MATERNAL OVERWEIGHT AND OBESITY: THE RISK OF CAESAREAN BIRTH

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Maternal Overweight and Obesity: The Risk of Caesarean Birth

by

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ABSTRACT

Maternal Overweight and Obesity: The Risk of Caesarean Birth

Purpose: To examine the relationship between pre-pregnancy overweight/obesity and caesarean birth, in labouring women, in the St. John's region.

Methods: Using administration data from the Provincial Perinatal Database, this study examined 1,065 women from the St. John's region with live births between January 1, 2002 to November 30, 2003.

Results: 151 (14.2%) women delivered by caesarean and 914 (85.8%) delivered vaginally. 519 (48.7%) were overweight/obese, 505 (47.4%) had acceptable weight, and 41 (3.8%) were underweight. Multiple logistic regression found that, after controlling for maternal age, parity, fetal size and pregnancy weight gain, obese/overweight women (BMI $\geq$ 25) are 1.53 times (95% CI 1.04-2.26) more likely to give birth by caesarean than women of healthy body weight (BMI 18.5 to 24.9)

Conclusion: Women who are overweight/obese prior to pregnancy are at increased risk for caesarean birth. Preconception and prenatal education promoting dietary and lifestyle modifications may reduce risk of caesarean birth.

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LIST OF ABBREVIATIONS

ACOG	American College of Obstetricians and Gynecologists
BMI	Body Mass Index
CIHI	Canadian Institute for Health Information
DAD	Discharge Abstract Data
EFM	Electronic Fetal Monitoring
ECV	External Cephalic Version
ICAN	International Caesarean Awareness Network
ICD 10	International Statistical Classification of Diseases and Related Health Problems, 10th Revision
IOM	Institute of Medicine
NLCHI	Newfoundland and Labrador Centre for Health Information
RCOG	Royal College of Obstetricians and Gynaecologists
SOGC	Society of Obstetricians and Gynaecologists of Canada
VBAC	Vaginal Birth After Caesarean
WHO	World Health Organization

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1.1 The Problem

1.1.1 Caesarean Birth

Caesarean birth has long been a part of human culture. According to Greek mythology, Apollo removed Asclepius, founder of the famous cult of religious medicine, from his mother's abdomen. The name "caesarean" is possibly derived from Roman law decreed under Caesar, that all women dead or dying in childbirth must be cut open to save the child, in an attempt to increase the state population. It was not until the nineteenth century that this operation was performed to preserve the mother's life (Sewell, 1998).

Today, caesarean birth is a common operative procedure. Capable physicians with readily accessible support services and the relative assurance of well-being for mother and baby can perform it. Escalation of the caesarean birth rate over the last 30 years has triggered debate concerning its over use. The World Health Organization (1985), from an examination of various national caesarean rates and maternal and perinatal mortality rates, advocates a maximum caesarean birth rate of 10 to 15% of all births, while the United States Healthy People 2010 project is targeting a 15% primary, or first time, caesarean rate for women by 2010 (Ohio Hospital Association, 2001).

In Canada, the caesarean birth rate increased from 6% of all births in 1970 to 19% in 1998 (Health Canada, 2000). The latest statistics available, for the years 2001-2002, show that Canada's caesarean birth rate has reached an all-time high of 22.5% of all births (Canadian Institute for Health Information, [CIHI], 2004). Newfoundland and Labrador has not only surpassed the national average every year since 1970, but has had the highest provincial rate since 1970, with the exception of 1984-85 and 2000-02

(Buehler & Moore-Orr, 1994; Health Canada 2003; CIHI). In 2001-02, the caesarean birth rate in Newfoundland and Labrador increased to 26.6% of all births (CIHI). The caesarean birth rate also varies regionally within Newfoundland, from 24.8% in Central to 31.5% in Eastern (CIHI).

This rising caesarean birth rate is also evident globally. The annual statistics vary from concerns of a 40% high in Brazil and Chile, and 23% in the developed countries of the United States, Italy, and Australia. In contrast, lower rates are still evident in Scandinavia at 12% and 9.2% in the Netherlands (International Caesarean Awareness Network, [ICAN], 2002).

The primary caesarean rate is the number of women having caesarean birth for the first time and this rate is also increasing. In Canada, the primary caesarean rate for 1998-99 was 14% of all births. The latest statistic from 2001-02, now reports an increase of the primary caesarean rate to 16.5%, which is comparable to that of the United States, England, Wales and Northern Ireland (CIHI, 2004). Within Canada, Newfoundland and Labrador again surpasses the national average, with a primary caesarean rate of 19.4%. Here too, the primary caesarean rate also varies regionally within the province, from 16.2% in Central to 23.7% in Eastern (CIHI).

There have been many efforts made to lower the caesarean birth rate. Canada, Scotland and the United States, have implemented clinical guidelines and promoted vaginal birth after caesarean (VBAC) (Health Canada, 2003). The results of these guidelines have been the stabilization of caesarean birth rates in the United States and Canada, but not in Scotland (RCOG, 2001).

Caesarean birth is not without maternal risk. The maternal mortality rate of a caesarean birth is three to seven times greater than for vaginal birth (American College of Obstetricians and Gynaecologists, [ACOG], 2000). Intraoperative complications include hemorrhage due to extension of the incision, placenta accreta, uterine atony, urinary tract injury, and injuries to the gastrointestinal tract increased by previous surgery or infection. Infection is the most common postoperative complication of caesarean birth, with the rate of uterine infection ranging from 10 to 50%, compared to the vaginal birth infection rate of 1 to 3% (ACOG). Caesarean birth increases the risk of placenta accreta, placenta previa, and scar dehiscence in subsequent pregnancies (McAleese, 2001). In Canada, the maternal mortality ratio is 6.1 per 100,000 live births, and the most common direct obstetric causes of death are pulmonary embolism, hypertensive disorders of pregnancy, amniotic fluid embolism, intra-cranial hemorrhage, ectopic pregnancy and hemorrhage (Health Canada, 2004). The leading causes of maternal mortality as a result of caesarean birth are deep vein thrombosis and pulmonary embolism (ACOG).

In terms of economic implications on a societal level, caesarean birth generally results in an increased maternal hospital stay and a longer physical recovery period, leading to higher hospitalization costs. In Newfoundland and Labrador, the average maternal length of a hospital stay is 5.5 days for caesarean births as opposed to 3.4 days for vaginal births (Health Canada, 2003). The longer hospital stay prolongs separation from family, and interferes with maternal care of the newborn.

A number of factors have been shown to increase the incidence of caesarean birth, such as variations in the practices of the delivering physician from working in teaching hospitals as opposed to private non-teaching facilities, increased maternal age, short maternal height, parity, and maternal socioeconomic status (Cnattingius, Cnattingius, & Notzon, 1998; Brost et al.1997). Maternal overweight and obesity are also related to a higher incidence of caesarean births, and a higher risk of anesthetic and postoperative complications in these births (Galtier-Dereure, Boegner, & Bringer, 2000).

1.1.2 Obesity

The World Health Organization (WHO) defines obesity as "a condition of abnormal or excessive fat accumulation in adipose tissue, to the extent that health may be impaired" (Health Canada, 2002a). Obesity is considered to be a disease in its own right as well as a major risk factor for other non-communicable diseases, such as coronary heart disease and diabetes. According to WHO there are more than 300 million obese adults worldwide, leading to a "modern day epidemic" (Frohlich, 2002). Obesity and overweight are particularly increasing in the Western world and have become a great public health concern. To date, the best estimate of body fat is the international standard of Body Mass Index (BMI). According to this index, adults are overweight if their BMI is between 25.00 and 29.99, and obese if their BMI is 30.00 or greater (WHO, 1998). The prevalence of overweight among American adults has increased by 61% from 1991 to 2000; roughly 97 million Americans are overweight, and of these, nearly 39 million are classified as obese (North American Association for the Study of Obesity, 2001). As documented by the 2003 Canadian Community Health Survey, 24.5% of Canadian women are overweight, and 13.3% are obese (Government of Newfoundland and Labrador, 2004). In Newfoundland and Labrador, the rate of overweight and obesity surpasses the national average; 29.5% of women are overweight while 19.3% are obese (Government of Newfoundland and Labrador).

Obesity during pregnancy predisposes women to increased risk of complications, such as gestational diabetes, hypertensive disorders, thrombophlebitis, prolonged labour, shoulder dystocia, cephalopelvic disproportion, and caesarean births, compared to average weight women (Edwards, Hellerstedt, Alton, Story, & Himes, 1996, and Jensen, Agger, & Rasmussen, 1999). Obese women who undergo caesarean delivery are at significantly increased risk for failed intubation, failed epidural placement, prolonged operative time, blood loss, postoperative endometritis, and prolonged hospitalization (Perlow & Morgan, 1994). Studies have also demonstrated that as prepregnancy maternal weight increases, so does birth weight (Schaefer-Graf, Heuer, Kilavuz, Pandura, Henrich, & Vetter, 2002)

1.2 Purpose of the Study

The aim of this study was to explore the relationship between pre-pregnancy overweight and obesity and the risk for caesarean birth in a labouring patient, in the St. John's region of Newfoundland and Labrador (research objective 1). Thus, the research question was as follows: Do pre-pregnancy overweight or obesity increase the occurrence of caesarean birth in labouring women, in the St. John's region of Newfoundland and Labrador?

Studies have documented that maternal obesity and overweight are risk factors in the occurrence of caesarean birth. I hypothesized that since Newfoundland and Labrador exceeds the national average in both caesarean birth rates, and overweight and obesity, that pre-pregnancy overweight or obesity increases the risk of caesarean birth among labouring women from the St. John's region. As well, studies have demonstrated a positive correlation between gestational weight gain, short stature, increased fetal size (newborn birth weight) and incidence of caesarean birth. This raised four secondary objectives to be addressed through this research study:

2) To examine the relationship between maternal height and incidence of caesarean birth: I hypothesized that decreased maternal height (i.e. short women) increases the risk of caesarean birth.
3) To examine the relationship between weight gain in pregnancy and incidence of caesarean birth: I hypothesized that gaining more than the recommended amount of weight in pregnancy, increases the risk of caesarean birth.
4) To examine the relationship between newborn birth weight and the incidence of caesarean birth: I hypothesized that large newborns increases the risk of caesarean birth.
5) To examine the relationship between maternal pre-pregnancy weight and newborn birth weight: I hypothesized that overweight or obese women are at increased risk for having large newborns.

1.3 Rationale

In Newfoundland and Labrador, the rate of female overweight or obesity and the caesarean birth rate, both exceed the national average. As obesity and overweight are associated with significantly increased risks of diabetes, hypertension, and coronary heart disease, this places a tremendous burden on healthcare utilization and costs. Other studies suggest pregnancy and childbirth are also affected by maternal weight, as overweight and obesity significantly increase birth weight and risk of caesarean birth, resulting in major economic consequences and serious complications for mother and child. However, the relationship between pre-pregnancy weight, gestational weight gain, maternal height and newborn birth weight has not been studied in a Newfoundland and Labrador population.

Maternal overweight and obesity is one of the few risk factors affecting pregnancy outcome that can be modified by alterations in nutrition and lifestyle behaviours, before a pregnancy. The results of this study can contribute to improving pregnancy outcomes by providing evidence based information to care providers and policy makers, to assist women of childbearing age to understand the importance of both healthy pre-pregnancy weight and gestational weight gain.

1.4 St. John's Region

At the time this study was conducted, Newfoundland and Labrador was divided into six regions for health and community services: St. John's, Eastern, Central, Western, Grenfell, and Labrador. These six regions were served by fourteen health boards that oversaw the delivery of services in the various regions. These boards were responsible for hospital and nursing home services, community health services, and cancer care (Government of Newfoundland & Labrador, 2002).

As shown in Figure 1, the area included in this study was the St. John's region included under the former Institutional Health Board of the Health Care Corporation of St. John's and St. John's Nursing Home Board. This region extended from St. Catherine's on the southern shore to Conception Bay South, the northeast Avalon, St. John's, Mount

Pearl and Bell Island[1].

Within this region, the Health Care Corporation of St. John's (now part of Eastern Health) is responsible for hospital services. It provides services to about 200,000 people, and serves as the major referral center for the whole province (Health Care Corporation of St. John's, 2004). Women's Health services are provided within the Health

Sciences Center, of Eastern Health. All births within the St. John's area are designated to occur at the Women's Health Center. In addition, it is the referral site for all

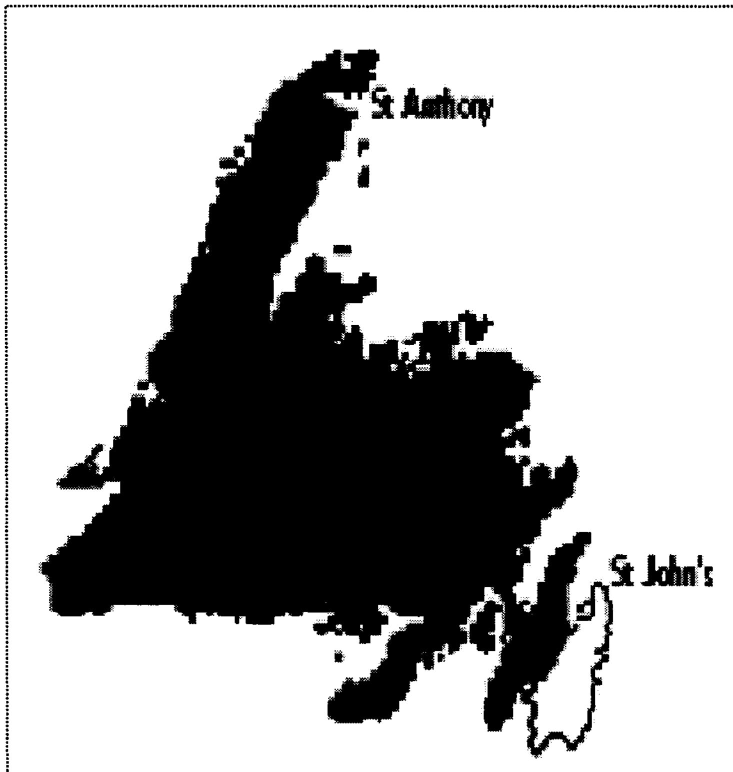

Figure 1. Map of St. John's Region
under the former Institutional Health Board of the Health Care Corporation of St. John's and St. John's Nursing Home Board
(Government of Newfoundland and Labrador, 2002)

[1]On April 1, 2005, these six health and community services regions and 14 health boards were integrated into four regional health authorities, and St. John's was incorporated under the Eastern Regional Integrated Health Authority (known as Eastern Health).

high-risk obstetrics in Newfoundland and Labrador. The total number of births recorded for the year 2002 at the Health Sciences Center was 2,193 (M. French, professional assistant to the program director of Women's Health, personal communication, April 29, 2003).

1.5 Definitions

The following terminology is defined as it is frequently used throughout this study.

Caesarean section is the surgical delivery of the fetus through an incision in the uterus. It is performed for a variety of fetal and maternal reasons. The indications are considered either absolute in which caesarean section is mandated, or relative in which the decision is based on the specific situation (Buckley & Kulb, 1993).

Caesarean birth rate is the number of deliveries by caesarean section expressed as a percentage of the total number of deliveries, in a given place and time (Health Canada, 2000a).

Primary caesarean rate is the number of caesarean deliveries to women who have not previously had a caesarean birth, expressed as a percentage of all deliveries to women who have not had a previous caesarean birth (Health Canada, 2000a).

Repeat caesarean rate is the number of caesarean deliveries to women who have had a caesarean birth previously, and expressed as a percentage of all births to women who have had a previous caesarean birth (Health Canada, 2002a)

Study caesarean rate is the number of caesarean deliveries to women who have laboured, not excluding those women who had a previous caesarean delivery, and is expressed as a percentage of the total number of deliveries from the study population.

Body Mass Index (BMI) measures weight for height. BMI is calculated by weight in kilograms divided by the square of height in meters (kg/m^2) (Health Canada, 2002). This measurement has some limitations, as it does not provide an estimate of fat distribution, such as abdominal fat. As outlined in Table 1, the international standard of BMI classifies adults as follows:

Table 1. International Standard of Adult BMI Classification (Statistics Canada, 2002)

Classification of Adults	**Body Mass Index**
Underweight	Less than 18.5
Acceptable weight	18.5 to 24.9
Overweight	25.0 to 29.9
Obese	30.0 or higher

A **nulliparous** woman is one who has not completed a pregnancy with a fetus (or fetuses) that has reached the stage of viability (Lowdermilk, Perry, & Bobak, 2000)[2]

A **primiparous** woman is one who has completed one pregnancy with a fetus or fetuses, who have reached the stage of fetal viability (Lowdermilk et al.)

A **multiparous** woman is one who has completed two or more pregnancies to the stage of fetal viability (Lowdermilk et al.).

Macrosomia, also known as high birth weight, is birth weight equal to or greater than 4000 grams or 8.8 pounds (Reproductive Health Report Working Group, 2004). Some sources, such as the American College of Obstetricians and Gynaecologists use 4500 grams or 9.9 pounds to define macrosomia (Haram, Pirhonen, & Bergsjo, 2002).

Large for Gestational Age infants have a birth weight above the 90th percentile of appropriate for gestational age infants (Reproductive Health Report Working Group,

[2] For study purposes, women pregnant or labouring with their first child were referred to as nulliparas

2004).

Low Birth Weight infants have a birth weight less than 2500 grams (Reproductive Health Report Working Group, 2004).

Small for Gestational Age (SGA) infants have a birth weight below the 10^{th} percentile of appropriate for gestational age infants (Reproductive Health Report Working Group, 2004).

Antenatal (or prenatal) means occurring before birth (May & Mahlmeister, 1994).

Antepartum means occurring before onset of labour (May & Mahlmeister, 1994).

Intrapartum means occurring during labour or birth (May & Mahlmeister, 1994).

Postnatal (partum) period is the period from birth to 6 weeks (42 days) after birth (May & Mahlmeister, 1994).

2.0 Literature Review

There is wide variation in the caesarean birth rates between countries, provinces and states, hospitals, and practitioners. As well, patient demographics and characteristics are also associated with varying rates of caesarean birth rates. For example, maternal age of first pregnancy is increasing and the rate of caesarean birth has been shown to increase with age. Yet Scandinavia, with similar demographic changes as Canada, has not reported the same increase in the caesarean birth rate (RCOG, 2001).

Many studies have tried to investigate the factors that may have contributed to this variation and increase of the caesarean birth rate over the last thirty years. This section of the thesis aims to address where my research falls within the current body of research and knowledge. It will identify gaps that my research will address.

2.1 Indications for Caesarean Birth

Absolute indications for caesarean birth are those conditions for which mother or fetus or both would die without surgical intervention. They include cephalopelvic disproportion, transverse or oblique lie of the fetus, placenta previa, major placental abruption, prolapse of the umbilical cord and severe preeclampsia (McAleese, 2001). However, more than 70% of caesarean births are the result of the following four relative indications in which the medical decision is based on the specific situation: failure to progress (or dystocia), non-reassuring fetal heart rate pattern, breech presentation, and repeat caesarean section. As the rates of caesarean births vary depending upon the degree of these relative four indications in institutions and geographic regions, they will be discussed in greater detail in this paper.

2.1.1 Failure to Progress (Dystocia)

In nulliparous patients, dystocia accounts for as much of 50% of caesarean births, compared with less than 5% of caesarean deliveries performed on multiparous women for dystocia (ACOG, 2000). A study by the Maternal Health Study Group of the Canadian Perinatal Surveillance System, attributed 63.9% of first time caesarean births to dystocia (Liu, et al. 2004).

