Baaqeel et al (2012) (87)
Antibiotic usage	Thornburg et al (2012) (69)
Apgar score (1 minute)	Schneid-Kofman (2005) (68)
Apgar score (5 minutes)	Schneid-Kofman (2005) (68)
ASA score	Wloch et al (2012) (31), Barwolff et al (2006) (32), Mitt et al (2005) (33), Cardoso Del Monte et al (2010) (39), Gong et al (2012) (52), Henman et al (2012) (54), Ziogos et al (2010) (63), Ward et al (2008) (65), Geubbels et al (2006) (67)
Bacterial vaginosis	Mitt et al (2005) (33), Opoien et al (2007) (40)
Blood loss (amount)	Salim et al (2012) (1), Wloch et al (2012) (31), Mitt et al (2005) (33), Cardoso Del Monte et al (2010) (39), Opoien et al (2007) (40), Ghuman et al (2011) (51), Gong et al (2012) (52), Vincent et al (2008) (62), Ziogos et al (2010) (63), Ward et al (2008) (65), Al Jama et al (2012) (66)
Blood transfusion (maternal)	Schneid-Kofman (2005) (68)
BMI (first prenatal visit)	Magann et al (2013) (9), Wloch et al (2012) (31)
BMI (pre-pregnancy)	Salim et al (2012) (1), Amer-Alshiek et al (2013) (6), Corcoran et al (2013) (18), Wloch et al (2012) (31), Thornburg et al (2012) (69)
BMI (delivery)	Stamilio et al (2014) (46), Olsen et al (2008) (47), Gong et al (2012) (52), Al Jama et al (2012) (66)

BMI (unspecified)	Menderes et al (2012) (10), Johnson et al (2006) (30), Cardoso Del Monte et al (2010) (39), Opoien et al (2007) (40), Farret et al (2014) (48), Ghuman et al (2011) (51), Brown et al (2013) (60), Ziogos et al (2010) (63), Ward et al (2008) (65)
Cardiovascular condition	Ziogos et al (2010) (63)
Catheterizations (number)	Gong et al (2012) (52)
Catheterization (urinary)	Farret et al (2014) (48), Vincent et al (2008) (62)
Cervical dilation	Koifman et al (2009) (59), Gungorduk et al (2009) (70), Allen et al (2005) (71), Liabsuetrakul et al (2011) (88)
Chorioamnionitis	Mitt et al (2005) (33), Olsen et al (2008) (47), , Al Jama et al (2012) (66), Thornburg et al (2012) (69)
Chronic respiratory disease	Ziogos et al (2010) (63)
Colonization (GBS)	Olsen et al (2008) (47)
Community infection	Cardoso Del Monte et al (2010) (39)
Complications	Wloch et al (2012) (31), Gong et al (2012) (52)
Congenital malformations	Schneid-Kofman (2005) (68)
Creatinine (amount)	Ziogos et al (2010) (63)
Diabetes (any)	Wloch et al (2012) (31), Olsen et al (2008) (47), Thornburg et al (2012) (69)
Diabetes (gestational)	Menderes et al (2012) (10), Henman et al (2012) (54), Al Jama et al (2012) (66), Geubbels et al (2006) (67), Schneid-Kofman (2005) (68), Son et al (2015) (85)
Diabetes (pre-existing)	Takoudes et al (2004) (49), Henman et al (2012) (54), Ziogos et al (2010) (63), Geubbels et al (2006) (67), Schneid-Kofman (2005) (68), Son et al (2015) (85)
Diabetes (unspecified)	Salim et al (2012) (1), Merchavy et al (2007) (11), Mitt et al (2005) (33), Cardoso Del Monte et al (2010) (39), Farret et al (2014) (48), Brown et al (2013) (60), Esmer et al (2014) (64)
Drain usage	Menderes et al (2012) (10), Olsen et al (2008) (47), Thornburg et al (2012) (69), Hellums et al (2007) (89)