The first stage of labour is composed of both the latent and active phases, of which the latent phase precedes the active phase and can last up to twenty hours in the nulliparous patient. A long latent phase is a time of increased stress for the pregnant woman, and it is in an effort to relieve this stress that clinicians are moved to intervene (Society of Obstetricians and Gynaecologists of Canada, [SOGC],1995). The proper diagnosis of when the active phase of labour begins, as opposed to the latent phase, is important in the management of dystocia. A diagnosis of dystocia should not be made prior to the active phase of labour (SOGC).

To facilitate the management of dystocia, the Society of Obstetricians and Gynaecologists of Canada have implemented clinical practice guidelines. Other jurisdictions have used an active management of labour approach. At the National Maternity Hospital in Dublin, Ireland, a program of "active management of labour" was initially implemented to reduce the length of labour, but was also found to be associated with a low rate of caesarean birth (O'Driscoll, Foley, & MacDonald, 1984). The premise of this technique is that labour is actively managed by a coordinated policy of early detection and effective treatment of abnormal uterine action. O'Driscoll et al., demonstrated that active management of labour was particularly effective in reducing the caesarean birth rate for nulliparous patients with dystocia, and cited a caesarean birth rate of 4.8 percent in 8,742 births. Central to this labour management technique is a definitive and standardized diagnosis of labour, rupture of membranes, oxytocin regimen, one to one nursing care, and prenatal education regarding protocol. Although active management of labour is widely known and practiced, opinions vary as to its actual benefits. Studies, such as those by Rogers, Gilson, Miller, Izquierdo, Curet, & Qualls (1997), and Turner, Brassill, & Gordon (1988), reported a significant decrease in the caesarean birth rate for dystocia after active management was introduced. However, a large randomized trial in Boston by Frigoletto et al. (1995), concluded that active management of labour did have some benefits, such as shorter labour and decreased incidence of maternal fever, but did not reduce the rate of caesarean birth in nulliparous women.

2.1.2 Non-Reassuring Fetal Heart Rate Pattern

Fetal hypoxic acidemia is generally accepted as occurring in pregnancy when there is an abnormal fetal heart rate pattern associated with a fetal blood (scalp) pH of less than 7.20 and base deficit greater than 16 mmol/L (SOGC, 2002). A fetus exposed to a sufficient amount and period of hypoxic academia can be left brain damaged with adverse neurological sequelae, other organ damage, or death. The goal of fetal surveillance is to identify fetuses with hypoxic academia at a point in time where the process is completely reversible by intrauterine resuscitation or expedited delivery (SOGC. The Maternal Health Study Group of the Canadian Perinatal Surveillance System, attribute 17.1% of the total increase in caesarean delivery rates to caesarean deliveries performed for fetal distress, 19.5% for primary caesareans and 4.2% for repeat caesarean births (Liu et al., 2004).

2.1.3 Breech Presentation

According to the Canadian Consensus on Breech Management at Term (1994), approximately 3 to 4% of all fullterm pregnancies present with a fetus in the breech presentation and in 2000-01, 4.9% of all caesarean births and 8.3% of primary caesarean births were attributable to breech presentation (Liu et al., 2004). A breech presentation occurs when the fetal buttocks, feet, or knees, are nearest the cervical opening and are born first. A breech presentation may be considered frank when the thighs may be flexed and the legs extended over the anterior surfaces of the body; or complete with the thighs flexed on the abdomen and the legs upon the thighs; or footling with one or both feet, or one or both knees, presenting first (Cunningham et al., 1993).

Vaginal birth versus caesarean birth for breech presentation is a controversial issue. Caesarean delivery primarily increases the risk to the mother, whereas a vaginal breech birth results in greater risk to the fetus (Buckley & Kulb, 1993). Fears in a vaginal breech birth are head entrapment in an incompletely dilated cervix, and the concern of extended fetal arms and hyperextension of the fetal head (ACOG, 2000). It is interesting to note, that some of the largest increases in caesarean birth rates due to breech presentation are in such countries as Denmark and the Netherlands, which also report the lowest caesarean birth rates in developed countries (Moore-Orr & Buehler, 1994).

A meta-analysis of randomized trials and cohort studies by Gifford, Morton, Fiske, & Kahn (1995) indicated that, generally, planned caesarean birth for breech presentation has better fetal outcomes, than vaginal breech births. A Cochrane meta-analysis of three randomized trials (including the multi-centered Term Breech Trial, involving 26 countries), found a significant reduction in adverse perinatal outcomes, and modest increase in maternal morbidity with planned caesarean birth, compared with planned vaginal birth (Hofmeyr & Hannah, 2000). A follow-up study to the Term Breech Trial also indicated no additional increased risks for women who had planned caesarean births, than women who had planned vaginal births (Hannah et al. 2002).

External cephalic version (ECV) is the conversion of the fetus from the breech to the cephalic (head) presentation (Buckley & Kulb, 1993). Studies have found that ECV at term is associated with a significant reduction in breech births and caesarean deliveries (RCOG, 2001). This procedure is also viewed by the American College of Obstetricians and Gynecologists as a strategy to reduce the rate of caesarean deliveries for breech presentation, and obstetricians are encouraged to perform ECV at 37 weeks of gestation or greater, if there are no contraindications (ACOG, 2000).

Given the increasing use of caesareans for breech presentations, there is concern that physicians may not have adequate skills to manage breech presentations by vaginal births. This could place a woman who delivers vaginally at increased risk for a poor outcome, due to physician inexperience (Cochrane Review, 2000).

The American College of Obstetricians and Gynecologists state that a planned vaginal delivery of a term singleton breech may no longer be appropriate. Patients with persistent breech presentation at term in a singleton should undergo a planned caesarean delivery (ACOG, 2001). The Society of Obstetricians and Gynaecologists in Canada, meanwhile, have developed a policy statement regarding management of breech presentation at term that incorporates guidelines to assist physicians in their clinical practice.

2.1.4 Repeat Caesarean Section

This category is the single largest contributor to the caesarean delivery rate. Approximately one third of all caesarean births occur as the result of a previous caesarean delivery (Paul & Miller, 1995). Management of previous caesarean delivery used to be under the frequently quoted guide by Edwin Cragin, 1916, of "once a caesarean, always a caesarean"(as cited by Walker, Turnbull & Wilkinson, 2002).

Now, a recent effort to increase the rate of vaginal birth after caesarean (VBAC) is a primary strategy to reduce the rate of caesarean delivery. However, there is wide variation in the proportion of women undergoing VBAC between countries. The VBAC rate refers to the number of women delivering by VBAC, divided by the total number of women bearing children after a previous caesarean delivery, times 100 (ACOG, 2000). In 1997, the American VBAC rate of 27.4% contrasted sharply with that of 50.0% in Europe (ACOG). Meanwhile, as of 2001-02, Canada's VBAC rate was 26.7% (CIHI, 2004). Currently, Newfoundland and Labrador's provincial VBAC rate is the lowest in Canada at 12.5%, while the VBAC rate of Women's Health in St. John's is 14.4% (CIHI, 2004).

It is accepted that a trial of labour following a caesarean birth involves some degree of risk for both mother and fetus, in that there is always a risk of uterine rupture, however small (SOGC, 2005). However, according to the Special Report on Maternal Mortality and Severe Morbidity in Canada (2004), the rate of uterine rupture has increased to 0.92 per 1,000 deliveries, from 0.58 per 1,000 deliveries in 1991-93. The authors of this report believe this may be attributable to changes in clinical practice, as the increase in the rate of uterine rupture has occurred simultaneously with the increase in the practice of VBAC.

Currently, the Society of Obstetricians and Gynaecologists of Canada suggest that, where there are no contraindications, a woman with one previous transverse low-segment caesarean birth, can safely give birth vaginally (2005). SOGC have developed VBAC clinical practice guidelines to assist physicians in their clinical management and to ensure both the obtainment of an informed patient consent and provision of appropriate hospital facilities capable of providing an emergency caesarean section. Contra-indications to VBAC by SOGC include; previous classical or inverted "T" uterine scar; previous hysterotomy or myomectomy entering the uterine cavity; previous uterine rupture; presence of any contraindications to labour, such as placenta previa or malpresentation; or the woman declines a trial of labour after caesarean and requests an elective repeat caesarean. For women with more than one previous transverse low segment caesarean section or delivering within 18 to 24 months of a caesarean birth, labour and vaginal delivery is an option. However, the incidence of uterine rupture is higher than that associated with one previous section or greater spacing between births (SOGC, 2005).

2.2 Medical Factors That Influence Caesarean Birth Rates

The rates of caesarean births are affected by both medical and nonmedical factors. Medical or obstetrical factors that influence caesarean birth rates are management of dystocia, breech presentation, fetal distress, and VBAC rates as previously discussed. Additional medical factors are extremely low birth weight, actual or suspected fetal macrosomia, labour induction, use of epidural analgesia and electronic fetal monitoring in labour. To avoid repetition, macrosomia will be discussed under induction and newborn birth weight.

2.2.1 Extremely Low Birth Weight

Low birth weight (less than 2500 grams) may result from preterm birth or restricted intrauterine growth, and in Canada in 2001, 6% of all births were less than 2500 grams (CIHI, 2004). As well in Canada, the rate of preterm birth has increased to 7.6% of all babies born in 2000, from 6.6% of babies prematurely born in 1991 (CIHI). Preterm birth increases the risk of nonvertex (other than a head) presentation and susceptibility of a fragile infant to trauma (ACOG, 2000).

The most common indications for caesarean birth in the extremely low birth weight (<800 grams) and extremely preterm (<26 weeks) infants are breech presentation and non-reassuring fetal heart rate changes (Bottoms et al., 1997). In a study by the National Institute of Child Health and Human Development of Maternal-Fetal Medicine Units in Maryland, the authors concluded, that after controlling for birth weight, a physician's view of the pregnancy as viable and the subsequent willingness to perform a caesarean significantly increased the likelihood of survival (Bottoms et al.). Redman and

Gonik (2002) reported that the rise in very pre-term caesarean birth was not accompanied by a change in neonatal mortality rates over time during the study period, and thereby could not ascertain whether the outcome of extremely preterm fetuses was improved by caesarean delivery. Currently, the management of extreme prematurity still raises concerns of medical, socioeconomic and ethical dilemmas, and there is still a paucity of evidence to determine which perinatal strategy is best to optimize outcome (Hakansson, Farooqi, Holmgren, Serenius and Hogberg, 2004). A joint statement with the Society of Obstetricians and Gynaecologists of Canada and the Canadian Pediatric Society (1994) recommended that for infants of 23 and 24 weeks gestation, careful consideration should be given to the limited benefits of the infant and potential harms of caesarean birth. However, caesarean birth for infants of 25 and 26 weeks gestation is recommended, when indicated.

2.2.2 Induction of Labour

Induction of labour is the artificial initiation of labour before its spontaneous onset for the purpose of delivery of the feto-placental unit (SOGC, 2001). Currently in Canada, about one in five pregnant women undergo labour induction, with the most common indication being for post term pregnancy of 41 completed weeks (Health Canada, 2003; SOGC). Induction of labour prior to 41 weeks is associated with increased caesarean delivery rates (ACOG, 2000). Both the Society of Obstetricians and Gynaecologists of Canada and the American College of Obstetricians and Gynecologists state that induction should be considered when the benefits outweigh the potential maternal or fetal risks of this procedure (SOGC; ACOG).

According to Flamm, Berwick & Kabcenell (1998), avoiding unnecessary inductions may be the key to decreasing unnecessary caesarean births for failed inductions. Inductions for nonmedical factors, such as social and geographic reasons, must alert physicians to evaluate the true need for labour induction in the first place.

In a study by Ekblad & Grenman (1992) obese women and women with excessive gestational weight gain were at increased risk for labour induction, compared to women with normal pre-pregnancy weight and normal gestational weight gain, possibly to prevent large for dates infants. The management of patients with suspected fetal macrosomia is controversial and elective induction, at or near term, has been proposed to prevent possible maternal and perinatal complications (Sanchez-Ramos, Bernstein, & Kaunitz, 2002). Literature reviews by Sanchez-Ramos et al. and Haram, Pirhonen, & Bergsjo (2002), found labour induction for the sole reason of suspected fetal macrosomia results in increased caesarean rates without improving perinatal outcomes.

The Society of Obstetricians and Gynaecologists of Canada (2001) recommends the indication for labour induction should be discussed with the patient, listing all potential benefits and risks. In addition, if the cervix is unfavorable for induction, ripening should be considered with prostaglandin, misoprostol, or mechanical methods. The American College of Obstetricians and Gynecologists (2000) have proposed that institutions and practitioners with high caesarean rates for low risk nulliparous women, should be reviewed to see how many of these patients underwent labour induction prior to 41 completed weeks of gestation.

2.2.3 Epidural Analgesia

More than 50% of labouring women in the United States receive epidural analgesia (Zhang, Yancey, Klebanoff, Schwarz, & Schweitzer, 2001). In Canada, the rate of epidurals for vaginal births was 45.4%, while the provincial rate for Newfoundland and Labrador was 34.4% (CIHI, 2004). The epidural rate of women in labour at the Health Care Corporation of St. John's for the years 2002-03 was 47.6% (Provincial Perinatal Program, 2003).

An epidural block is a type of regional (an area of the body) analgesia produced by injection of a local anesthetic into the epidural (peridural) space (Lowdermilk et al. 2000). It is generally agreed that epidural analgesia provides the most effective pain relief in labour, yet it remains controversial whether it increases the risk of caesarean births. A review of studies by the American College of Obstetricians and Gynecologists (2000) found considerable evidence suggesting there is an association between the use of epidural analgesia for labour and the risk of caesarean delivery. Women receiving epidurals have an increased risk for caesarean birth when compared to women who experience labour without epidural analgesia. However, as most studies are not randomized, it is possible that reported positive associations are the result of uncontrolled confounding.

Epidural analgesia slows labour, and is associated with increased use of oxytocin and operative births (King, 1997). It appears that the risk for caesarean birth is less if epidural analgesia is administered after the active phase of labour has started, and the fetal presenting part has advanced into the lower half of the maternal pelvis (ACOG, 2000).

Perlow & Morgan (1994) studied the risks specific to obese women undergoing caesarean birth. The authors found that there was significant difficulty in the administration of epidural analgesia to massively obese women (weighing more than 300 pounds) resulting in an increased risk for failed epidural placement. Perlow & Morgan recommend anesthesia/analgesia consultation on admission when in labour, and emphasized the potential benefit of prophylactic epidural catheter placement, so as to potentially decrease perinatal and anesthetic complications that may result from emergency placement of either regional or general anesthesia.

2.2.4 Electronic Fetal Monitoring (EFM)

The goal of fetal surveillance in labour is to improve outcomes by identifying those fetuses with hypoxia at a time when the process is reversible either by appropriate interventions or expedient delivery (SOGC, 2002). It was perhaps by coincidence that the increase in the caesarean rate in the early 1970s paralleled the increase of electronic fetal monitoring (ACOG, 2000). However, research has indicated that EFM, compared to intermittent auscultation (listening for the fetal heart by either stethoscope, hand-held Doppler ultrasound, or by the intermittent use of the external ultrasound transducer of an electronic monitor at recommended intervals), has not improved fetal or neonatal outcome, and has been associated with an increase in the rate of caesarean births, operative vaginal deliveries, and anesthesia (SOGC). Researchers hypothesize that EFM is related to an increased caesarean rate due to inconsistent interpretation of EFM patterns, the additive effect of mild EFM changes with other developing problems, and the decreased likelihood of electronically monitored patients to ambulate in labour (ACOG, 2000).

2.3 Nonmedical Factors That Influence Caesarean Birth Rates

Nonmedical factors are those affecting the caesarean birth rate that cannot be explained totally by obstetrical or medical differences (ACOG, 2000). These are variations in geography, institutions, physician characteristics, fear of obstetrical litigation, midwifery, labour support, and maternal characteristics such as socioeconomic status, smoking, caesarean request, age, parity, height, pre-pregnancy weight, gestational weight gain, and newborn birth weight.

2.3.1 Geographic Regions

Caesarean birth rates vary considerably between countries. In the developed world, high rates of 24 and 22% in Portugal and the United States, contrast with the low rates of 9.2 and 12% in the Netherlands and Sweden (ICAN, 2002). In some developing countries, like Malaysia and Chile, the caesarean birth rates have risen to 27 and 40% respectively of all births.

Additionally, the caesarean birth rates also vary considerably within countries. In the United States, caesarean birth rates are lower in the western and midwestern states (14.6 and 17.2% in Hawaii and New Mexico respectively) compared to the southern and northeastern states (28.3 and 27% in Mississippi and New Jersey respectively) (ICAN, 2002). In Canada, the caesarean birth rates are as low as 9.2 and 18.2% in Nunavut and Manitoba respectively, and as high as 27.9 and 27.1% in Prince Edward Island and British Columbia respectively (CIHI, 2004). Additionally, the Canadian primary caesarean rates vary from a low of 7.6 and 12.4% again in Nunavut and Manitoba respectively, and as high as 21.9 and 21% respectively in the Yukon and Prince Edward Island (CIHI).

Regional variations within provinces also exist. In Newfoundland and Labrador, the 2001-02 caesarean rates vary from 24.8% in the Central Region to 31.5% in the Eastern Region, while primary caesarean rates vary again from 16.2% in the Central Region, to 23.7% in the Eastern Region (CIHI, 2004).

There is very little information in the literature regarding factors contributing to regional and provincial variation. It may possibly be the result of such factors as patient income and education level, practitioner training and call schedules, availability of anesthesiology services, and women's and practitioners' expectations about the conduct, course, and duration of labour and pain management (Kirby & Hanlon- Lundberg, 1999). Variation between countries may be attributed to differences in the availability of private versus public health care, and specific cultural and social factors which lend themselves to labour and delivery management (Murray & Pradenas, 1997).

2.3.2 Institutional Variations

Caesarean birth rates are lower in teaching hospitals, than in non-teaching institutions (ACOG, 2000). In the state of Utah, Clark, Xu, Porter, & Love (1998) found that teaching institutions with the availability of in-house obstetric and anesthesiology specialists, high number of deliveries, urban location, and the presence of maternal-fetal medicine and newborn intensive care units, have a lower caesarean birth rate for uncomplicated patients. The authors believe that this is attributable to increased expertise in the interpretation of fetal heart rate patterns, improved understanding of the processes of normal and abnormal labour, and peer review.

With regard to this study, the Women's Health Center is the obstetrical high-risk referral site for Newfoundland and Labrador. It has all the characteristics as cited by Clark et al; a large urban teaching hospital, the availability of in-house obstetricians, neonatalogists and anesthesiologists, high number of deliveries, and the presence of maternal-fetal medicine and neonatal intensive care units.

2.3.3 Physician Characteristics

Increased attention has been directed toward the clinical behavior of individual physicians, as a factor influencing the caesarean birth rate. According to American studies, caesarean birth rates are higher for male obstetricians (ACOG, 2000). Klasko, Cummings, Balducci, DeFulvio, & Reed (1995) stated that physician characteristics, such as group versus solo practice, may affect the type of delivery. The authors demonstrated that the presence of in-hospital attending physician coverage lowered the primary caesarean rate, thereby reducing or eliminating the physician "convenience factor". In addition, caesarean birth rates may vary as a result of different philosophies in the management of labour and deliveries, resulting in different maternity care practices (Baruffi, Strobino, & Paine, 1990).

2.3.4 Fear of Litigation

As threats of maternal complications and mortality have decreased with enhanced safe caesarean medical services, the focus now is on fetal outcome. The public has expectations of a "perfect outcome" and when any adverse or compromised event occurs, questions are asked, care is scrutinized and statements such as "a caesarean should have been done sooner" are debated (Paul & Miller, 1995). Society's attitudes regarding legal recourse has placed care providers under a constant threat of litigation. Localio et al. (1993) demonstrated a positive association between malpractice risk and the odds of caesarean delivery. The fact that most obstetricians have been sued for medical malpractice in the United States at least once, has promoted caesarean births as good defensive medicine (ACOG, 2000). According to the Canadian Medical Protective Association, one in seven obstetricians/gynaecologists can expect to be sued in Canada every year (Sibbald, 1999).

Nelson, Dambrosia, Ting & Grether (1996) who critically assessed long term outcomes, showed that only a small percentage of cases of cerebral palsy can be attributed to labour events. A suggested strategy by the American College of Obstetricians and Gynecologsts is to educate physicians, nurses, lawyers and the public, regarding the actual relationship between brain damage and perinatal events, with a recommendation for reform of medical liability laws and legal procedures (ACOG, 2000). The Society of Obstetricians and Gynaecologists of Canada have promoted an intensive two-day ALARM (Advances in Labour and Risk Management) session for specialists to learn the latest clinical guidelines concerning high-risk situations in an attempt to reduce their risk (Sibbald, 1999).

2.3.5 Midwifery

Midwifery practice is based on the concepts of health and well-being. Childbearing is viewed as a normal physiologic process for most women, and midwives work alone or in collabouration with other health providers to provide continuity of care from preconception, through pregnancy, labour, birth, and the postpartum period (Association of Midwives of Newfoundland and Labrador, 2001). Obstetrical care which is organized to include the full skills of nurse-midwives, has low rates of intervention, good outcomes, and is cost effective compared with physician-only care (Schimmel, Schimmel, & DeJoseph, 1997). A study by Butler, Abrams, Parker, Roberts, & Laros (1993) documented midwifery patients were at lower risk than physician patients for being diagnosed with abnormal labour or non reassuring heart rate changes, and caesarean birth. The authors listed the characteristics of nurse-midwife labour management that reduced the risk of caesarean birth as one to one labour support, and promotion of patient ambulation (to increase comfort, decrease the need for analgesia and anesthesia, and shorten labour). Additionally, as midwives act as an additional active voice, more time may elapse before medical intervention, thereby permitting further labour progress (Butler et al.).

Presently in Newfoundland and Labrador, there are no licenses issued by the Provincial Government permitting the practice of midwives in this province. However, there is a special agreement between the Department of Health and Community Services, the Newfoundland Medical Board, and the Association of Registered Nurses of Newfoundland and Labrador, that enables midwives who are nurses employed in the Labrador-Grenfell Region (coastal Labrador, Goose Bay and the Great Northern Peninsula) to practice midwifery (Association of Midwives of Newfoundland and Labrador, 2001).

2.3.6 Labour Support

Labour support is continuous support provided to the mother during labour, either by nurses, midwives, or lay people (doulas). Support is defined as including tangible assistance (physical comfort), emotional support (presence, listening, reassurance, and affirmation), and advice and information (Davies & Hodnett, 2002). A Cochrane meta-analysis determined that the continuous presence of a support person during labour can reduce the likelihood of caesarean birth (Hodnett, 2002). Also, such support decreased the need for pain relief, and reduced the likelihood of operative vaginal delivery (forceps or vacuum extraction) and a five-minute Apgar score less than seven.

2.3.7 Maternal Socioeconomic Status

Gould, Davey, & Strafford (1989) of the United States demonstrated a strong relationship between maternal socioeconomic status and the rate of primary caesarean birth. In countries that do not have a national health care system, poor women who are likely to give birth in public hospitals, have a lower caesarean birth rate compared to higher income women delivered by private-practice physicians. In Chile, caesarean birth rates in private facilities tend to be much higher than in public institutions, with recorded rates of between 50 and 70% (Murray & Pradenas, 1997).

In Canada, there is general access to standardized antenatal and obstetric care. Alternatively, Gould et al. (1989) stated that different clinical decision-making rules may be applied to poor women regardless of differences in the health care settings, due to either socioeconomic differences in patients' attitudes toward benefits of obstetrical intervention, or greater social congruity between obstetricians and middle-class patients resulting in different clinical management.

There is discrepancy in the literature on the level of maternal education and risk of caesarean birth. Studies cited by Gould et al. (1989), and Johnson, Longmate, & Frentzen (1992), state a higher caesarean rate among college-educated women, than those who had not completed high school. However, Harlow et al. & the RADIUS Study Group (1995) state women with less than a college education had a slightly greater risk for caesarean birth compared with college-educated women, and R. Cnattingius et al. (1998) in Sweden state a lack of influence of maternal education on risk for caesarean birth.

2.3.8 Maternal Requests

The idea that a woman should have the right to demand that her baby be delivered surgically is an emotional and debatable issue. In fact, the British media have labeled the 5% of pregnant women, identified by a Royal College of Obstetricians and Gynaecologists National Sentinel Audit, who requested a caesarean birth although not medically indicated as "to posh to push"(Feinmann, 2002). The debate over maternal choice for elective caesarean births has been on going for some time in the United Kingdom, and is now topical in North America. At the 51st annual meeting of the American College of Obstetricians and Gynecologists, a second scientific session was devoted to caesarean delivery on demand (Peck, 2003).

The two opposing ideologies in this maternal choice debate are childbirth as a risky event in need of medical interventions versus childbirth as a normal, healthy process, with interventions when only specifically indicated (Young, 2000). Yet both want a safe and healthy pregnancy outcome. In the United Kingdom, a constructive effort is being started to understand and come to grips with these issues over practice and maternal choice, by the National Institute for Clinical Excellence's set of evidence based guidelines (Feinmann, 2002).

In Hong Kong and China, there has been an increasing trend for caesarean request for an uncomplicated pregnancy. According to Yin King Lee, Holroyd, & Ng (2001), this is influenced by the desire to ensure a perfect birth outcome, the cultural value placed on medical care as a sign of influence, concern over neonatal morbidity, and a belief based on fortune related to correct birth and birth data. A literature review by McAeese (2001) for the Association of Radical Midwives, summarized women's reasons for a choice caesarean included psychosocial factors, such as fear of giving birth and previous traumatic delivery. According to the author, women with these psychosocial factors should be treated with psychological care rather than surgery.

In Canada, the Society for Obstetricians and Gynaecologists released an advisory statement in March 2004 regarding cesarean birth on demand. The SOGC stated that a decision to perform surgery should be based on medical indications, and strongly recommends continuous support during labour and birth to promote natural childbirth. Ultimately, the SOGC believes that every woman should be completely informed of all options for labour and birth, and that the final decision rests between the individual and her health care provider as to the safest birthing route (2004).

2.3.9 Maternal Age

In Canada, the proportion of live births to older mothers has been steadily increasing over the past 19 years. In 2000, 41.9% of all live births in Canada were to women 30 years and older, compared with 23.7% in 1981 (Health Canada, 2003; 2000). This trend was also evident in all health regions of Newfoundland and Labrador (Newfoundland and Labrador Center for Health Information, [NLCHI], 2000).

Women aged 30 years and older, have a 2 to 3 times higher rate of caesarean delivery (Institute of Medicine, [IOM], 1989). The reason is unclear, but is possibly attributed to increased incidence of pregnancy complications (such as labour dysfunction, cephalopelvic disorders and fetal non-reassuring heart rate pattern changes), age-related physiological changes, or changes in maternal or clinician preferences (RCOG, 2001; IOM; Health Canada, 2000). In Sweden and Hungary, nulliparous women aged 30 to 34 years faced an increased risk of caesarean delivery (odds ratio 2.6 and 2.5 respectively), even though the risks of pregnancy complications and adverse outcomes were considered modest (R. Cnattingius et al.1998; Kozinsky et al, 2002). R. Cnattingius et al. suggested that even in a country with a low caesarean rate like Sweden, older nulliparous women are more likely to be delivered by caesarean for other reasons than medical ones. In the study by the Maternal Health Study Group of the Canadian Perinatal Surveillance System, older maternal age was again cited as a strong risk factor for Caesarean birth. In 2000/01, the caesarean birth rate ranged from a low of 13.8% for women < 20 years of age to 34.6% among women 40 years of age and older (Liu et al., 2004).

As more women are delaying childbirth, the issue of a higher caesarean birth rate for first time mothers is significant. In Canada, the primary caesarean rate for women ≥ 35 years of age is 20.6% compared to the 15.7% rate for women < 35 years (CIHI, 2004). In Newfoundland and Labrador, the primary caesarean rates once again surpasses the national average, with a 24.3% rate for women ≥ 35 years of age compared to the 18.9% rate for women < 35 years (CIHI).

2.3.10 Parity

The risk of caesarean birth in a first pregnancy differs from subsequent pregnancies. According to studies reviewed by the Royal College of Obstetricians and Gynaecologists in the National Sentinel Caesarean Section Audit (2001, p.29), the rate of caesarean births is lowest in (a) women who have only ever had previous vaginal births, (b) increased in women who have had a previous caesarean birth, and (c) reduced in women who have had a previous vaginal delivery in addition to their previous caesarean birth. Joseph et al. (2003) also reported in their study from Nova Scotia that increases in the primary caesarean delivery rates are explained by changes in maternal characteristics, such as reduced parity.

2.3.11 Maternal Height

Johnson, Longmate, & Frentzen (1992) reported that in their adjusted analyses of unscheduled caesarean births, maternal height exhibited a more significant effect than BMI or pre-pregnancy weight. Johnson et al. postulated that maternal height probably serves as a better indicator of pelvic size when analyzed alone, than when expressed in the ratio that defines BMI. In a Swedish study of low risk nulliparous women, R. Cnattingius et al. (1998) reported that the effect of pre-pregnant BMI on caesarean birth rate is influenced by maternal height. Tall and lean women have the lowest caesarean birth rate (5%), followed by tall and obese (11%), and short and lean (19%), with the highest caesarean birth rate (36%) being short and obese women. Both Kaiser & Kirby

(2001) and Witter, Caulfield & Stoltzfus (1995) documented increased risk of caesarean birth with a maternal height of 1.55 meters or less.

Harlow et al. (1995) reported with each 10 cm increase in height there was a 40% decrease in risk for maternal indicated caesarean births, such as failure to progress, failed induction, failed forceps or vacuum extraction, preeclampsia, and gestational diabetes, and a 30% decrease in risk for fetal indicated caesarean births, such as fetal distress and macrosomia.

Both R. Cnattingius et al. (1998) and Brabin, Verhoff, & Brabin (2002) attribute the differences in risk for caesarean birth by maternal height to the differences in risk of cephalopelvic disproportion. Maternal short stature and its correlation with pelvic size, rather than birth weight, is a critical risk factor in caesarean births.

2.3.12 Maternal Pre-pregnancy Weight

American studies have noted a significant association between high maternal pre-pregnancy weight (obesity) and an increased risk of caesarean birth. Crane, Wojtowycz, Dye, Aubrey & Artal (1997), Baeten, Bukusi, & Lambe (2001), and Garbaciak, Richter, Miller & Barton (1985) demonstrated an increased risk of caesarean birth with increasing body mass index category or maternal weight. Baeten et al. emphasized that even overweightness in nulliparous women increases the risk of gestational diabetes, pregnancy induced hypertension and caesarean birth, compared with lean women. Garbaciak et al., however, reported that maternal weight in itself is not associated with a poorer pregnancy outcome in the absence of antenatal complications, but there is an association between maternal obesity and increased antenatal complications. In very obese patients with no antenatal complications, increased risk of intrapartum complications also exists.

A Danish study by Jensen, Agger, & Rasmussen (1999) investigated the influence of pre-pregnancy BMI on labour complications. Contrary to American studies, Jensen et al. noted an increasing but statistically insignificant trend towards more caesarean births in the overweight and obese groups. Instead, overweight and obesity were statistically associated with primary labour inertia and to a less, but significant degree, with secondary labour inertia and cephalopelvic disproportion. This is of course an interesting conclusion, given the low Scandinavian caesarean birth rate of 12% (ICAN, 2002).

Studies have demonstrated a significant relationship between risk of caesarean birth and massive obesity. Perlow, Morgan, Montgomery, Towers, & Porto (1992), and Isaacs, Magann, Martin, Chauhan, & Morrison (1994) of the United States, along with an Arab study by Kumari (2001), all indicated massively obese women have a greater incidence of primary caesarean births than lean women, and are at increased risk for chronic hypertensive disorders and both non-insulin and insulin-dependent diabetes mellitus. Kumari also found a significantly higher rate of gestational diabetes and pregnancy induced hypertension in morbidly obese women. Perlow et al., in contrast to the other two studies, concluded that when those subjects with insulin-dependent diabetes mellitus and/or chronic hypertension were excluded from the analysis, no statistical difference remained. Isaacs et al. (1994) concluded that the indication for caesarean birth in massively obese women is more likely the result of cephalopelvic disproportion.

Harlow et al. (1995) documented in an epidemiological study of low risk nulliparous women, that maternal anthropometric factors are more strongly associated with the incidence of caesarean birth for maternal indications, such as failure to progress, failed induction, pregnancy induced hypertension, diabetes, and failed forceps or vacuum extraction, than for fetal indications, such as fetal distress and macrosomia. Harlow et al. reported that for every ten kilogram increase in prepregnancy weight, there was a 25% increase in risk for maternal indicated caesarean births compared to a 13% increase for fetal indications. Garbaciak et al. (1985) and Crane et al. (1997) have postulated that the increased risk of caesarean birth with increased maternal weight and BMI may be the result of dystocia due to an increased deposition of soft tissues in the maternal pelvis, narrowing the diameters of the birth canal.

Perlow & Morgan (1994) found massively obese women (weighing more than 300 pounds) to be at significantly increased risk for failed epidural placement, emergency caesarean section, prolonged labour and total operative times, blood loss, postoperative infection, and prolonged hospitalization. Perlow et al. (1992) also indicated significant risk of massive obesity resulting in neonatal admission to the intensive care unit.

2.3.13 Gestational Weight Gain

Maternal weight gain during pregnancy is an important determinant in both the incidence of large and small for gestational age infants (Cogswell, Serdula, Hungerford & Yip, 1995). The Society of Obstetricians and Gynaecologists of Canada (1998) recommends that the optimal weight gained during pregnancy depends on the pre-pregnancy weight, and may vary from 6.8 to 18.2 kilograms, or 15 to 40 pounds, with underweight women and teenagers being encouraged to gain at the upper end of this range. In addition, the SOGC does not advocate weight loss by obese women during pregnancy. The Institute of Medicine, in the United States, published guidelines in 1990 also based on pre-pregnancy BMI. Women entering pregnancy underweight with a BMI less than 19.8 should gain 12.7 to 18.2 kg (28 to 40 lb), average BMI between 19.8 and 26.0 should gain 11.4 to 15.9 kg (25 to 35 lb), overweight BMI between 26.1 and 29 should gain 6.8 to 11.4 kg (15 to 25 lb), and obese BMI greater than 29.0 should gain only 6.0 kg (13 lb) (Caulfield, Stoltzfus, & Witter, 1998). Health Canada's guidelines for gestational weight gain were adapted from the Institute of Medicine (Health Canada, 2002a). As the BMI categories established by Health Canada correspond closely to the Institute of Medicine but are not exactly the same, the guidelines are as follows in Table 2 and do not apply to multiple gestations:

Table 2: Health Canada Guidelines for Gestational Weight Gain Ranges (Health Canada, 2002a)

BMI Category	Recommended Total Gain Kg	(lb)
BMI < 20	12.5 - 18.0	(28-40)
BMI 20-27	11.5 - 16.0	(25-35)
BMI > 27	7.0 - 11.5	(15-25)

Both the Institute of Medicine and the Society of Obstetricians and Gynaecologists of Canada acknowledge that gestational weight gain is a controversial issue that lacks consensus (SOGC, 1998; Edwards, Hellerstedt, Alton, Story & Himes, 1996). It is not clear what range of weight gain for obese women reduces the risk of delivering either small or heavy infants. Parker & Abrams (1992) reported that infants of obese women who gained less than 15 pounds during pregnancy, were two times more likely to be small for gestational age than infants of obese women who gained at least 15 pounds. A study by Edwards et al., demonstrated that weight loss in obese women was associated with low birth weight and small for gestational age infants, and also advocated an increase in gestational weight gains of 15 to 25 pounds for obese women to optimize fetal growth. Cogswell et al. (1995) found that an upper weight gain of 25 pounds is a threshold of gestational weight gain that increased the incidence of high birth weight without a corresponding reduction in the incidence of low birth weight in obese women. However, Johnson et al. (1992) have reported that weight gain at or above the recommended guidelines were associated with a decreased frequency of low birth weight, but this benefit is outweighed by an increased frequency of macrosomia and caesarean birth, thereby emphasizing that gestational weight gain recommendations warrant careful review. Frentzen, Dimpero, & Cruz (1988) advise that dietary quality, rather than a minimum weight gain, should be emphasized.

Studies by Johnson et al. (1992), Ekblad & Grenman (1992), Witter et al. (1995), Brost et al. (1997), and Kaiser & Kirby (2001), have examined the effects of both pre-pregnancy weight and weight gain as risk factors for caesarean births. All authors stated that both increased pre-pregnancy weight (BMI) and increased gestational weight gain were associated with increased risk for caesarean births. Brost et al. and Witter et al. both stated that the risk for caesarean birth increases linearly with pregnancy weight gain, but Witter et al. could not define a threshold for pre-pregnant BMI or total pregnancy weight gain above which caesarean rates increased rapidly. Additionally, Joseph et al. (2003) explained increases in primary caesarean rates in Nova Scotia, as attributable to changes in maternal characteristics; such as pre-pregnancy weight and weight gain during pregnancy.

The study by Harlow et al. (1995), of low risk nulliparous women, indicated that for every five kilogram increase in total gestational weight gain there was a 34% increase in maternal indicated caesarean birth risk, such as failure to progress, failed induction, diabetes and preeclampsia, whereas fetal indicated caesarean births, such as fetal distress and macrosomia, were not significantly influenced by the amount of weight gained during pregnancy.

2.3.14 Newborn Birth Weight

Garbaciak et al. (1985) reported that fetal weight is directly proportional to maternal size. This tendency for increased birth weight as the maternal weight increased, occurred in the presence or absence of antenatal complications. Edwards, Dickes, Alton, & Hakanson (1978) documented large infants (greater than 4000 grams) were found in 20.6% of obese patients compared with 5.3% of nonobese patients. As well, infants of massively obese women were an average of 209 grams heavier than those of nonobese women. Johnson et al. (1992) demonstrated a significant association between increasing body mass index and gestational weight gain, and frequency of macrosomia. Additionally, R. Cnattingius et al. (1998) stated that birth weight also increases with maternal height.

Baeten et al. (2001) found that overweight and obese women had significantly higher rates of fetal macrosomia, which remained even after excluding women with pre-gestational or gestational diabetes, or hypertension. Even though large fetal size is attributed to diabetes as a result of maternal hyperglycemia, Scherfer-Graf et al. (2002)

found that maternal obesity, not maternal glucose values, correlates best with high rates of fetal macrosomia in pregnancies complicated by gestational diabetes.

Garbaciak et al. (1985) have postulated that the increase in caesarean births of obese women may be attributable to increased fetal size and a narrowing of the birth canal by the deposition of soft tissue in the maternal pelvis.

2.4 Gaps in the Literature

To date, there has been a paucity of Canadian studies investigating the effects of maternal anthropometrical status and gestational weight gain on risk of caesarean birth. Only the two Canadian published studies by Joseph et al. (2003) and Liu et al. (2004) were cited in the literature review on this matter; the rest were Scandinavian, American, or Arab.