Duration of labour	Mitt et al (2005) (33), Cardoso Del Monte et al (2010) (39), Olsen et al (2008) (47), Farret et al (2014) (48), Ghuman et al (2011) (51), Brown et al (2013) (60), Al Jama et al (2012) (66), Geubbels et al (2006) (67)
Duration of surgery	Salim et al (2012) (1), Menderes et al (2012) (10), Johnson et al (2006) (30), Wloch et al (2012) (31), Barwolff et al (2006) (32), Mitt et al (2005) (33), Cardoso Del Monte et al (2010) (39), Opoien et al (2007) (40), Ghuman et al (2011) (51), Gong et al (2012) (52), Henman et al (2012) (54), Brown et al (2013) (60), Ziogos et al (2010) (63), Esmer et al (2014) (64), Ward et al (2008) (65), Al Jama et al (2012) (66)
Electrocauterization	Cardoso Del Monte et al (2010) (39)
Ethnicity/race	Merchavy et al (2007) (11), Wloch et al (2012) (31), Olsen et al (2008) (47), Farret et al (2014) (48), Ghuman et al (2011) (51), Thornburg et al (2012) (69)
Fat closure	Wloch et al (2012) (31)
Fertility treatments	Schneid-Kofman (2005) (68)
Fetal birth weight	Hager et al (2004) (8), Thornburg et al (2012) (69)
Fever	Amer-Alshiek et al (2013) (6), Opoien et al (2007) (40), Brown et al (2013) (60), Vincent et al (2008) (62)
Foreign material	Menderes et al (2012) (10)
Gestational age/preterm delivery	Hager et al (2004) (8), Corcoran et al (2013) (18), Wloch et al (2012) (31), Cardoso Del Monte et al (2010) (39), Farret et al (2014) (48), Gong et al (2012) (52), Thornburg et al (2012) (69)
Gravidity	Menderes et al (2012) (10)
Subcutaneous hematoma	Olsen et al (2008) (47)
Hemoglobin (preoperative)	Farret et al (2014) (48), Esmer et al (2014) (64), Gong et al (2012) (52)
Hemoglobin (postoperative)	Esmer et al (2014) (64)
Hemorrhage (postpartum)	Thornburg et al (2012) (69)
HIV status	Farret et al (2014) (48)
Hospital stay (preoperative)	Mitt et al (2005) (33), Farret et al (2014) (48), Ward et al (2008) (65), Geubbels et al (2006) (67)
Hospital stay (length of previous stay)	Farret et al (2014) (48)

Hospital stay (length of postoperative)	Opoien et al (2007) (40)
Hospital stay (total length)	Farret et al (2014) (48), Gong et al (2012) (52), Henman et al (2012) (54), Ziogos et al (2010) (63)
Hospital type (private vs teaching)	Olsen et al (2008) (47)
Hypertension (any)	Ziogos et al (2010) (63)
Hypertension (gestational)	Geubbels et al (2006) (67)
Hypertension (preeclampsia)	Mitt et al (2005) (33), Esmer et al (2014) (64), Thornburg et al (2012) (69),
Hypertension (mild preeclampsia)	Schneid-Kofman (2005) (68)
Hypertension (severe preeclampsia)	Schneid-Kofman (2005) (68)
Hypertension (pre-existing)	Schneid-Kofman (2005) (68)
Hypertension (unspecified)	Merchavy et al (2007) (11), Cardoso Del Monte et al (2010) (39), Farret et al (2014) (48)
Indication for surgery	Cardoso Del Monte et al (2010) (39), Gong et al (2012) (52), Geubbels et al (2006) (67)
Indigenous status	Henman et al (2012) (54)
Internal fetal monitoring	Salim et al (2012) (1), Mitt et al (2005) (33), Olsen et al (2008) (47)
Intrauterine growth restriction (suspected)	Schneid-Kofman (2005) (68)
Labour (failed induction)	Al Jama et al (2012) (66), Schneid-Kofman (2005) (68)
Labour (induced)	Allen et al (2006) (5), Schneid-Kofman (2005) (68)
Labour (prolonged; time not specified)	Farret et al (2014) (48)
Labour (yes/no)	Allen et al (2006) (5), Allen et al (2003) (73)
Labour (non-progressing first stage)	Schneid-Kofman (2005) (68)
Labour (non-progressing second stage)	Schneid-Kofman (2005) (68)
Labour (stage)	Pergialiotis et al (2014) (72)
Leukocyte count (preoperative)	Farret et al (2014) (48)
Malpresentation	Schneid-Kofman (2005) (68), Thornburg et al (2012) (69)
Meconium staining	Gong et al (2012) (52), Schneid-Kofman (2005) (68)
Nationality	Mitt et al (2005) (33), Opoien et al (2007) (40)
Non-reassuring fetal heart rate	Schneid-Kofman (2005) (68)
Number of diagnoses (at discharge)	Geubbels et al (2006) (67)
Other procedures during surgery	Cardoso Del Monte et al (2010)
Oxygen during surgery (amount)	Williams et al (2013) (90)