The American studies by Johnson et al. (1992) and Witter et al. (1995) are similar in objectives and methodology to my proposed study. Both studies are database audits, retrospectively investigating the correlation between maternal body mass index, gestational weight gain, maternal height, and birth weight. However, as these studies took place in Gainesville, Florida, and Baltimore, Maryland, they are unlike the St. John's demographic in that they include a large black population (40 and 68% respectively). According to Caulfield et al. (1998), the relationship between BMI and fetal growth appears to be race specific, and so the results of a Newfoundland and Labrador study may differ from American research on this account. Additionally, Johnson et al. stated the majority of their study population are low income and living below the federal poverty level, whereas the population of St. John's has a more varied income status with average earnings of $28,872 (Statistics Canada, 2003).

The Scandinavian studies by R. Cnattingius et al. (1998) and Ekblad & Grenman (1992) examined risk factors for caesarean delivery and pregnancy outcome in a population with a low caesarean birth rate. These studies reported the effects of maternal height and weight of nulliparous women in Sweden, and maternal weight and gestational weight gain in Finland, both of which have a low caesarean birth rate of 12%, as opposed to the high Newfoundland and Labrador rate of 26.6% (ICAN, 2002; CIHI, 2004). Additionally the study by Jensen et al. (1999), also investigated the influence of BMI on labour complications of women with normal pregnancies in Denmark. Like Canada (and Newfoundland and Labrador), Jensen et al. state a prevalence of obesity in younger Danish women of at least 15 to 20%. Thus comparisons can be made between these two countries with similar obesity rates, but alternate high and low caesarean birth rates.

The Canadian study by Joseph et al. (2003) in Nova Scotia also bears similarity to this study. Both studies used database audits to retrospectively study the effects of maternal pre-pregnancy weight and weight gain in pregnancy, on caesarean birth rates. Joseph et al., however, solely studied the effects on primary caesarean rates by excluding all women who had a previous caesarean delivery, while this study examined the effects on all women who laboured, regardless of whether they had a previous caesarean birth. More importantly, Joseph et al. did not refer to maternal height and categorized women as overweight or obese based solely on their kilogram weight, while this study categorized women as overweight or obese according to their BMI.

3.0 Methods

Using a retrospective, cohort design, this descriptive study used data from the perinatal database of the Newfoundland and Labrador Provincial Perinatal Program to study the relationship between pre-pregnancy overweight and obesity and the risk for caesarean birth of a labouring patient in the St. John's Region of Newfoundland and Labrador.

3.1 Data Procurement.

Following ethics approval from the Human Investigations Committee of the Faculty of Medicine, Memorial University, and permission from the Research Proposal Approval Committee of the Health Care Corporation of St. John's (now Eastern Health), I obtained data from the perinatal database through the Provincial Perinatal Program, with the assistance of health records personnel.

The perinatal database is a project of the Newfoundland and Labrador Provincial Perinatal Program, which is funded by the provincial Department of Health and Community Services. This database is compiled in collaboration with Eastern Health and contains all the births that occur in the Women's Health Center and, therefore, the St. John's region. The Canadian Institute for Health Information (CIHI) maintains the Discharge Abstract Database (DAD) and requires all Canadian acute care institutions to collect data on each hospitalization, including demographic information, length of stay, most responsible diagnosis, co-morbid diagnoses and procedures. All diagnoses are coded using the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD 10). The Provincial Perinatal Program then works in collaboration with Health Records of Eastern Health, to obtain an additional 102 data elements, for a more extensive perinatal database. While Eastern Health owns the data, the Provincial Perinatal Database is custodian of this perinatal database.

Based on my review of the literature, I requested the following variables from the database: parity (number of viable births), maternal age, marital status, maternal smoking, maternal height, maternal pre-pregnancy weight, maternal pre-delivery weight, gestational age at delivery, induction of labour, epidural analgesia, type of birth, newborn birth weight, vaginal birth after caesarean, presence of maternal comorbidity of diabetes and/or hypertension, and pregnancy complications of oligohydramnios or polyhydramnios.

3.2 Sample

3.2.1 Inclusion/Exclusion Criteria

I obtained the records of all women who delivered from January 1, 2002, until November 30, 2003 for a total of 4, 224 births.

To be included in this study, women must have; 1) been a resident of the St. John's region; 2) delivered a live birth at the Women's Health Center; 3) underwent a trial of labour; 4) did not have suspected or confirmed fetal anomalies; 5) did not have multiple gestation; 6) have all available information on maternal height and weight; and 7) have all relevant newborn data. It was important that women included in this study were only from the St. John's region and representative of the general population, as the Women's Health Center is a tertiary care unit that receives high risk referrals from all regions of Newfoundland and Labrador. Women must have actually delivered at Women's Health, so as to ensure the same standard of care was applied to all women in the study. Additionally, only those who gave birth to a live newborn were included, as management of care differs in those women diagnosed with intrauterine fetal death.

The study only included women who underwent a trial of labour, so as to ensure that the study group contained women who were considered to be free of any known pregnancy complications requiring mandatory caesarean birth, such as: placenta previa, significant abruptio placenta, or abnormal fetal lie; comorbidity of the mother requiring mandatory caesarean birth, such as active genital herpes; and elective caesarean delivery.

Interventions provided to the mother during labour and birth may be influenced by the presence of suspected or confirmed fetal anomalies, as well as the presence of two or more fetuses. As women identified in this regard are often subjected to a different plan of care from the general population, they were not included in the study group.

As my research question was studying the relationship between pre-pregnancy overweight and obesity and the occurrence of caesarean birth, it is important that I had a format by which to estimate body fat. As BMI is an estimate of body size and is calculated by weight in kilograms divided by the square of height in meters (kg/m^2), it was necessary to have documented pre-pregnancy weight and height, so as to obtain this index (Health Canada, 2002). For the study group, I additionally included only those cases that had complete newborn data and complete data on maternal height and weight. For clarity, Figure 2 represents how the final sample was obtained:

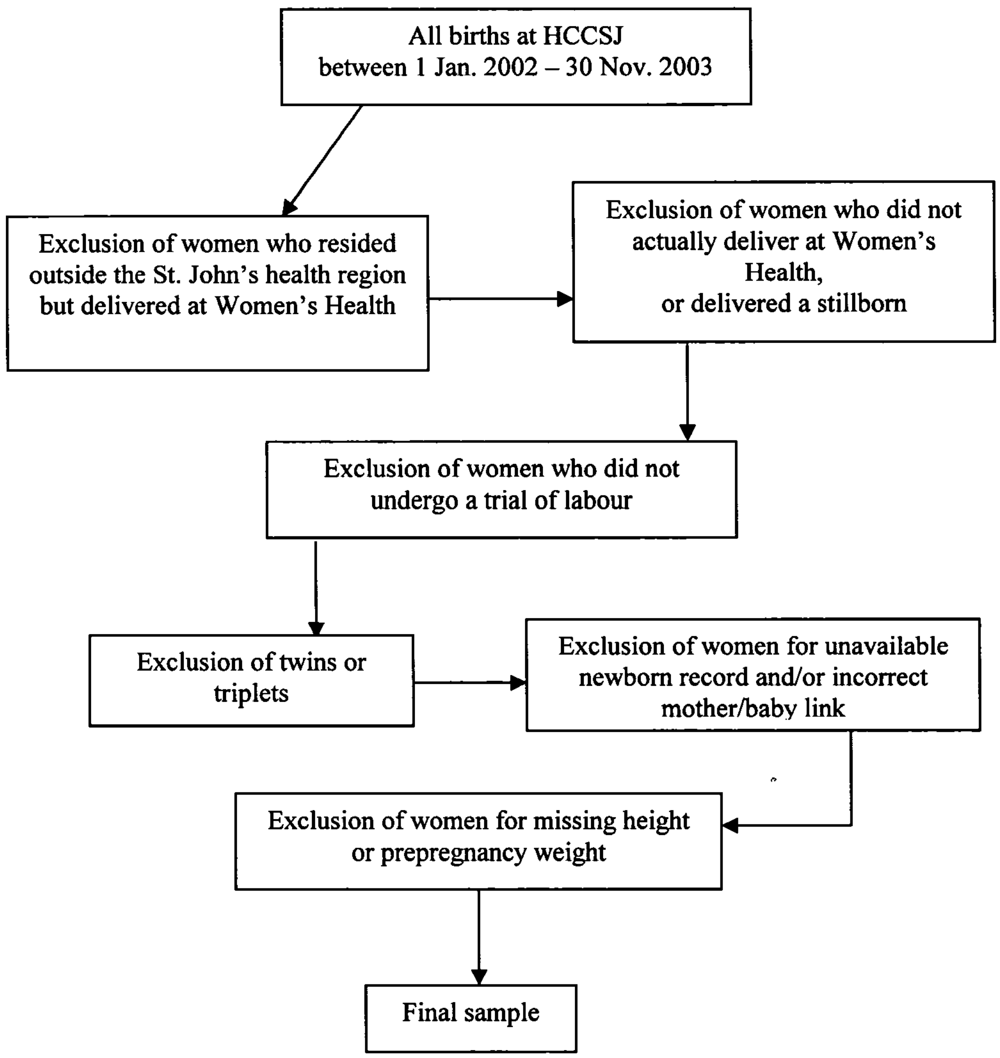

Figure 2. Determination of Study Sample

3.2.2 Sample Size

The sample size was calculated using Cramer's V of interest, e=MV^2, and reference to Newfoundland and Labrador's caesarean birth and obesity rates (Marascuilo & Serlin, 1988). In order to have an assurance of 80% and the ability to detect significant differences at 95%, a minimum sample size of 436 women was necessary. However, as I also studied the relationship between caesarean birth and maternal height, fetal size, and gestational weight gain, this would have decreased the power and increased the incidence of a type 2 error. Yet, according to Norman and Streiner (2000), there is a lack of literature to indicate the sample size needed to perform multivariate statistics, and the authors recommended the old standby of ten subjects per variable. As these three additional independent variables have three categories each, such as gestational weight gain with above, below and as recommended classifications, I accounted for 30 additional subjects per variable. This then required 90 additional subjects, in addition to the 436, for a total of 526. However, as I had access to almost two complete years of perinatal data, I included all eligible cases in the study sample.

3.3 Data Management

The data elements of mothers and babies were transferred into an excel software program and down loaded on two separate files—mothers and babies. The data from the computer discs were converted into a Statistical Package for Social Sciences (SPSS) computer analysis software program, again, as two separate files.

To prepare for analysis, the maternal study sample required the creation of separate maternal comorbity variables, as maternal diagnoses were provided in general long and short text formats, with the first presented diagnosis being the most responsible diagnosis for length of maternal hospitalization. All like maternal diagnoses were categorized together.

Maternal data entry errors and duplications or omissions were detected by using both the data sort and frequency commands in SPSS. These errors were verified, corrected and/or entered by consulting with the data base coordinator of the Provincial

Perinatal Program. This process often required the data base coordinator going back to the original 3M database of the Health Care Corporation of St. John's (now Eastern Health) to verify missing entries and/or to notify the data entry operators of errors or omissions. The neonatal data entry errors, duplications or omissions were also verified, corrected and/or entered by the same process.

The merging of the mother and baby files, to provide one complete file for maternal and neonatal outcome, was the final step in preparing the data for analysis. The files were merged using the hospital generated mother/baby link number (HN number) and mothers' provincial Medicare number. This process detected data entry errors, duplications and/or omissions. Again, consultation with the data base coordinator was required for verification of data in her files or linkage back to the original 3M database. This step provided insight into the cause of the problem enabling rectification, except in one instance where there was an incorrect mother/baby linkage, resulting from an error originating in data entry when a mother was give an incorrect HN number. This situation, could not be rectified either by the database coordinator or me, and thus necessitated exclusion of that mother from the study.

3.4 Data Analysis

3.4.1 Dependent Variable

In this study, the outcome or dependent variable for research objectives one through four was the type of birth: that is caesarean versus vaginal birth. For the fifth research objective (to examine the association between pre-pregnancy weight and newborn birth weight), two new dependent variables were created: small versus average size newborns and large versus average size newborns.

3.4.2 Independent Variables

Four independent variables examined in the study were pre-pregnancy maternal weight; maternal height; gestational weight gain; and newborn birth weight.

3.4.2.1 Pre-pregnancy maternal weight. Individual pre-pregnancy weight information was extracted from the database, which may have been self reported to the health care provider. Lederman & Paxton (1998) documented that there was a high correlation between pre-pregnancy weight measured by researchers in early pregnancy and with the value reported by the mother (differing significantly only in underweight women who over reported by 2.4 lbs). Weight at the first antenatal visit was used if the pre-pregnant value was unknown, provided the patient was in her first trimester of pregnancy. The average woman gains two to four pounds during the first trimester, so the overall effect of errors in pre-pregnancy weight may be considered small (Kaiser & Kirby, 2001).

Pre-pregnancy BMI was calculated by using the formula pre-pregnancy weight in kilograms divided by the height squared (kg/m^2) (Health Canada, 2002). I classified BMI according to the International Standard categories: under 18.5 (underweight); 18.5 to 24.9 (acceptable weight); 25.0 to 29.9 (overweight); 30.0 or higher (obese) (Statistics Canada, 2002). For purposes of this research study, overweight and obese BMIs were grouped together.

3.4.2.2 Maternal height. Individual maternal height information was extracted from the database which may have been self reported to the health care provider.

Maternal height was classified as; less than 1.55 meters (62 inches); 1.55 to 1.73 meters (62 to 69 inches); and greater than 1.73 meters (69 inches). This classification of height was adopted from previous studies by Kaiser & Kirby (2001) and Witter et al. (1995).

3.4.2.3 Gestational weight gain. Total pregnancy weight gain was calculated by subtracting the pre-pregnancy weight (or weight from first antenatal visit) from the weight measured at the last prenatal visit (referred to as pre-delivery weight). As Health Canada (2002a) recommends gestational weight gain ranges depending on BMI category (as outlined previously on page 37), the total gestational weight gain was classified as; above weight gain recommendations; recommended weight gain; or below weight gain recommendations.

3.4.2.4 Newborn birth weight. Newborn birth weight was measured and recorded in the clinical records at delivery. For research objectives one to four, newborn birth weight was an independent variable and coded into three categories: low birth weight (less than 2500 grams); average birth weight (2500 to 4000 grams); and macrosomia (greater than 4000 grams) (Shah & Ohlsson, 2002; Health Canada, 2003). For research objective five, birth weight was coded into two dependent variables: small newborns and large newborns (see section 3.4.1). This alternate coding was used for research objective five because multiple logistic regression requires a dichotomous variable. The small newborn variable had two categories: average size newborns (2500 to 4000 grams) and small newborns (< 2500 grams). The large newborn variable was divided into two categories: average size newborns (2500 to 4000 grams) and large newborns (> 4000 grams).

3.4.3 Covariates

Fourteen covariates were considered in the study. They were selected based on their influence on the dependent and independent variables as cited in the literature and availability in the perinatal database.

3.4.3.1 Parity. Parity may be indicative of caesarean birth as risk of caesarean decreases with parity (RCOG, 2001). Parity was categorized as: nullipara (para 0) ; para 1; or para 2 and greater.

3.4.3.2 Maternal age. The risk of caesarean birth increases with advancing maternal age, as women aged 30 years and older have a two to three times higher rate of caesarean birth (IOM, 1989). Age was categorized as: less than 20 years of age; 20 to 29; 30 to 34; and 35 years of age and older.

3.4.3.2 Living status. There is also a relationship between socioeconomic status and the rate of primary caesarean birth, in that poorer women have a lower incidence of caesarean birth, attributable to either lack of publicly funded health care or greater social congruity between obstetricians and patients (Gould et al., 1989). As I did not have access to the incomes of women included in this study, marital (living) status was the best indicator available to determine socioeconomic status, as the Newfoundland and Labrador Community Accounts (2003) reported single parent income as substantially lower than family income. Additionally, I did not include maternal occupation as an indicator of socioeconomic status in this study, as the data element of occupation in the Perinatal Database contained too many diverse entries to categorize and many entries were too vague to determine their relevance, for example—employed at Canadian Tire. Would occupation actually be as an owner/operator, accountant, cashier or janitor?

From the Provincial Perinatal Database, marital status was entered as one of seven classifications: married; common-law; divorced; widowed; separated; single; and unknown. As the numbers in some of the classifications were very small, I grouped marital status into two categories: partnered and not partnered. Through out the remainder of this paper, this categorization of partnered or not partnered will be referred to as living status.

3.4.3.4 Smoking. As smoking during pregnancy is known to increase the risk of intrauterine growth restriction, and thus influence birth weight, it was important for this variable to be included (Health Canada, 2003). Smoking was categorized as: yes or no. This refers to smoking at any time during the prenatal period (Provincial Perinatal Program, 2003).

3.4.3.5 Gestation at birth. Gestation may be indicative of risk for caesarean birth as preterm birth increases the risk of nonvertex presentation and susceptibility of a fragile infant to trauma (ACOG, 2000). Gestation at birth was categorized as: term (37 to 40 weeks); post dates (41 weeks and greater); preterm (30 to 36 weeks); and very preterm (less than 30 weeks).

3.4.3.6 Labour. The clinical practice of labour induction has been documented to demonstrate a correlation with caesarean rates. The American College of Obstetricians and Gynecologists (2000) found considerable evidence suggesting increased risk for caesarean birth in women who had their labour induced prior to 41 weeks. Labour was categorized as: spontaneous or induced.

3.4.3.7 Epidural analgesia. The risk of caesarean birth increases in women receiving epidural analgesia (ACOG, 2000). Epidural analgesia was categorized as: yes or no.

3.4.3.8 VBAC. The practice of a trial of labour following a caesarean birth (VBAC) involves some degree of risk for both mother and fetus, and should only be conducted adhering to SOGC guidelines (2005). Therefore, the identification of VBAC is important, as this may influence the clinical management of labour. VBAC was categorized as: yes or no.

3.4.3.9 Pre-existing diabetes. Maternal diabetes that is not well controlled is associated with large fetal size ((Cunningham, MacDonald, Gant, Leveno & Gilstrap, 1993). Pre-existing diabetes was categorized as: yes or no.

3.4.3.10 Gestational diabetes. Obesity during pregnancy predisposes women to increased risk of diabetes (Edwards et al, 1996). Large fetal size may be attributed to maternal diabetes that is not well controlled (Cunningham et al., 1993). Gestational diabetes was categorized as: yes or no.

3.4.3.11 Pre-existing hypertension. Small fetal size may be attributed to fetal growth restriction resulting from significant maternal vascular disease (Cunningham et al., 1993). Pre-existing hypertension was categorized as: yes or no.

3.4.3.12 Gestational hypertension. Obesity during pregnancy predisposes women to increased risk of hypertensive disorders, while small fetal size may be attributed to fetal growth restriction resulting from significant maternal vascular disease (Edwards et al., 1996; Cunningham et al., 1993). Gestational hypertension was categorized as: yes or no.

3.4.3.13 Oligohydramnios. Oligohydramnios (diminished amniotic fluid) could affect the categorization of the independent variable of gestational weight gain, in that the reduced weight gain attributable to oligohydramnios could possibly place the patient in a different category of gestational weight gain than would otherwise have occurred. Oligohydramnios was categorized as: yes or no.

3.4.3.14 Polyhydramnios. Polyhydramnios (excessive amniotic fluid) also could affect the categorization of the independent variable of gestational weight gain in that the inflated gestational weight gain attributable to polyhydramnios could possibly place the patient in a different category of gestational weight gain than would otherwise have occurred. Polyhydramnios was categorized as: yes or no.

3.5 Statistical analysis

To assess the representativeness of the study sample, chi square tests were used to compare the study sample with the sample of eligible women (i.e. those who met all inclusion criteria but were missing pre-pregnancy weight and/or height). These two samples were compared on all independent, dependent and control variables, except BMI.

To determine whether the women in the study were representative of the prevalent overweight and obesity rates in the St. John's region, I compared reported BMI of the study sample with data from Statistics Canada. In 2000/01, 48.1% of females in the St. John's region were classified according to the international standard BMI as overweight or obese, compared to 48.7% in the study sample (Statistics Canada, 2002).

In order to describe the characteristics of the study sample I ran a frequency analysis on all the dependent and independent variables, and covariates. I then used Pearson Chi-Square or Fisher's Exact Test (x^2) analyses to look for differences in the characteristics of women who had: caesarean versus vaginal birth; different BMI classification; different gestational weight gain classification; different maternal height classification; and different newborn birth weight classification.

Multiple logistic regression was used to examine the association between birth by caesarean and pre-pregnancy weight, gestational weight gain, maternal height and newborn birth weight (research objectives one to four), and the association between newborn birth weight and pre-pregnancy weight (research objective five) after controlling for other significant predictors. All covariates and independent variables with a $p \leq 0.05$ from Chi-Square analysis were first of all entered into an univariate logistic regression. Those variables with a significance of $p \leq 0.05$ using the Wald Statistic were included in the multiple logistic regression. As multiple logistic regression is sensitive to the order in which variables are entered into the model, Nagelkerke's R^2 values from the univariate regression was used to determine the order of entry; the variables with the largest Nagelkerke's R^2 was entered first, followed by variables with lower values (Kleinbaum, Kupper, Muller & Nizam, 1998). Independent variables were entered into the variable last (to provide the most rigorous test of their association) after controlling for all other significant variables. Additional interactive terms were tested in the model if appropriate. For example, an interaction between gestational weight gain and newborn birth weight was tested in the regression model.

For goodness-of-fit, the –2 log likelihood statistic was used conjointly with the

Wald statistic to determine whether a variable was included in the multiple logistic regression. The Wald statistic first determined whether the variable was significant ($p \leq 0.05$), and then the change in the –2 log likelihood statistic determined whether the regression model was improved by the addition of that variable. If the Wald statistic and the difference in the –2 log likelihood were significant, then the variable was included in the regression model (Kleinbaum et al., 1998; Tabachnick & Fidell, 2001).

Inflated standard error values, indicative of multicollinearity, were not detected in the models (Tabachnick & Fidell, 2001).

3.6 Confidentiality

During data procurement, anonymity of patients was upheld, as I did not have access to the personal identifiers of name or address. Information obtained from the database was entered into excel software using two mother/child link codes and transferred into the SPSS software. The database coordinator, however, had access to medical records to clarify and verify data entry errors.

The computer used in the analysis of data was password protected, both due to the medical information contained in the data sheets and as a result of strict confidentiality regulations required of the Health Care Corporation of St. John's (now Eastern Health). Also, the computer used was kept in a locked office at the Health Sciences Center.

The research results will be reported in an aggregate form only. Individuals will never be identified in any report, publication, or presentation.

4.0 Results

4.1 Sample

For the study period of January 1, 2002, until November 30, 2003, there were a total of 4,224 births at the Women's Health Center. As shown in Figure 3, 628 women who were non-residents of the St. John's region were excluded. Women were also excluded who: did not deliver at the Women's Health Center or had stillbirths (n=28); did not undergo a trial of labour (n=440); had known or suspected fetal anomalies (n=7); or were pregnant with twins or triplets (n=60). Two patients were excluded because their babies were discharged outside the study period so the newborn records were not available, and one other patient was incorrectly linked to the wrong baby. Of the remaining 3058 cases, 1993 patients (65.2%) were excluded because of missing height or pre-pregnancy weight. The resulting study size was 1065 women.

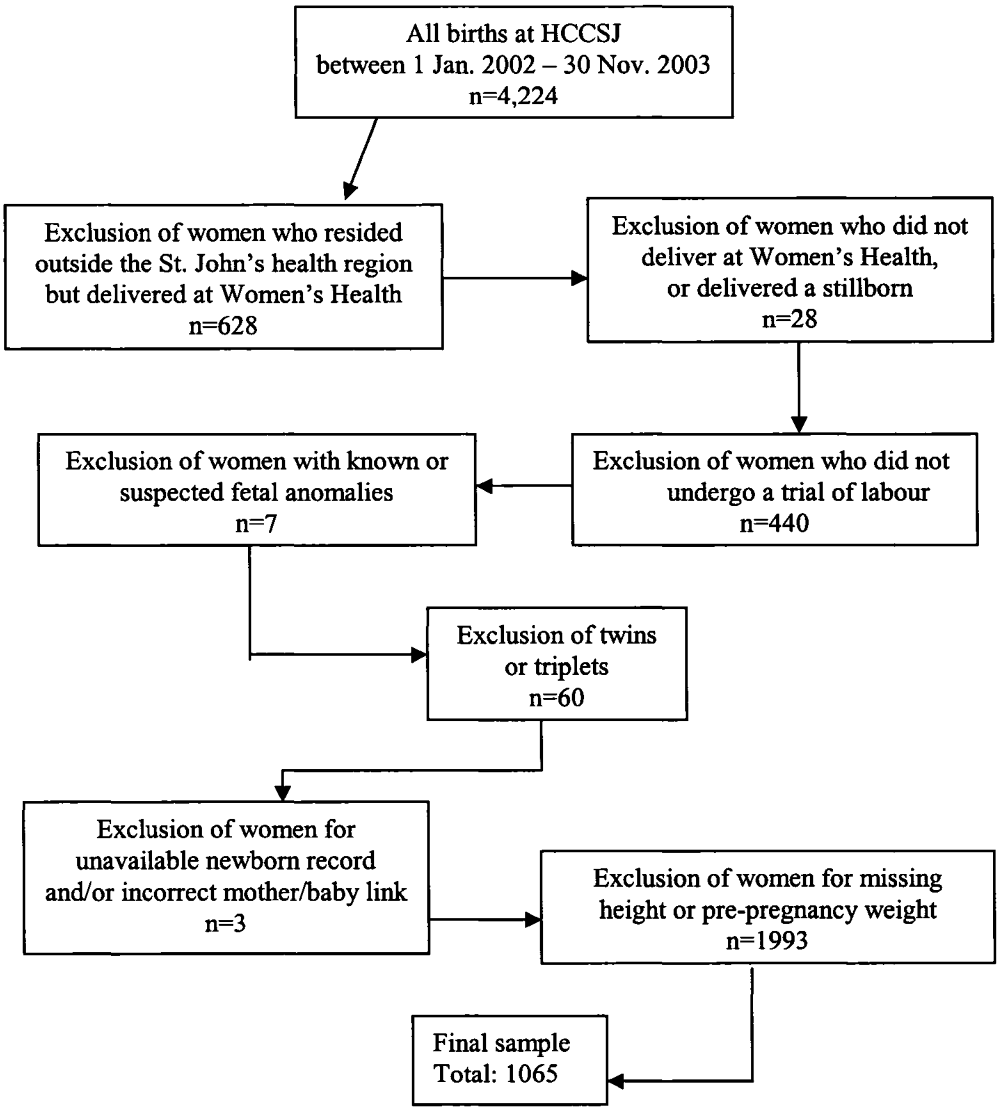

Figure 3. Study Sample Determination and Size

4.2 Representativeness of Sample

To assess the representativess of the study sample, Pearson Chi-Square or Fisher's Exact Test (x^2) tests were used to look for differences between the study sample and the eligible sample of women who were missing height or pre-pregnancy weight. As summarized in Table 3, there were no differences between the study group and those women who gave birth at Women's Health with missing height or pre-pregnancy weight information in age (p=0.067); being partnered or not partnered (p=0.095); smoking (p=0.298); gestation at birth (p=0.229); VBAC (p=1.000); pre-existing (p=0.819) and gestational diabetes (p=0.304); pre-existing (p=0.573) and gestational induced hypertension (p=0.099); oligohydramnios (p=0.561); polyhydramnios (p=1.000); pre-pregnancy weight (p=0.749); maternal height (p=0.087); birth weight (p=0.179); and caesarean birth (p=0.913). There was a difference between the study group and those women who gave birth with missing maternal height or pre-pregnancy weight information, in parity (p=0.000), type of labour (p=0.049) and epidural analgesia (p=0.034).

While, both the study and missing groups had approximately the same proportion of nulliparous and primiparous women, at 58.1% and 51.4%, and 32.5% and 34.0% respectively, the missing group had a larger proportion of multiparas (14.6%) than the study group (9.4%). Meanwhile, the study group had a larger proportion of women who had induced labour (35.7%) compared to the missing group (32.1%), while the missing group had a larger proportion of women who had spontaneous labour (67.9%) compared to the study group (64.3%). The study group also had a higher proportion of women with epidural analgesia (55.3%) than the group who had missing maternal height or pre-pregnancy weight information (51.3%).

It is also interesting to note the similarity between the rate of female overweight and obesity in this study sample, and that of the St. John's region. In this study 48.7% of the women are either overweight or obese, compared to 48.1% of women (aged 20 to 64

Table 3. Differences Between Women in Study Group and Those with Missing Height and/or Pre-pregnancy Weight

Variable	Study Group		Missing ht and/or wt		p value
	n	(%)	n	(%)	
Parity					0.000
Nullipara (Para 0)	619	(58.1)	1024	(51.4)	
Para 1	346	(32.5)	678	(34.0)	
Para 2 and greater	100	(9.4)	291	(14.6)	
Maternal Age					0.067
20 to 29	489	(45.9)	956	(48.0)	
< 20	34	(3.2)	97	(4.9)	
30 to 34	370	(34.7)	640	(32.1)	
35+	172	(16.2)	300	(15.1)	
Living Status					0.095
Partnered	774	(72.9)	1384	(69.7)	
Not Partnered	278	(26.2)	589	(29.7)	
Unknown	10	(0.9)	13	(0.7)	
Currently Smoking					0.298
Yes	190	(17.8)	311	(15.6)	
No	840	(78.9)	1628	(81.7)	
Unknown	35	(3.3)	54	(2.7)	
Gestation at Birth (weeks)					0.229
37 to 40	792	(74.5)	1422	(71.3)	
41+	217	(20.4)	438	(22.0)	
30 to 36	53	(5.0)	122	(6.1)	
<30	2	(0.2)	10	(0.5)	
Missing	0	(0.0)	1	(0.10)	
Labour					0.049
Induced	380	(35.7)	640	(32.1)	
Spontaneous	685	(64.3)	1353	(67.9)	
Epidural analgesia*	589	(55.3)	1018	(51.3)	0.034
VBAC*	14	(1.3)	28	(1.4)	1.000
Pre-existing diabetes*	8	(0.8)	13	(0.7)	0.819
Gestational diabetes*	43	(4.0)	65	(3.3)	0.304
Pre-existing hypertension*	9	(0.8)	22	(1.1)	0.573
Gestational hypertension*	92	(8.6)	139	(7.0)	0.099
Oligohydramnios*	20	(1.9)	32	(1.6)	0.561
Polyhydramnios*	7	(0.7)	14	(0.7)	1.000
Pre-pregnancy wt. (kgs)					0.749
55 to 55.9	167	(15.7)	105	(14.3)	
< 55	153	(14.4)	108	(14.7)	
60 to 69.9	298	(28.0)	198	(26.9)	
≥ 70	447	(42.0)	324	(44.1)	
Maternal height (meters)					0.087
<1.55	63	(5.9)	36	(6.9)	
1.55 to 1.73	941	(88.4)	443	(84.7)	
>1.73	61	(5.7)	44	(8.4)	

Table 3 continued. Differences Between Women in Study Group and Those with Missing Height and/or Pre-pregnancy Weight

Variable	Study Group n	(%)	Missing ht and/or wt n	(%)	p value
Birth weight (grams)					0.179
<2500	33	(3.1)	87	(4.4)	
2500-4000	870	(81.7)	1572	(79.0)	
>4000	162	(15.2)	331	(16.6)	
Missing	0	(0.0)	1	(0.1)	
Birth Type					0.913
Caesarean birth	151	(14.2)	279	(14.0)	
Vaginal birth	913	(85.8)	1711	(86.0)	

•The numbers cited are those entered as "yes" in the database; "no" is not stated in the table

years) being either overweight or obese in the St. John's region (Statistics Canada, 2002).

4.3 Characteristics

The characteristics of the 1065 women studied are summarized in Table 4. Slightly more than half of the women (58.1%) were nulliparas, 45.9% were between 20 to 29 years of age, 72.7% were partnered, 17.3% were currently smoking, and 74.5% of the women delivered at full term gestation. Labour was spontaneous in 64.3% of the women studied, while the remaining 35.7% had their labour induced. Additionally, 8.6% of the women in the study group were diagnosed with gestational hypertension and 4.0% with gestational diabetes.

According to the international standard of BMI, 48.7% of the women were either overweight or obese, and 88.5% were of average height. Over one half of the participants, 53.6%, exceeded the recommendations of Health Canada for gestational weight gain, and 81.7% of the newborns weighed between 2500 and 4000 grams at birth. Of the women in the study, 14.2% (n=151) of the women delivered by caesarean birth, while 85.8% (n=913) delivered vaginally.

Table 4: Characteristics of Study Sample (n=1065)

Characteristics	n	(%)
Parity		
Null*ipara (Para 0)*	619	(58.1)
Para 1	346	(32.5)
Para 2 and greater	100	(9.4)
Maternal age (years)		
< 20	34	(3.2)
20 to 29	489	(45.9)
30 to 34	370	(34.7)
35+	172	(16.2)
Mean + SD	29.3 + 5.2	
Living status		
Partnered	774	(72.7)
Not partnered	278	(26.1)
Missing	13	(1.2)
Smoking status		
Smoker	184	(17.3)
Non smoker	855	(80.3)
Missing	26	(2.4)
Gestation at delivery (weeks)		
37 to 40	793	(74.5)
41+	217	(20.4)
30 to 36	53	(5.0)
<30	2	(0.2)
Labour		
Induced	380	(35.7)
Spontaneous	685	(64.3)
Pre-existing diabetes*	8	(0.8)
Gestational diabetes*	43	(4.0)
Pre-existing hypertension*	10	(0.9)
Gestational hypertension*	92	(8.6)
Epidural analgesia*	588	(55.2)
Vaginal Birth After Caesarean*	14	(1.3)
Oligohydramnios*	20	(1.9)
Polyhydramnios*	7	(0.7)
Pre-pregnancy BMI		
Underweight	41	(3.8)
Acceptable weight	505	(47.4)
Overweight	287	(26.9)
Obese	232	(21.8)
*(Overweight or Obese)***	519	(48.7)
Maternal height (meters)		
<1.55	62	(5.8)
1.55 to 1.73	942	(88.5)
> 1.73	61	(5.7)
Gestational weight gain		
As recommended	327	(30.7)
Above	571	(53.6)
Below	67	(15.7)

Table 4 Continued. Characteristics of Study Population

Characteristics	n	(%)
Birth weight (grams)		
<2500	33	(3.1)
2500-4000	870	(81.7)
>4000	162	(15.2)
Birth Type		
Caesarean birth	151	(14.2)
Vaginal birth	914	(85.8)

*Entered as" yes" in the database; "no" is not stated in the table
**For purposes of this study, women, who were either overweight or obese (according to their BMI), were grouped together and referred to as "overweight or obese".

4.4 Vaginal versus Caesarean Births

The differences between women who delivered vaginally as opposed to those who delivered by caesarean birth are summarized in Table 5. As parity increases, the incidence of caesarean birth decreases. Of those women with caesarean birth, 80.1% were nulliparas (Para 0) and 15.2% were giving birth to their second child (Para 1), compared to 54.5% of nulliparas, and 35.3% of Para 1's who delivered vaginally (p = 0.000). As maternal age increased, the incidence of caesarean birth also increased (p=0.029). Of those who gave birth by caesarean, 37.7% and 21.9% of women were aged 30 to 34 and 35+ years respectfully, compared to 34.2% and 15.2% who delivered vaginally. There was no difference between women who delivered vaginally and by caesarean birth based on their living status (p=0.055), smoking status (p=0.242), or gestation at birth (p=0.054).

The incidence of caesarean birth increased with medical induction of labour. Of those women who delivered by caesarean birth, 47.7% were induced compared to the 33.7% who were induced and gave birth vaginally (p=0.001). As well, of those women who gave birth by caesarean, 82.8% had epidural analgesia compared to 50.8% who gave birth vaginally (p=0.000). There was, however, no difference between vaginal and caesarean birth based on whether women labored following a previous birth by caesarean (p=0.116).

There was a greater incidence of caesarean birth in women who developed gestational diabetes and gestational hypertension. In women diagnosed with gestational diabetes and gestational hypertension, 7.3% and 20.5% respectively delivered by caesarean compared to 3.5% and 6.7% who gave birth vaginally (p=0.031 and p=0.000). However, there was no difference between women who delivered vaginally and by caesarean with pre-existing diabetes (p=0.091) and pre-existing hypertension (p=0.426). Additionally, in women who delivered by caesarean, there was a greater incidence of polyhydramnios at 2.6%, compared to 0.3% in women who delivered vaginally (p=0.010). There was no difference, however, between vaginal and caesarean birth with oligohydramnios (p=0.141).

As pre-pregnancy weight increased, so did the incidence of caesarean birth. The largest proportion of women who delivered by caesarean were overweight or obese (62.9%), while the largest proportion of women who delivered vaginally (49.2%) were of acceptable weight (p=0.000). Similarly, a greater proportion of women who gave birth by caesarean, than vaginally, exceeded Health Canada's recommended gestational weight gain (64.9% versus 51.8%), while conversely, a greater proportion of women who gave birth vaginally, than by caesarean, gained less than the recommended amount during their pregnancy (17.2% versus 6.0%; p=0.001). There was no difference between women who delivered vaginally and by caesarean birth based on height (p=0.881). A significantly larger proportion of babies (p=0.022) who were greater than 4000 grams (21.9%) and less

Table 5. Differences Between Women of Vaginal and Caesarean Births					
Variable	**Caesarean**		**Vaginal**		**p value**
	n	**(%)**	**n**	**(%)**	
Parity					0.000
Nullipara (Para 0)	121	(80.1)	498	(54.5)	
Para 1	23	(15.2)	323	(35.3)	
Para 2 and greater	7	(4.6)	93	(10.2)	
Maternal Age					0.029
< 20	1	(0.7)	33	(3.6)	
20 to 29	60	(39.7)	429	(46.9)	
30 to 34	57	(37.7)	313	(34.2)	
35+	33	(21.9)	139	(15.2)	
Living Status					0.055
Partnered	118	(79.2)	656	(72.6)	
Not partnered	31	(20.8)	247	(27.4)	
Currently Smoking*	31	(21.2)	153	(17.1)	0.242
Gestation at Birth (wks)					0.054
37 to 40	100	(66.2)	693	(75.8)	
41+	43	(28.5)	174	(19.0)	
30 to 36	8	(5.3)	45	(4.9)	
< 30	0	(0.0)	2	(0.2)	
Labour					0.001
Induced	72	(47.7)	308	(33.7)	
Spontaneous	79	(52.3)	606	(66.3)	
Epidural analgesia*	125	(82.8)	464	(50.8)	0.000
VBAC*	0	(0.0)	14	(1.5)	0.116
Pre-existing diabetes*	3	(2.0)	5	(0.5)	0.091
Gestational diabetes*	11	(7.3)	32	(3.5)	0.031
Pre-existing hypertension*	2	(1.3)	8	(0.9)	0.426
Gestational hypertension*	31	(20.5)	61	(6.7)	0.000
Oligohydramnios*	5	(3.3)	15	(1.6)	0.141
Polyhydramnios*	4	(2.6)	3	(0.3)	0.010
Pre-pregnancy BMI					0.000
Underweight	1	(0.7)	40	(4.4)	
Acceptable	55	(36.4)	450	(49.2)	
Overweight or Obese	95	(62.9)	424	(46.4)	
Gestational Weight Gain					0.001
Above	98	(64.9)	469	(51.8)	
Below	9	(6.0)	156	(17.2)	
As recommended	44	(29.1)	281	(31.0)	
Maternal Height (meters)					0.881
<1.55 s	10	(6.6)	52	(5.7)	
1.55 to 1.73	133	(88.1)	809	(88.5)	
>1.73	8	(5.3)	53	(5.8)	
Birth Weight (grams)					0.022
<2500	7	(4.6)	27	(3.0)	
2500-4000	111	(73.5)	757	(82.9)	
>4000	33	(21.9)	129	(14.1)	

* Entered as" yes" in the database; "no" is not stated in the table

than 2500 grams (4.6%) were born by caesarean rather than vaginal birth (14.1% and

3.0% respectively).