Parity	Salim et al (2012) (1), Amer-Alshiek et al (2013) (6), Menderes et al (2012) (10), Mitt et al (2005) (33), Cardoso Del Monte et al (2010) (39), Opoien et al (2007) (40), Ghuman et al (2011) (51), Gong et al (2012) (52), Vincent et al (2008) (62), Ziogos et al (2010) (63), Esmer et al (2014) (64), Thornburg et al (2012) (69)
Payer status (insurance type)	Olsen et al (2008) (47)
Perinatal mortality	Schneid-Kofman (2005) (68)
Placenta previa	Schneid-Kofman (2005) (68), Thornburg et al (2012) (69)
Placental abruption	Schneid-Kofman (2005) (68)
Placental removal (manual)	Merchavy et al (2007) (11), Mitt et al (2005) (33)
Polyhydramnios	Merchavy et al (2007) (11)
Pre-existing disease	Gong et al (2012) (52)
Pre-existing infection	Gong et al (2012) (52)
Prenatal care (yes/no)	Ziogos et al (2010) (63), Al Jama et al (2012) (66) , Shrestha et al (2014) (91)
Prenatal visits (number of visits)	Mitt et al (2005) (33), Cardoso Del Monte et al (2010) (39), Farret et al (2014) (48)
Preoperative clip usage	Menderes et al (2012) (10)
Previous abdominal surgery	Menderes et al (2012) (10)
Previous Caesarean section (number)	Salim et al (2012) (1), Alchalabi et al (2007) (4), Amer-Alshiek et al (2013) (6), Gasim et al (2013) (7), Merchavy et al (2007) (11), Corcoran et al (2013) (18), Wloch et al (2012) (31), Silver et al (2006) (50), Brown et al (2013) (60), Vincent et al (2008) (62), Esmer et al (2014) (64), Schneid-Kofman (2005) (68)
Place of residence (rural vs urban)	Salim et al (2012) (1)
Risk index	Wloch et al (2012) (31), NNIS (2004) (35), Edwards et al (2009) (36), Friedman et al (2007) (53)
Room type (private, semiprivate, public)	Corcoran et al (2013) (18)
Rupture of membranes (yes/no)	Salim et al (2012) (1), Merchavy et al (2007) (11), Johnson et al (2006) (30), Gong et al (2012) (52), Brown et al (2013) (60), Vincent et al (2008) (62), Ziogos et al (2010) (63), Esmer et al (2014) (64), Ward et al (2008) (65), Al Jama et al (2012) (66), Thornburg et al (2012) (69), Schneid-Kofman (2005) (68), Shrestha et al (2014) (91)