4.4.1 Maternal Pre-Pregnancy Weight

The differences in women by Body Mass index (BMI) classification of underweight, acceptable weight, and overweight or obese are summarized in Table 6. There was no relationship between pre-pregnancy weight and parity (p=0.994), but there was a difference between maternal age and pre-pregnancy weight (p=0.020). Of women in the 20 to 29 years age group, there are proportionally more women who are underweight (65.9%), than in the other age groups. There was an insignificantly larger proportion of overweight and obese women who were partnered than those women who were underweight and of acceptable weight (p=0.050). Significantly more women who were overweight or obese smoked (21.2%), compared to those women who are underweight (17.9%) or of acceptable weight (14.1%; p=0.014).

There was no difference between pre-pregnancy weight and gestation at birth (p=0.315), but there was a significant inverse relationship between type of labour and pre-pregnancy weight (p=0.000). As pre-pregnancy weight increased, so did the incidence of medical induction, with a greater proportion of women induced (41.2%) being overweight or obese, while as pre-pregnancy weight decreased there was a greater proportion of women who laboured spontaneously that were underweight (80.5%) or of acceptable weight (68.7%).

There was no relationship between pre-existing diabetes and pre-pregnancy weight (p=0.673), but there was a relationship between gestational diabetes and pre-pregnancy weight (p=0.019). More women with gestational diabetes were overweight or obese (5.8%), compared to underweight women or those of acceptable weight (2.4%). Similarly, there was no relationship between pre-existing hypertension and pre-pregnancy weight (p=0.373), but there was a relationship between gestational hypertension and pre-pregnancy hypertension (p=0.000). A greater proportion of overweight or obese women (12.9%) developed gestational hypertension compared to women who were of acceptable weight (5.0%), while there was no incidence of gestational hypertension in women who were underweight (0.0%).

There was no difference between oligohydramnios and pre-pregnancy weight (p=0.580), but there was a significant difference between pre-pregnancy weight and polyhydramnios (p=0.025). Polyhydramnios occurred only in women who were overweight or obese (1.3%) and not in women who were underweight or of acceptable weight (0.0%).

As pre-pregnancy weight increased so did the incidence of epidurals, with a 60.5% incidence in the obese group compared to 39.0% in underweight women (p=0.001). There was no relationship between VBAC and pre-pregnancy weight (p=0.060).

There was also a significant relationship between gestational weight gain and pre-pregnancy weight (p=0.000). As pre-pregnancy weight increased, so did the proportion of women who exceeded Health Canada's recommended gestational weight gain, as 64.5% of these women were overweight or obese. Conversely, as pre-pregnancy weight decreased, the proportion of women who gained Health Canada's recommended amount increased, as 53.7% of underweight women adhered to the recommendations compared to

Table 6: Differences in Women by Pre-pregnancy Weight (BMI)							
Variable	**Underweight**		**Acceptable**		**Overweight /Obese**		**p value**
	n	**(%)**	**n**	**(%)**	**n**	**(%)**	
Parity							0.978
Nullipara (Para 0)	25	(61.0)	296	(58.6)	298	(57.4)	
Para 1	12	(29.3)	161	(31.9)	173	(33.3)	
Para 2 and >	4	(9.8)	48	(9.5)	48	(9.2)	
Maternal Age							0.020
< 20	3	(7.3)	21	(4.2)	10	(1.9)	
20 to 29	27	(65.9)	227	(45.0)	235	(45.3)	
30 to 34	7	(17.1)	175	(34.7)	188	(36.2)	
35+	4	(9.8)	82	(16.2)	86	(16.6)	
Living Status							0.050
Partnered	25	(62.5)	355	(71.4)	394	(76.5)	
Not partnered	15	(37.5)	142	(28.6)	121	(23.5)	
Currently smoking*	7	(17.9)	70	(14.1)	107	(21.2)	0.014
Gestation (wks)							0.315
37 to 40	35	(85.4)	377	(74.7)	381	(73.4)	
41+	4	(9.8)	99	(19.6)	114	(22.0)	
30 to 36	2	(4.9)	29	(5.7)	22	(4.2)	
< 30	0	(0.0)	0	(0.0)	2	(0.4)	
Labour							0.000
Induced	8	(19.5)	158	(31.3)	214	(41.2)	
Spontaneous	33	(80.5)	347	(68.7)	305	(58.8)	
Pre-existing diabetes*	0	(0.0)	3	(0.6)	5	(1.0)	0.673
Gestational diabetes*	1	(2.4)	12	(2.4)	30	(5.8)	0.019
Pre-existing hypertension*	0	(0.0)	3	(0.6)	7	(1.3)	0.373
Gestational hypertension*	0	(0.0)	25	(5.0)	67	(12.9)	0.000
Oligohydramnios*	0	(0.0)	11	(2.2)	9	(1.7)	0.580
Polyhydramnios*	0	(0.0)	0	(0.0)	7	(1.3)	0.025
Epidural analgesia*	16	(39.0)	259	(51.3)	314	(60.5)	0.001
VBAC*	0	(0.0)	11	(2.2)	3	(0.6)	0.060
Gestational Weight Gain							0.000
Recommended	22	(53.7)	175	(34.7)	130	(25.0)	
Above	12	(29.3)	224	(44.4)	335	(64.5)	
Below	7	(17.1)	106	(21.0)	54	(10.4)	
Maternal Height (meters)							0.020
<1.55	0	(0.0)	24	(4.8)	38	(7.3)	
1.55 to 1.73	38	(92.7)	443	(87.7)	461	(88.8)	
>1.73	3	(7.3)	38	(7.5)	20	(3.9)	
Birth Weight (grams)							0.032
<2500	2	(4.9)	16	(3.2)	15	(2.9)	
2500-4000	37	(90.2)	425	(84.2)	408	(78.6)	
>4000	2	(4.9)	64	(12.7)	96	(18.5)	
*Numbers are 'yes' in the database; "no" is not stated in the table							

25% of overweight or obese women.

In women who were tall, there were a smaller proportion of overweight or obese women (3.9%), compared to the 7.3% of women who were short (p=0.020). As well, a greater proportion of overweight or obese women (18.5%), than underweight (4.9%) or acceptable weight women (12.7%), gave birth to babies weighing greater than 4000 grams. A greater proportion of underweight women (4.9%) gave birth to babies weighing less than 2500 grams, than either women of acceptable weight (3.2%) or overweight or obese (2.9%; p=0.032)

4.4.2 Gestational Weight Gain

The differences in women by gestational weight gain are summarized in Table 7. A larger proportion of nulliparas exceeded recommended gestational weight gain (63.0%), than those experiencing their second (30.5%) and third or more birth (6.5%) (p=0.000). Significantly more women in the 20 to 29 age group (49.4%) exceeded the recommended weight gain than women in the other age groups (p=0.020). There was no difference between gestational weight gain and whether women were partnered or not (p=0.133), or smoked (p=0.488). A larger proportion of women who were post dates (41+ weeks) exceeded recommended weight gain than not achieving recommended weight. As well, a larger proportion (73.7%) of women who gained less weight than recommended during their pregnancy had spontaneous labour, compared to the women who gained more weight than recommended (60.8%) or the recommended amount (65.7%; p=0.008).

There was no difference in women with pre-existing diabetes and gestational weight gain (p=0.119). However, in women who gained less than the recommended amount of weight in pregnancy, a larger proportion (6.6%) had gestational diabetes than among women who met or exceeded the recommended weight gain guidelines (p=0.016).

A larger proportion of women who gained the recommended amount of weight had pre-existing hypertension (2.1%), than among those who gained more (0.4%) or less than (0.6%) the recommended amount of weight in pregnancy (p=0.025). However, a larger proportion of women who exceeded recommended weight had gestational hypertension (10.9%) compared to 4.2% who gained below and 7.0% who gained the recommended amount (p=0.012). There was no difference between gestational weight gain and oligohydramnios (p=0.356), or weight gain and polyhydramnios (p=0.482).

As weight gain in pregnancy increased so did the incidence of epidural analgesia, with a greater proportion of women who exceeded recommended gestational weight gain (61.5%) receiving epidural analgesia compared to 50.2% who gained weight as recommended and 44.3% of those who did not gain the recommended amount (p=0.000). A greater proportion of women who gained below the recommended gestational weight gain (3.6%) had VBAC compared to the 0.9% of women who gained either the recommended or above recommended weight gain (p=0.019).

There was no difference between gestational weight gain and maternal height (p=0.184). However, there was a significant relationship between gestational weight gain and newborn birth weight (p=0.000). A greater proportion of women who gained below the recommended weight (7.2%) gave birth to babies weighing less than 2500 grams, compared to those who gained the recommended amount (2.8%) or more than the recommended amount of weight (2.1%) during their pregnancy. Conversely, a greater proportion of women who gained more weight than recommended (19.8%), gave birth to babies weighing more than 4000 grams, compared to those women who gained below

Table 7: Differences in Women by Gestational Weight Gain							
Variable	**As Recommended**		**Above**		**Below**		**p value**
	n	**(%)**	**n**	**(%)**	**n**	**(%)**	
Parity							0.000
Nullipara (Para 0)	180	(55.0)	360	(63.0)	79	(47.3)	
Para 1	114	(34.9)	174	(30.5)	58	(34.7)	
Para 2 and >	33	(10.1)	37	(6.5)	30	(18.0)	
Maternal Age							0.020
< 20	7	(2.1)	18	(3.2)	9	(5.4)	
20 to 29	139	(42.5)	282	(49.4)	68	(40.7)	
30 to 34	123	(37.6)	194	(34.0)	53	(31.7)	
35+	58	(17.7)	77	(13.5)	37	(22.2)	
Living Status							0.133
Partnered	243	(75.7)	419	(74.2)	112	(67.5)	
Not partnered	78	(24.3)	146	(25.8)	54	(32.5)	
Currently smoking*	61	(19.1)	99	(17.8)	24	(14.7)	0.488
Gestation (weeks)							0.006
37 to 40	251	(76.8)	413	(72.3)	129	(77.2)	
41+	61	(18.7)	133	(23.3)	23	(13.8)	
30 to 36	13	(4.0)	25	(4.4)	15	(9.0)	
< 30	2	(0.6)	0	(0.0)	0	(0.0)	
Labour							0.008
Induced	112	(34.3)	224	(39.2)	44	(26.3)	
Spontaneous	215	(65.7)	347	(60.8)	123	(73.7)	
Pre-existing diabetes*	0	(0.0)	7	(1.2)	1	(0.6)	0.119
Gestational diabetes*	18	(5.5)	14	(2.5)	11	(6.6)	0.016
Pre-existing hypertension*	7	(2.1)	2	(0.4)	1	(0.6)	0.025
Gestational hypertension*	23	(7.0)	62	(10.9)	7	(4.2)	0.012
Oligohydramnios*	9	(2.8)	8	(1.4)	3	(1.8)	0.356
Polyhydramnios*	3	(0.9)	4	(0.7)	0	(0.0)	0.482
Epidural analgesia*	164	(50.2)	351	(61.5)	74	(44.3)	0.000
VBAC*	3	(0.9)	5	(0.9)	6	(3.6)	0.019
Maternal Height (meters)							0.184
<1.55	22	(6.7)	25	(4.4)	15	(9.0)	
1.55 to 1.73	286	(87.5)	515	(90.2)	141	(84.4)	
>1.73	19	(5.8)	31	(5.4)	11	(6.6)	0.000
Birth Weight (grams)							
<2500	9	(2.8)	12	(2.1)	12	(7.2)	
2500-4000	283	(86.5)	446	(78.1)	141	(84.4)	
>4000	35	(10.7)	113	(19.8)	14	(8.4)	
*Numbers are 'yes' in the database; "no" is not stated in the table							

(8.4%) or the recommended amount (10.7%).

4.4.3 *Maternal Height*

The differences in women by height are summarized in Table 8. There were no differences between height and parity (p=0.659); maternal age (p=0.691); living status

Table 8: Differences in Women by Height							
Variable	< 1.55 meters		1.55 to 1.73 m		>1.73 meters		p value
	n	(%)	n	(%)	n	(%)	
Parity							0.659
Nullipara (0)	34	(54.8)	547	(58.1)	38	(62.3)	
Para 1	20	(32.3)	306	(32.5)	20	(32.8)	
Para 2 and >	8	(12.9)	89	(9.4)	3	(4.9)	
Maternal Age							0.691
< 20	2	(3.2)	31	(3.3)	1	(1.6)	
20 to 29	25	(40.3)	437	(46.4)	27	(44.3)	
30 to 34	22	(35.5)	322	(34.2)	26	(42.6)	
35+	13	(21.0)	152	(16.1)	7	(11.5)	
Living Status							0.768
Partnered	45	(72.6)	684	(73.4)	45	(77.6)	
Not partnered	17	(27.4)	248	(26.6)	13	(22.4)	
Currently smoking*	7	(11.5)	169	(18.4)	8	(13.1)	0.242
Gestation (weeks)							0.531
37 to 40	51	(82.3)	693	(73.6)	49	(80.3)	
41+	7	(11.3)	200	(21.2)	10	(16.4)	
30 to 36	4	(6.5)	47	(5.0)	2	(3.3)	
< 30	0	(0.0)	2	(0.2)	0	(0.0)	
Labour							0.840
Induced	21	(33.9)	339	(36.0)	20	(32.8)	
Spontaneous	41	(66.1)	603	(64.0)	41	(67.2)	
Pre-existing diabetes*	0	(0.0)	8	(0.8)	0	(0.0)	0.591
Gestational diabetes*	5	(8.1)	38	(4.0)	0	(0.0)	0.076
Preexisting hypertension*	0	(0.0)	9	(1.0)	1	(1.6)	0.634
Gestational hypertension*	10	(16.1)	77	(8.2)	5	(8.2)	0.096
Epidural analgesia*	38	(61.3)	522	(55.4)	29	(47.5)	0.303
VBAC*	1	(1.6)	11	(1.2)	2	(3.3)	0.365
Oligohydramnios*	2	(3.2)	18	(1.9)	0	(0.0)	0.410
Polyhydramnios*	0	(0.0)	6	(0.6)	1	(1.6)	0.518
Birth Weight (grams)							0.027
<2500	5	(8.1)	28	(3.0)	0	(0.0)	
2500-4000	53	(85.5)	768	(81.5)	49	(80.3)	
>4000	4	(6.5)	146	(15.5)	12	(19.7)	
*Numbers are "yes" in the database; "no" are not stated in the table							

(p=0.768); smoking (p=0.242); gestation at birth (p=0.531); labour type (p=0.840); pre-existing diabetes (p=0.591); gestational diabetes (p=0.076); pre-existing hypertension (p=0.634); gestational hypertension (p=0.096); epidural analgesia (p=0.303); VBAC (p=0.365); oligohydramnios (p=0.410); or polyhydramnios (p=0.518).

There was a significant difference, however, between maternal height and newborn birth weight (p=0.027). Women, who were shorter than 1.55 meters, had a higher incidence of giving birth to babies who weighed less than 2500 grams (8.1%), while women who were taller than 1.73 meters had a higher incidence of giving birth to babies who weighed more than 4000 grams (19.7%).

4.4.4 Newborn Birth Weight

The differences in women by category of newborn birth weight are summarized in Table 9. The greatest proportion of babies weighing less than 2500 grams at birth (78.8%) were born to nulliparous women, compared to 9.1% of women having their second child and 12.1% having their third or more child (p=0.000). There was no difference between newborn birth weight and maternal age (p=0.144); living status (p=0.104); or smoking (p=0.253).

The greatest proportion of babies weighing less than 2500 grams were born less than 37 weeks gestation (60.6%), while babies born weighing more than 4000 grams were at least 37 weeks gestation (100%; p=0.000). There is no difference between newborn birth weight and type of labour (p=0.711); epidural analgesia (p=0.807); or VBAC (p=0.204).

The greatest proportion of newborns weighing greater than 4000 grams were born to women with pre-existing diabetes (2.5%), compared to 0.5% of average weight newborns and none weighing less than 2500 grams (p=0.022). There was no difference, however, between newborn birth weight and gestational diabetes (p=0.421). There was also no difference between pre-existing hypertension and newborn birth weight (p=0.323), but there was a significant relationship between gestational hypertension and birth weight (p=0.026). A greater proportion of babies weighing less than 2500 grams at

Table 9: Differences in Women by Category of Newborn Birth Weight							
Variables	<2500 grams		<2500 gms		>4000gms		p value
	n	(%)	n	(%)	n	(%)	
Parity							0.000
Nullipara (0)	26	(78.8)	525	(60.3)	68	(42.0)	
Para 1	3	(9.1)	271	(31.1)	72	(44.4)	
Para 2 and >	4	(12.1)	74	(8.5)	22	(13.6)	
Maternal Age							0.144
< 20	3	(9.1)	27	(3.1)	4	(2.5)	
20 to 29	16	(48.5)	405	(46.6)	68	(42.0)	
30 to 34	9	(27.3)	292	(33.6)	69	(42.6)	
35+	5	(15.2)	146	(16.8)	21	(13.0)	
Living Status							0.104
Partnered	19	(57.6)	636	(74.2)	119	(73.5)	
Not partnered	14	(42.4)	221	(25.8)	43	(26.5)	
Currently smoking*	3	(9.1)	157	(18.5)	24	(15.2)	0.253
Gestation (weeks)							0.000
37 to 40	13	(39.4)	671	(77.1)	109	(67.3)	
41+	0	(0.0)	164	(18.9)	53	(32.7)	
30 to 36	19	(57.6)	34	(3.9)	0	(0.0)	
< 30	1	(3.0)	1	(0.1)	0	(0.0)	
Labour							0.711
Induced	14	(42.4)	309	(35.5)	57	(35.2)	
Spontaneous	19	(57.6)	561	(64.5)	105	(64.8)	
Epidural analgesia*	17	(51.5)	485	(55.7)	87	(53.7)	0.807
VBAC*	0	(0.0)	14	(1.6)	0	(0.0)	0.204
Pre-existing diabetes*	0	(0.0)	4	(0.5)	4	(2.5)	0.022
Gestational diabetes*	0	(0.0)	35	(4.0)	8	(4.9)	0.421
Pre-existing hypertension*	0	(0.0)	10	(1.1)	0	(0.0)	0.323
Gestational hypertension*	7	(21.2)	74	(8.5)	11	(6.8)	0.026
Oligohydramnios*	4	(12.1)	14	(1.6)	2	(1.2)	0.000
Polyhydramnios*	0	(0.0	5	(0.6)	2	(1.2)	0.567
*Numbers are "yes" in the database; "no" are not entered in the table							

birth (21.2%) were born to women with gestational hypertension, compared to 8.5% of average weight newborns and 6.8% who were greater than 4000 grams.

The greatest proportion of babies weighing less than 2500 grams (12.1%) were born to women with oligohydramnios, compared to the 2.8% of babies who were of average birth weight or greater (p=0.000). There was no difference between newborn birth weight and polyhydramnios (p=0.567).

4.4.5 Predictors of Caesarean Birth

For research objectives one to four, that is, examining the relationship between caesarean birth and maternal pre-pregnancy weight, gestational weight gain, maternal height and newborn birth weight, multiple logistic regression was used to identify predictors for caesarean birth. Potential covariates included all variables that were significant in the chi-square analyses (as listed in table 5). The regression model produced odds ratios with categorical variables, in that one category acted as a reference group to which other categories were compared. If the odds ratio for a category within a variable was not statistically significant, then compared to the reference category, there was no difference in the likelihood of the outcome occurring. Confidence intervals that contain one are not statistically significant.

As summarized in Table 10, epidural analgesia, parity, maternal age, newborn birth weight, weight gain in pregnancy and maternal pre-pregnancy weight are predictors of caesarean birth.

After controlling for other significant predictors, women who had epidural analgesia were 3.5 times more likely to deliver by caesarean birth than those women who did not have epidural analgesia (p=0.000). The risk of caesarean delivery, however, decreases after delivery of one child (p=0.000). Compared to nulliparous women, women having their second child were 3.5 times less likely to have a caesarean, while multiparous women were 2.7 times less likely (based on the reciprocal of the odds ratio).

The likelihood of caesarean birth increases with advancing maternal age (p=0.000). Women, 30 to 35 years old, were 1.5 times more likely than women under 29

Table 10. Predictors of Caesarean Birth					
Variable	**p value**	**Odds Ratio**	**95% CI**		
			Lower	**-**	**Upper**
Epidural Analgesia	0.000				
No	-	1.00			
Yes	0.000	3.48	2.16	-	5.61
Parity	0.000				
Nullipara (Para 0)	-	1.00			
Para 1	0.000	0.28	0.17	-	0.47
Para 2	0.029	0.37	0.15	-	0.90
Maternal Age (years)	0.000				
20 to 29	-	1.00			
< 20	0.079	0.16	0.02	-	1.24
30 to 34	0.048	1.53	1.00	-	2.32
35+	0.000	3.00	1.76	-	5.11
Birth Weight (grams)	0.004				
2500 - 4000	-	1.00			
<2500	0.286	1.72	0.63	-	4.66
>4000	0.001	2.20	1.36	-	3.56
Weight Gain	0.043				
As recommended	-	1.00			
Above	0.960	1.01	0.66	-	1.54
Below	0.019	0.39	0.18	-	0.86
Pre-Pregnancy Weight	0.026				
Acceptable weight	-	1.00			
Underweight	0.174	0.24	0.03	-	1.87
Overweight or Obese	0.030	1.53	1.04	-	2.26

years to give birth by caesarean, while women over the age of 35 years, were 3 times more likely. Also, women who gave birth to babies weighing greater than 4000 grams, were 2.2 times more likely to have a caesarean birth compared to women who gave birth to babies weighing between 2500 and 4000 grams. There was no difference between low birth weight babies (<2500 grams) and babies of average birth weight (2500 to 4000 grams).

The amount of weight gained during pregnancy is also a predictor of caesarean birth, but only in those women who gained less than Health Canada's recommended amount. These women were 2.5 times less likely to deliver by caesarean, compared to women who gain the recommended amount of weight during pregnancy (based on the reciprocal of the odds ratio). Maternal height was not related to birth by caesarean.

The likelihood of caesarean birth also increases with increasing maternal pre-pregnancy weight (p=0.026). Compared to women of acceptable weight, women who were overweight or obese were 1.5 times more likely to have a caesarean birth.

4.5 Predictors of Birth Weight

In order to examine the relationship between maternal weight and newborn weight in research objective five, two new logistic regression models were developed. Two variables were created: small newborns and large newborns. The small newborn variable was divided into two categories of average size newborns (2500 to 4000 grams) and small newborns (<2500 grams), while the large newborn variable was divided into two categories of average size newborns (2500 to 4000 grams) and large newborns (> 4000 grams). Potential covariates included all variables that were significant in the Chi-square analyses.

Table 11 summarizes the differences between small newborns and all potential covariates. A greater proportion of newborns (78.8%) weighing less than 2500 grams were born to first time mothers, than 21.2% collectively in subsequent pregnancies (p=0.025). There was no difference in small and average newborns based on their mother's age (p=0.274), but there was a greater proportion (42.2%) of small newborns born to women who were not partnered compared to those women (25.8%) who were partnered (p=0.043). There was no difference in average or small newborns based on their mothers smoking (p=0.248).

The greatest proportion of newborns weighing less than 2500 grams at birth, were born at less than 37 weeks' gestation (60.6%) compared to the 39.4% who were born at term (p=0.000). There was no difference in newborns of small or average size according to their mothers' labour type (p=0.461), epidural analgesia (p=0.722), VBAC (p=1.000),

Table 11. Differences Between Small Newborns

Variable	Average Newborn		Small Newborn		p value
	n	%	n	%	
Parity					0.025
Nullipara (Para 0)	525	60.3	26	78.8	
Para 1	271	31.1	3	9.1	
Para 2 and greater	74	8.5	4	12.1	
Maternal Age (years)					0.274
< 20	27	3.1	3	9.1	
20 to 29	405	46.6	16	48.5	
30 to 34	292	33.6	9	27.3	
35+	146	16.8	5	15.2	
Living Status					0.043
Partnered	636	74.2	19	57.6	
Not Partnered	221	25.8	14	42.4	
Currently Smoking*	157	18.5	3	9.1	0.248
Gestation at Birth (weeks)					0.000
37 to 40	671	77.1	13	39.4	
41+	164	18.9	0	0.0	
30 to 36	34	3.9	19	57.6	
<30	1	0.1	1	3.0	
Labour					0.461
Induced	309	35.5	14	42.4	
Spontaneous	561	64.5	19	57.6	
Epidural Analgesia*	485	55.7	17	51.5	0.722
VBAC*	14	1.6	0	0.0	1.000
Pre-existing Diabetes*	4	0.5	0	0.0	1.000
Gestational Diabetes*	35	4.0	0	0.0	0.634
Pre-existing Hypertension*	10	1.1	0	0.0	1.000
Gestational Hypertension*	74	8.5	7	21.2	0.023
Oligohydramnios*	14	1.6	4	12.1	0.003
Polyhydramnios*	5	0.6	0	0.0	1.000
Pre-Pregnancy Weight					0.880
Underweight	37	4.3	2	6.1	
Acceptable	425	48.9	16	48.5	
Overweight or Obese	408	46.9	15	45.5	
Gestational Weight Gain					0.010
Above	446	51.3	12	36.4	
Below	141	16.2	12	36.4	
As recommended	283	32.5	9	27.3	
Maternal Height (meters)					0.051
< 1.55	53	6.1	5	15.2	
1.55 to 1.73	768	88.3	28	84.8	
>1.73	49	5.6	0	0.0	

* Numbers are "yes" in the database; "no" are not stated in table

pre-existing diabetes (p=1.000), gestational diabetes (p=0.634), and pre-existing hypertension (p=1.000). A greater proportion (21.2%) of newborns weighing less than 2500 grams were born to women with gestational induced hypertension, compared to the 8.5% of newborns who were of average birth weight (p=0.023).

Approximately 12% of small newborns were born to women with oligohydramnios, compared to 1.6% of average weight newborns (p=0.003). There was no difference in average and small newborns born to women with polyhydramnios (p=1.000), or as a result of their mothers' pre-pregnancy weight (p=0.880). A greater proportion of small newborns (36.4%) were born to women who gained below Health Canada's recommended gestational weight gain, compared to the 16.2% of average weight newborns (p=0.010). There was no difference in small or average newborns based on their mothers' height (p=0.051).

Table 12 summarizes the differences between large newborns and all potential covariates. A greater proportion of large newborns (58%) were born to women having their second or more pregnancy, while a greater proportion (60.3%) of average weight newborns were born to women having their first pregnancy (p=0.000). There was no difference in small or average newborns according to their mothers' age (p=0.156), living status (p=0.455), or smoking status (p=0.367).

The incidence of large newborns (100%) only occurred beyond 37 weeks gestation (p=0.000). There was no difference between average and large newborns as a result of their mothers' labour type (p=1.000), epidural analgesia (p=0.667), or VBAC (p=0.144). A greater proportion of large newborns (2.5%) were born to women with pre-

Table 12. Differences Between Large Newborns					
Variable	Average Newborn		Large Newborn		p value
	n	%	n	%	
Parity					0.000
Nullipara (Para 0)	525	60.3	68	42.0	
Para 1	271	31.1	72	44.4	
Para 2 and greater	74	8.5	22	13.6	
Maternal Age (years)					0.156
< 20	27	3.1	4	2.5	
20 to 29	405	46.6	68	42.0	
30 to 34	292	33.6	69	42.6	
35+	146	16.8	21	13.0	
Living Status					0.455
Partnered	636	74.2	119	73.5	
Not Partnered	221	25.8	43	26.5	
Currently Smoking*	157	18.5	24	15.2	0.367
Gestation at Birth (weeks)					0.000
37 to 40	671	77.1	109	67.3	
41+	164	18.9	53	32.7	
30 to 36	34	3.9	0	0.0	
<30	1	0.1	0	0.0	
Labour					1.000
Induced	309	35.5	57	35.2	
Spontaneous	561	64.5	105	64.8	
Epidural Analgesia*	485	55.7	87	53.7	0.667
VBAC*	14	1.6	0	0.0	0.144
Pre-existing Diabetes*	4	0.5	4	2.5	0.024
Gestational Diabetes*	35	4.0	8	4.9	0.527
Pre-existing Hypertension*	10	1.1	0	0.0	0.377
Gestational Hypertension*	74	8.5	11	6.8	0.536
Oligohydramnios*	14	1.6	2	1.2	1.000
Polyhydramnios*	5	0.6	2	1.2	0.303
Pre-Pregnancy Weight					0.006
Underweight	37	4.3	2	1.2	
Acceptable	425	48.9	64	39.5	
Overweight or Obese	408	46.9	96	59.3	
Gestational Weight Gain					0.000
Above	446	51.3	113	69.8	
Below	141	16.2	14	8.6	
As recommended	283	32.5	35	21.6	
Maternal Height (meters)					0.134
< 1.55	53	6.1	4	2.5	
1.55 to 1.73	768	88.3	146	90.1	
>1.73	49	5.6	12	7.4	
* Numbers are "yes" in the database; "no" are not stated in table					

existing diabetes, compared to only 0.5% of newborns of average weight (p=0.024). However, there was no difference between average and large newborns of women with gestational diabetes (p=0.527), pre-existing hypertension (p=0.377), gestational hypertension (p=0.536), oligohydramnios (p=1.000) and polyhydramnios (p=0.303).

As maternal pre-pregnancy weight increased, so did the incidence of macrosomic newborns (p=0.006). The greatest proportion of newborns weighing more than 4000 grams (59.3%) were born to women who were overweight or obese, compared to 1.2% of large newborns born to mothers who were underweight. Similarly, the greatest proportion of macrosomic newborns (69.8%) were born to women who exceeded Health Canada's recommendations for gestational weight gain, compared to 21.6% of large infants born to women who gained the recommended amount (p=0.000). There was no difference between average and large newborns and their mothers' height (p=0.134).

The logistic regression model for small newborns was limited by the small number of low birth weight newborns (< 2500 grams) in this study, and therefore will not be discussed in this portion of the document. Results of this analysis are summarized in Table A1 of Appendix A.

As summarized in Table 13, gestation at delivery, parity, maternal pre-existing diabetes and gestational weight gain are predictors of newborn macrosomia. There was no association, however, between maternal pre-pregnancy overweight and obesity and newborn birth weight (p=0.124). Babies, who were born past the expected delivery date, at 41+ weeks gestation, were twice as likely as those born at term (37 to 40 weeks gestation), to weigh over 4000 grams (p=0.005). As parity increased, so did the odds of giving birth to heavier babies (p=0.000). Women having their second baby were 2.4 times as likely to give birth to a baby weighing greater than 4000 grams than women having their first, while women having their third or more baby were 3 times more likely.

Table 13. Predictors of Large Newborns (Macrosomia)			
Variable	**p value**	**Odds Ratio**	**95% CI** **Lower - Upper**
Gestation (weeks)	0.005		
37 to 40	-	1.00	
30 to 36	0.998	0.00	0.00
< 30	1.000	0.00	0.00
41+	0.000	2.04	1.38 - 2.99
Parity	0.000		
Nullipara (Para 0)	-	1.00	
Para 1	0.000	2.40	1.65 - 3.51
Para 2 and >	0.000	3.05	1.72 - 5.43
Pre-existing Diabetes Mellitus	0.010		
No	-	1.00	
Yes	0.010	7.67	1.65 - 35.77
Gestational Weight Gain	0.000		
As recommended	-	1.00	
Above	0.001	2.03	1.33 - 3.11
Below	0.370	0.74	0.38 - 1.44
Pre-pregnancy weight	0.124		
Acceptable	-	1.00	
Underweight	0.308	0.47	0.11 - 2.02
Overweight or obese	0.106	1.35	0.94 - 1.93

Women who were diagnosed with diabetes prior to pregnancy, were 7.67 times more likely to have a macrosomic newborn, compared to women who were not diabetic (p=0.010). Also, women who gained more than Health Canada's recommended amount during their pregnancy were twice as likely as those women who gained the recommended amount, to give birth to babies weighing greater than 4000 grams (p=0.000).

5.0 Discussion

The rise in the caesarean birth rate over the last thirty years has raised global concern regarding over use of this procedure. Canada's caesarean birth rate has reached an all time high of 22.5% of all births, while Newfoundland and Labrador exceeds the national average at 26.6% (CIHI, 2004). Caesarean birth is not without maternal risk, due to intraoperative and postoperative complications, such as hemorrhage, injuries to the urinary and gastrointestinal tracts, and infection. On a socioeconomic level, caesarean birth results in an increased maternal hospital stay and a longer physical recovery period, leading to higher hospitalization costs.

A number of factors, including maternal overweight and obesity, have been attributed to the increase in the incidence of caesarean birth. Overweight and obesity is increasing worldwide, particularly in the western world. Obesity is considered to be a disease in its own right, as well as a major risk factor for other diseases, such as hypertension and diabetes.

Research to date has shown that maternal pre-pregnant overweight and obesity place a pregnant woman at increased risk for caesarean birth. The primary objective of this study was to examine the relationship between pre-pregnancy overweight and obesity, and caesarean birth in labouring women (research objective one). This study also examined the relationship between caesarean birth and maternal height, gestational weight gain and newborn birth weight (objectives two to four), and the relationship between pre-pregnancy weight and newborn birth weight (objective five).

5.1 Caesarean Rates

The overall study caesarean rate was 14.2%. It is important to note that this is not a primary caesarean rate, as it includes women who had a previous caesarean birth. Rather, it is the caesarean rate of only those women who underwent labour with the expectation of a vaginal birth, so as to eliminate scheduled and mandatory caesareans that would confound the findings in studying the relationship between overweight or obesity and caesarean birth.

This study excluded women who did not labour, thereby deviating from others. For example, Joseph et al. (2003) and Jensen et al. (1999), studied the effects of maternal characteristics such as pre-pregnancy body mass on the primary caesarean rate only, and excluded any woman with a previous caesarean birth (no exclusion for not labouring in elective caesareans). Others, such as Garbaciak et al. (1985), simply studied the effects of obesity on birth outcomes of women who gave birth within a particular study period. These are important points, as the caesarean rate was only 14.2% in my study, yet, when the 440 women who did not labour (yet met all the other criteria) were included, the caesarean rate increased to 24.9%. These statistics suggest that many caesareans are performed without labour, and review of the indications for these caesareans could prove beneficial.

5.1.1 Pre-pregnancy Weight and Caesarean Birth

The first research objective was to examine the relationship between pre-pregnancy weight and caesarean birth. Approximately 39% of Canadian women are either overweight or obese; while in the St. John's region that rate is 48.1%, well above the national average (Statistics Canada, 2002). In this study, the sample was determined to be representative of women giving birth from the St. John's region, where 48.7% of the women were, also, either overweight or obese.

After controlling for other significant predictors, in support of my hypothesis, the study found that overweight or obese women were 1.5 times more likely to give birth by caesarean, compared to women who were of acceptable weight. This is particularly alarming when one considers that one in two women admitted to the Women's Health Center, were either overweight or obese. The findings of this study are consistent with studies elsewhere, as for example, Beaten et al. (2001) and Witter (1995) reported that the risk of caesarean birth increases with increasing BMI.

This study also identified an unadjusted association between overweight and obesity during pregnancy and gestational diabetes, gestational hypertension and polyhydramnios. Galtier-Dereure, Boegner & Bringer (2000) reported that even moderate overweight is a risk factor for gestational diabetes and hypertensive disorders of pregnancy. Harlow et al. (1995) documented in an epidemiological study of low risk nulliparous women, that maternal anthropometric factors are more strongly associated with the incidence of caesarean delivery for maternal indications, such as pregnancy induced hypertension and diabetes, than for fetal indications, such as fetal distress. Harlow et al. reported that for every 10 kilogram increase in pre-pregnancy weight, there was a 25% increase in risk for maternal indicated caesarean births.

It is important to note that while the results of this study are consistent with research elsewhere, there were variations in approach with regard to comparison groups and referent groups, definitions of body weight and sample characteristics. While this study examined the risk of both overweight and obesity on birth outcome, many of the previous studies, for example Crane et al. (1997), focused exclusively on the effects of just obesity on pregnancy outcomes or complications. Since surveillance reports cite both overweight and obesity rates, and medical literature refers to risks of both, I felt it important in the interest of public health to study the effects of both overweight and obesity on the risk of caesarean birth.

This study used a different referent BMI classification group than others. In this study, the BMI international standard average range of 18.5 to 24.9 was used as the referent classification in determining if pre-pregnant overweight and obesity increased the risk of caesarean birth. In other words, overweight and obese women were compared to average weight women to determine if they were at increased risk for a caesarean birth. However, R. Cnattingius et al. (1998) and Beaten et al. (2001) used underweight women (BMI< 20.0) as their referent classification. While these researchers may have had valid reasons for using this referent, it should be remembered that underweight women are not the norm in our society, and are often linked with concerns regarding their medical health. One must be vigilant not to characterize underweight women, as the norm, and risk encouraging others to strive for a goal that may not be viewed by health care providers or society as realistic or desirable.

It is also important to acknowledge the use of different measures in the study of overweight and obesity. This study used BMI, while Joseph et al. (2003) classified pre-pregnancy weight simply by kilogram weight. Unfortunately, using maternal body weight without knowledge of maternal height makes it difficult to generalize these findings to other populations in determining the risk of caesarean birth.

5.1.2 Maternal Height and Caesarean Birth

The second research objective was to examine the relationship between maternal height and caesarean birth. Unlike other research, and contrary to my hypothesis, this study did not identify an association between maternal height and caesarean birth. It is possible that this deviation may be attributable to differences in the sample population resulting from environmental and genetic factors (Tigchelaar, Jong, & Godwin, 1998). For example, Witter et al. (1995), Kaiser & Kirby (2001) and R. Cnattingius et al. (1998) documented that women of short stature are at increased risk for caesarean birth, regardless of the caesarean rates in their institutions. While the St. John's population was primarily English in origin, the studies of Witter et al. and Kaiser & Kirby were comprised of a primarily black population, while that of Cnattingius was Scandinavian (Encyclopedia of Newfoundland and Labrador, 1994).

These studies may be compared to the caesarean rate among Inuit women. While female Inuit lie between the 10^{th} and 50^{th} percentile of US standards for height, the caesarean rate in Nunavut is only 9.2% (Tigchelaar et al.1998; CIHI, 2004). It is examples such as this, which accentuate the point that birth outcome is a complex issue, and often not attributable to simply one variable. In Nunavut, where women are of short stature, the low caesarean rate may possibly be the result of a cumulative effect of diverse variables, such as different attitudinal, cultural, and clinical childbirth practices.