Rupture of membranes (duration)	Amer-Alshiek et al (2013) (6), Cardoso Del Monte et al (2010) (39), Opoien et al (2007) (40), Farret et al (2014) (48), Ghuman et al (2011) (51), Henman et al (2012) (54), Ziogos et al (2010) (63), Geubbels et al (2006) (67)
Rupture of membranes (at admission)	Cardoso Del Monte et al (2010) (39)
Sexually transmitted disease	Olsen et al (2008) (47), Brown et al (2013) (60)
Skin incision (type)	Menderes et al (2012) (10), Wylie et al (2010) (15), Olsen et al (2008) (47), Maars et al (2014) (55), Thornburg et al (2012) (69), Shrestha et al (2014) (91)
Skin preparation (method)	Henman et al (2012) (54)
Smoking during pregnancy	Menderes et al (2012) (10), Olsen et al (2008) (47), Farret et al (2014) (48), Ghuman et al (2011) (51), Brown et al (2013) (60)
Steroids (corticosteroids)	Ziogos et al (2010) (63)
Subcutaneous closure	Menderes et al (2012) (10), Esmer et al (2014) (64), Thornburg et al (2012) (69)
Subcutaneous thickness	Esmer et al (2014) (64)
Surgeon grade/level of training/speciality	Salim et al (2012) (1), Menderes et al (2012) (10), Merchavy et al (2007) (11), Corcoran et al (2013) (18), Johnson et al (2006) (30), Wloch et al (2012) (31), Ward et al (2008) (65)
Suture type	Shrestha et al (2014) (91)
Time in delivery room	Salim et al (2012) (1)
Trial of labour	Amer-Alshiek et al (2013) (6)
Twin pregnancy	Schneid-Kofman (2005) (68)
Urgency (elective/emergency)	Salim et al (2012) (1), Amer-Alshiek et al (2013) (6), Menderes et al (2012) (10), Merchavy et al (2007) (11), Corcoran et al (2013) (18), Johnson et al (2006) (30), Mitt et al (2005) (33), Cardoso Del Monte et al (2010) (39), Opoien et al (2007) (40), Olsen et al (2008) (47), Farret et al (2014) (48), Ghuman et al (2011) (51), Gong et al (2012) (52), Henman et al (2012) (54), Brown et al (2013) (60), Vincent et al (2008) (62), Ziogos et al (2010) (63), Esmer et al (2014) (64), Ward et al (2008) (65), Al Jama et al (2012) (66), Geubbels et al (2006) (67), Thornburg et al (2012) (69), Shrestha et al (2014) (91)

Urinary tract infection (at admission)	Vincent et al (2008) (62)
Urinary tract infection (during pregnancy)	Brown et al (2013) (60), Vincent et al (2008) (62)
Vaginal cleansing before surgery	Yildirim et al (2012) (92)
Vaginal exams (number)	Salim et al (2012) (1), Mitt et al (2005) (33), Olsen et al (2008) (47), Farret et al (2014) (48), Gong et al (2012) (52), Ziogos et al (2010) (63), Al Jama et al (2012) (66), Shrestha et al (2014) (91)
Wound closure (method)	Menderes et al (2012) (10), Corcoran et al (2013) (18), Johnson et al (2006) (30), Wloch et al (2012) (31), Figueroa et al (2013) (44), Olsen et al (2008) (47), Ghuman et al (2011) (51), Henman et al (2012) (54), Brown et al (2013) (60), Ward et al (2008) (65)
Wound contamination class	Wloch et al (2012) (31), Barwolff et al (2006) (32), Cardoso Del Monte et al (2010) (39), Geubbels et al (2006) (67)

<u>Maternity Unit/Hospital-Level Risk Factors</u>

Number Caesarean sections/month	Vincent et al (2008) (62)
Number of deliveries/month	Vincent et al (2008) (62)
Number of vaginal deliveries/month	Vincent et al (2008) (62)
Year of participation in surveillance system	Barwolff et al (2006) (32)