5.1.3 Gestational Weight Gain and Caesarean Birth

The third research objective was to examine the relationship between gestational weight gain and caesarean birth. In this study population the majority of women (except for those who were underweight) exceeded Health Canada's recommendations for weight gain in pregnancy. Only 25% of overweight or obese women, and 35% of women with acceptable weight, gained the recommended amount during their pregnancy. Contrary to my hypothesis, the study did not find that weight gain exceeding recommended guidelines increased the risk of caesarean birth. Rather, in this study, the association between weight gain during pregnancy and risk of caesarean birth was significant, but only in women who gained less weight during pregnancy than recommended by Health Canada. These women were 2.5 times less likely to deliver by caesarean compared to women who gained weight as recommended.

Even though the results of this study suggest that women are less likely to deliver by caesarean if they gain less weight than recommended by Health Canada, it is not a finding that promotes a "healthy" population health message. Pregnant women should be encouraged and supported to gain the recommended amount of weight as determined by Health Canada.

5.1.4. Newborn Birth Weight and Caesarean Birth

The fourth research objective was to examine the relationship between newborn birth weight and caesarean birth. After controlling for other significant predictors, in support of my hypothesis, the study found that women who have babies weighing greater than 4000 grams at birth are 2.2 times more likely to give birth by caesarean, compared to women who have babies weighing between 2500 and 4000 grams.

As results of this study highlight the connection between newborn size and the other variables of pre-pregnancy weight and gestational weight gain, newborn size will be discussed in greater detail in sections 5.2.1 and 5.2.2.

5.1.5 Other Predictors of Caesarean Birth

Consistent with other research, this study found that the odds of having a caesarean birth increase with advanced maternal age, and conversely, decrease with increased parity. It appears the societal trends of delaying childbirth and having small families combine to increase the risk of caesarean birth. This continues to be an important thought to keep in mind, when reviewing caesarean rates and studying perinatal trends.

Meanwhile, the clinical practice of epidural analgesia is increasingly emerging as standard practice. The proportion of labouring women in this study group who were given epidural analgesia was 55%. Of those women, 60.5% were overweight or obese, while only 39% were underweight. The fact that labouring women with epidural analgesia were 3.5 times more likely to have a caesarean birth certainly highlights this clinical practice and its role in contributing to the increased caesarean rate. However, as there are many confounders apparent when studying the relationship between epidural analgesia and cesarean birth, such as length of labour and fetal position, further research on the clinical practice of epidural analgesia and birth outcomes is certainly warranted.

5.2 Newborn Birth Weight

Both health care providers and the general population in the St. John's area have speculated, based on anecdotal evidence, that newborns "weigh more today than years ago". This assumption has been supported by Surkan, Hsieh, Johansson, Dickman & Cnattingius (2004), who reported an increase in the mean birth weight and proportions of large for gestational age infants in the past 20 years. Many studies have attributed this increase in fetal size to maternal obesity.

In this study the relationship between pre-pregnancy weight and newborn birth weight was examined (research objective number five), and two variables were created: small newborns and large newborns.

5.2.1 Maternal Pre-pregnancy Weight and Newborn Birth Weight

Unlike other research, and contrary to my hypothesis, this study did not find an association between pre-pregnancy overweight and obesity and newborn birth weight. This apparent discrepancy may be explained by differences in comparison, referent and sample groups between my study and previous research. For example, the Finnish study by Ekblad & Grenman (1992) studied obese women only, and used underweight women as their referent group, while Edwards et al. (1978) studied morbidly obese women. As a result of these findings, it would be very interesting to conduct further research using the definition of macrosomia as sometimes used by the American College of Obstetricians and Gynecologists (that is, birth weight equal to or greater than 4500 grams) to determine if this revised criterion presents different findings.

5.2.2 Other Predictors of Newborn Birth Weight

Over one half of the study population, and 65% of those women who delivered by caesarean, exceeded Health Canada's recommendations for gestational weight gain. Even though there was no association between gestational weight gain and caesarean birth, there was an association between gestational weight gain and newborn birth weight. Women, who exceeded Health Canada's recommendations for weight gain in pregnancy, were twice as likely to give birth to an infant weighing more than 4000 grams, and, in turn, women with macrosomic infants were twice as likely to deliver by caesarean.

There is obviously a need to educate and encourage women to comply with Health Canada's recommendations and strive for recommended weight gain as per their BMI. There is also a concern that prenatal care providers are not providing adequate guideline information to their patients during pregnancy. For example, only 37.6% of the 4,136 women, who gave birth at the Women's Health Center in 2002-03 with a completed prenatal record, had their BMI calculated and recorded (Provincial Perinatal Program, 2002 & 2003).

This study also found an unadjusted association between those women who gained less than the recommended amount and infants weighing less than 2500 grams. Johnson et al. (1992) reported that findings such as these warrant careful review of weight gain advice. Poor growth in utero, resulting in low birth weight, increases the risk of infant mortality and morbidity (Shah & Ohlsson, 2002). Maternal nutritional factors, such as underweight, low pregnancy weight gain and low caloric intake, account for approximately 10 to 15% of all low birth weight newborns (Health Canada, 2003).

Maternal comorbidities, such as pre-existing or gestational diabetes, are well documented in the literature as contributing to macrosomia. This study found that a significant association occurred between maternal pre-existing diabetes and newborn birth weight, in that women with pre-existing diabetes were almost eight times more likely to have a macrosomic infant than those women without this disease. It is imperative, therefore, that those with diabetes receive pre-conception counseling and plan for a pregnancy long before it occurs. Ideally, conception should occur at the time of ideal metabolic control and body weight, regular physical activity and other population health pre-conception measures, such as folic acid supplementation and smoking cessation (Shandro & Toth, 2003).

This study also demonstrated an interesting association between increasing parity and macrosomia. Even though women having their second baby are 2.5 times more likely than first time mothers to have a baby weighing greater than 4000 grams, and women having their third or more baby are 3 times as likely, the risk of caesarean birth actually decreases for these women. A study involving only labouring nulliparas may prove beneficial in further explaining birth outcomes to this group of women most at risk for caesarean birth.

Women who exceeded their expected date of delivery, and delivered beyond 41+ weeks gestation were also twice as likely to deliver a macrosomic infant. Due to the association between macrosomia and caesarean birth, it appears that those women who exceed their expected date of delivery are also at increased risk for caesarean birth. This finding is one that does not appear to have an easy solution. According to ACOG, the prenatal diagnosis of macrosomia is often very imprecise, and delivering an apparent macrosomic infant by inducing labour before it reaches full term may, instead, increase the caesarean rate as a result of failed inductions (2000).

5.3 Policy Implications

The findings of this study highlight the link between overweight and obesity, pregnancy weight gain, and cesarean birth, macrosomia, and other maternal comorbidities and labour interventions. In recent years, there has been a great deal of medical and media attention focused on the global increase of overweight and obesity. There is growing public awareness that excess weight is associated with an increased incidence of such diseases as coronary heart disease, hypertension and type 2 diabetes mellitus. Additionally, when these comorbidities of diabetes and hypertension occur in pregnancy, it complicates the health of both mother and baby and affects pregnancy outcomes.

Given the high prevalence of overweight and obesity among women of childbearing age in the St. John's region (and more specifically among pregnant women) this study underscores the need for greater public policy in this area. Preconception health promotion strategies should highlight the importance of a healthy prepregnancy weight in addition to folic acid supplementation and smoking cessation. Weight reduction, exercise programs, and stabilization of existing medical problems are more safely achieved prior to pregnancy.

The study findings also highlight that pregnancy weight gain is as important as prepregnancy weight in terms of reducing caesarean and macrosomia risk. Excessive weight gain in pregnancy affects not only the mother, but also the fetus. Excessive weight gain during pregnancy worsens maternal obesity, while macrosomic infants are more likely to become obese in later life (Galtier-Dereure et al., 2000). Public policy to promote healthy eating in pregnancy is imperative, with emphasis on dietary quality, not just quantity. There is an urgent need to promote healthy pregnancy weight gain as approximately 65% of overweight and obese women in this study exceeded Health Canada's recommended pregnancy weight gain.

These findings suggest that a multipronged strategy, targeting both women and prenatal health care providers, is required. These strategies should increase awareness of and compliance with weight gain guidelines. Likewise, there is a need to educate health providers to calculate patients' BMI and counsel them accordingly. It is important to ensure that pregnant women receive adequate nutrition that promotes optimal weight gain and a healthy newborn weight, and barriers to healthy eating must also be kept in mind, such as the inability of women to afford to purchase nutritious foods. Additional time should be taken to determine the quality of maternal nutritional intake, acknowledging there could be maternal weight loss with increased fetal growth as a result of improved maternal food choices, or increased maternal weight gain with fluid retention and decreased fetal growth. Potentially, weight gain advice may be better served with recommendations for meal plans to follow during pregnancy, and /or individual nutritional counseling, rather than simply focusing on weight gain per BMI index.

5.4 Limitations

As this study was limited to the data available in the Provincial Perinatal database, height and pre-pregnancy weight may have been provided by patient recall. However, as previously discussed, a study by Lederman and Paxton (1998) found that such data recalled from the mother was extremely reliable. There was also an assumption that health records technicians correctly transcribed information from clinical records to the perinatal database. Moreover, many of the health and prenatal records were not completed by medical and nursing staff, which resulted in missing data, such as maternal height and pre-pregnancy weight. Additionally, the data from the perinatal database do not capture information that also may influence caesarean rates, such as attitudes of patients and health care providers.

In the study, covariates such as VBAC, polyhydramnios, oligohydramnios, hypertension and diabetes contained very small numbers, which possibly affected significance. There were also a very small number of infants born weighing less than 2500 grams.

Expansion of the perinatal database to include information from outside the St. John's region would be a positive step towards accomplishing province wide studies to include urban/rural differences.

5.5 Dissemination and Research Transfer

This study will be of interest to health care providers, policy makers and the general public. Presently in Newfoundland and Labrador, as a result of the Provincial Wellness Strategy, recommendations are being developed to improve the overall health and well being of the population (Government of Newfoundland & Labrador, 2003). This study provides information to those developing policy and initiating programs in health promotion and primary prevention, which can be generalized to improve the health of all women of reproductive age. Additionally, this information could assist health care providers by providing evidence-based research, enabling them to counsel patients on appropriate choices and behaviours, to improve their health and pregnancy outcomes.

Dissemination of the study includes presentation at the Division of Community Health seminars and obstetrical research symposiums. A summary report will also be written and distributed to stakeholder groups, such as physicians, special interest groups and organizations, and government.

6.0 Conclusion

6.1 Summary

Approximately one half of the women in Newfoundland and Labrador are either overweight or obese. This statistic is also reflected in the fact that approximately one half of women who become pregnant, are also either overweight or obese. This "modern day epidemic" is associated with, and perceived to be, the cause of many complications that impact on the health of women and their babies.

As studies have documented that maternal obesity and overweight are risk factors in the occurrence of caesarean birth, the primary objective of this study was to explore the relationship between pre-pregnancy overweight and obesity and the risk for caesarean birth in labouring patients, in the St. John's region. Additionally, since studies have demonstrated a positive correlation between gestational weight gain, short stature, increased fetal size (newborn birth weight) and incidence of caesarean birth, research objectives two to four of this study examined the relationship between caesarean birth and maternal height, gestational weight gain and newborn birth weight. Studies have also documented an association between maternal overweight and obesity and large newborn birth weight. Research objective number five examined the relationship between maternal pre-pregnancy weight and newborn birth weight.

Using data obtained from the Newfoundland and Labrador Provincial Perinatal Program database, this study examined 1,065 women who were from the St. John's region and delivered live births at the Women's Health Center between January 1, 2002 and November 30, 2003. The study only included women who underwent a trial of labour.

For research objectives one through four, the dependent variable was the type of birth: that is caesarean versus vaginal birth. For the fifth objective (to examine the association between pre-pregnancy weight and newborn birth weight) two new variables were created: small newborns and large newborns. Fourteen covariates were also considered in the study. They were selected based on their influence on the dependent and independent variables as cited in the literature and availability in the perinatal database.

Multiple logistic regression was used to examine the association between birth by caesarean and pre-pregnancy weight, pregnancy weight gain, maternal height and newborn weight (research objectives one to four), and the association between newborn birth weight and pre-pregnancy weight (research objective five) after controlling for other significant predictors.

Epidural analgesia, parity, maternal age, newborn birth weight, weight gain in pregnancy and maternal pre-pregnancy weight were predictors of caesarean birth. Women, who gave birth to babies weighing greater than 4000 grams, were 2.2 times more likely to have a caesarean birth compared to women who gave birth to babies of average weight ($p=0.004$). The amount of weight gained during pregnancy was also a predictor of caesarean birth, but only in those women who gained less than Health Canada's recommended amount. These women were 2.5 times less likely to deliver by caesarean, compared to women who gain the recommended amount of weight during pregnancy ($p=0.043$). The likelihood of caesarean birth also increased with increasing maternal pre-pregnancy weight. Compared to women of acceptable weight, women who were overweight or obese were 1.5 times more likely to have a caesarean birth (p=0.026).

Gestation at delivery, parity, maternal pre-existing diabetes and gestational weight gain were predictors of newborn macrosomia. Babies, who were born at 41+ weeks gestation, were twice as likely as those born at term (37 to 40 weeks gestation), to weigh over 4000 grams (p=0.005). As parity increased, so did the odds of giving birth to heavier babies (p=0.000). Women who were diagnosed with diabetes prior to pregnancy, were 7.67 times more likely to have a macrosomic newborn, compared to women who were not diabetic (p=0.010). Also, women who gained more than Health Canada's recommended amount during their pregnancy were twice as likely as those women who gained the recommended amount, to give birth to babies weighing greater than 4000 grams (p=0.000). There was no association, however, between maternal pre-pregnancy overweight and obesity and newborn birth weight (p=0.124).

6.2 Recommendations

The study suggests a number of recommendations for perinatal health care providers, the Government of Newfoundland and Labrador (specifically Department of Health and Community Services), the Provincial Perinatal Program and other researchers. These recommendations pertain to public health policy, support of data infrastructure to monitor and evaluate perinatal health in Newfoundland and Labrador, areas for further research, and research methodology.

6.2.1 Healthy Body Weight

The Department of Health and Community Services, the Provincial Perinatal Program, and prenatal heath care providers should promote healthy preconception body weight.

Expanded public health education is needed to inform women of reproductive age that preparing for pregnancy involves a variety of measures to promote optimal pregnancy outcomes The preconception period is the optimal time to promote healthy body weight and lifestyle behaviours for women considering pregnancy. Weight reduction, exercise programs, and stabilization of existing medical problems are more safely achieved prior to pregnancy Preconception education campaigns should highlight folic acid supplementation, smoking cessation as well as healthy body weight.

6.2.2 Pregnancy Weight Gain

The Department of Health and Community Services, Provincial Perinatal Program, and prenatal health care providers should develop strategies to increase awareness of and compliance with recommended weight gain guidelines

It is important to ensure that pregnant women receive adequate nutrition that promotes optimal weight gain and a healthy newborn birth weight. However, it is very clear that excessive weight gain increases the likelihood of a macrosomic infant, and a macrosomic infant increases the likelihood of caesarean birth. It is a concern that over one half of the women in the study population exceeded Health Canada's weight gain recommendations, and a greater concern that 65% of these women were already overweight or obese.

When counseling women on weight gain in pregnancy it is considered best practice to follow the recommendations of Health Canada. Work needs to be done on educating care providers to calculate patients' BMI and counsel them accordingly.

Additional time should be taken to determine the quality of maternal nutritional intake, acknowledging there could be maternal weight loss with increased fetal growth as a result of improved maternal food choices, or increased maternal weight gain with fluid retention and decreased fetal growth. Potentially, weight gain advice may be better served with recommendations for meal plans to follow during pregnancy, and /or individual nutritional counseling, rather than simply focusing on weight gain per BMI index.

6.2.3 Perinatal Database

The Department of Health and Community Services and the Provincial Perinatal Program should expand the perinatal database to include the entire province.

Presently, the Provincial Perinatal Program collects obstetrical and newborn information, for its perinatal database, only from women who give birth at the Women's Health Center (and as of January 1, 2005, from Labrador). A province wide database would be both a valuable resource for researchers and an aid in provincial perinatal surveillance. Additionally, in order to ensure that the database is as complete as possible, it is important that all care providers strive to provide complete and reliable health documentation.

6.2.4 Research Methods

Researchers should adopt consistent methods for measuring obesity and comparing weight groups.

The consistent use of BMI by researchers would facilitate a smoother transfer of findings to clinical practice. Even though BMI is not the perfect tool, as it does not differentiate fat from muscle, nor measure abdominal girth, it allows the clinician to at least classify individuals in a consistent manner with others. Simply generalizing the finding of a study, based solely on weight, without knowledge of height, proves much more difficult.

Secondly, the consistent use of the same referent groups would again promote the ability to generalize findings. If researchers were to use the "norm" as the means of comparison, such as average or acceptable weight, others could apply the study findings more easily to different populations..

6.2.5 Additional Research Topics

Researchers (with support of the Department of Health and Community Services, Provinical Perinatal Program and other funders) should continue to study the impact of obesity on pregnancy, birth, and maternal and fetal outcomes.

Weight gain in pregnancy continues to be a complex issue and guidelines for recommended weight gain in pregnancy is not clear-cut. As women who gain less than Health Canada's recommended amount are less likely to have a caesarean birth, further study is needed to determine if the guidelines for acceptable weight gain are, in fact, too high, and could be lowered. Studies to determine this, while taking into account healthy fetal size without increasing the risk of low birth weight, could be extremely beneficial in the prevention of caesarean birth. Conversely, the high incidence of women exceeding Health Canada's recommended amount of weight gain during pregnancy also necessitates further study. Research to better understand the principal factors that contribute to or cause excessive weight gain would be of value.

Women having more than one pregnancy are more likely than first time mothers to have a baby weighing greater than 4000 grams, yet the risk of caesarean birth actually decreases for these women. A study of labouring nulliparas may prove beneficial in further explaining birth outcomes to this group of women most at risk for caesarean birth.

This study found that labouring women with epidural analgesia were 3.5 times more likely to have a caesarean birth, and the majority of women receiving an epidural were overweight or obese. Further study into this increasingly common clinical practice could provide insight into the rising caesarean birth rate.

6.3 Conclusion

Using data from the Newfoundland and Labrador Provincial Perinatal database, this study found that maternal pre-pregnancy overweight and obesity increased the risk of caesarean birth in labouring women in the St. John's region. Moreover, excessive pregnancy weight gain, not pre-pregnancy overweight and obesity, increases the likelihood of having macrosomic (> 4000 grams) newborns.

These findings further support the need for healthy public policy to address obesity, particularly among women of reproductive age. Furthermore, the study highlights the need for increased education and awareness of healthy weight gain during pregnancy.

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Appendix A

Table A1. Predictors of Low Birth Weight				
Variable	**p value**	**Odds Ratio**	**95% CI Lower**	**95% CI Upper**
Gestation (weeks)	0.000			
37 to 40	-	1.00		
30 to 36	0.000	53.12	19.74	142.93
< 30	0.001	313.96	10.49	9397.83
41+	0.995	0.00	0.00	
Parity	0.019			
Primipara	-	1.00		
Para 1	0.005	0.14	0.03	0.54
Para 2 and >	0.591	0.69	0.18	2.68
Oligohydramnios	0.000			
No	-	1.00		
Yes	0.000	17.98	3.73	86.74
Gestational Induced Hypertension	0.007			
No	-	1.00		
Yes	0.007	5.13	1.57	16.79
Living Status	0.031			
Partnered	-	1.00		
Not partnered	0.031	2.73	1.10	6.77
Gestational Weight Gain	0.048			
As recommended	-	1.00		
Above	0.777	0.85	0.28	2.56
Below	0.064	3.00	0.94	9.6