

UNIVERSITY OF CALGARY

Maternal Risk Factors for Cesarean Delivery in Alberta

by

Sophie Yue Chen

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF COMMUNITY HEALTH SCIENCES

CALGARY, ALBERTA

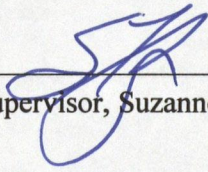
January, 2005

© Sophie Yue Chen 2005

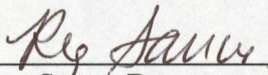
UNIVERSITY OF CALGARY

FACULTY OF GRADUATE STUDIES

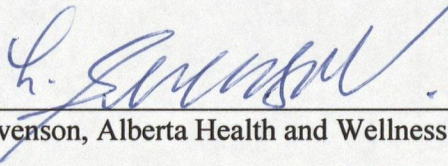
The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Maternal Risk Factors for Cesarean Delivery in Alberta" submitted by Sophie Yue Chen in partial fulfilment of the requirements of the degree of Master of Science.



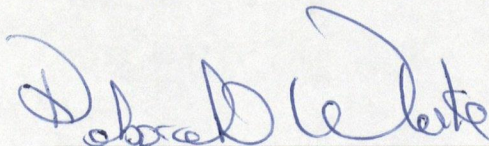
Supervisor, Suzanne Tough, Department of Community Health Sciences



Reg Sauvé, Department of Community Health Sciences



Larry Svenson, Alberta Health and Wellness



Deborah White, Department of Faculty of Nursing

Date: December 14, 2004

Abstract

Rates of cesarean delivery (CD) have increase over the past decade. Although generally CD is safe, it is not without medical risk. Objective: 1) To determine regional and provincial trends in CD rates from 1997 to 2002 in Alberta? 2) To determine the characteristics of mothers who underwent CD? 3) To determine age group specific risk factors for CD? 4) To determine risk factors for CD among those with spontaneous and induced labour?

Methods: A population-based analysis of the Notice of Live Birth or Stillbirth database.

Results: CD rates increased over time. CD was associated with advance maternal age, nulliparity, induced labour and gestational age less than 37 weeks. Identifical risk factors were noted between those with spontaneous and induced labour.

Conclusion: This study provides information on CD risk factors, which may assist physicians and women to develop appropriate plans for birth.

Acknowledgements

I would like to thank Dr. Suzanne Tough, Dr. Reginald Sauve and Mr. Larry Svenson for their advice and support throughout this study. I am privileged to have all of you on my supervisory committee. I particularly wish to thank my supervisor Dr. Suzanne Tough for her excellent supervision throughout my master study. I wish to thank Ms. Karen Tofflemire, a research associate of the Decision Support Research Team, for her help. I also gratefully acknowledge my External Examiner, Dr. Deborah White, from the Faculty of Nursing, University of Calgary.

I would like to thank Alberta Health and Wellness for giving me permission to access the data. I also gratefully acknowledge Student Research Award offered to me by 10th Annual Child Health Research Symposium to encourage me to continue to do better research in this area and the personal support awarded to me by the Child Health Research Group of the Calgary Health Region, the Faculty of Graduate Studies of the University of Calgary and Alberta Learning.

Dedication

To my loving family

Table of Contents

Approval Page.....	ii
Acknowledgements.....	iv
Dedication.....	v
Table of Contents.....	vi
List of Tables	viii
Chapter One: Introduction.....	1
1.1 Research Questions.....	1
1.2 Research Hypotheses	1
1.3 Study Rationale.....	2
Chapter Two: Review of the Literature	4
2.1 Indications of Cesarean Delivery.....	4
2.2 Potential Risk Factors of Cesarean Delivery	4
2.2.1 Maternal Age	5
2.2.2 Parity.....	6
2.2.3 Induced labour	7
2.2.4 Birth Weight and Gestational Age.....	7
2.2.5 Multiple Birth.....	8
2.2.6 Smoking	9
2.2.7 Alcohol and Drug Use	9
2.2.8 Prenatal Care and Marital Status.....	10
2.2.9 History of Previous Abortion.....	10
2.2.10 Geographic Differences	11
Chapter Three: Methodology	13
3.1 Operational Definitions.....	13
3.2 Design Type and Rationale.....	16
3.3 Target Population.....	16
3.4 Data Source and Location for the Study.....	17
3.5 Access to the Research Setting	17
3.6 Data Analysis Procedures	18
3.6.1 Study Variables.....	18
3.6.2 Data Cleaning.....	19
3.6.3 Data Analysis	19
3.7 Ethical Considerations	24
Chapter Four: Results.....	25
4.1 Cesarean Delivery Rate in Alberta	25
4.1.1 Annual Provincial Cesarean Delivery Rate	26
4.1.2 Annual Age-Specific Cesarean Delivery Rate.....	27
4.1.3 Annual Cesarean Delivery Rates in Spontaneous and Induced Labour Groups.....	28
4.1.4 Regional Variations of Cesarean Delivery Rate	30
4.2 Characteristics of Mothers Who Underwent CD in Comparison to Those Who Did Not.....	35
4.2.1 Baseline Characteristics of Cesarean Delivery	35
4.2.2 Characteristics of Mother with Cesarean Delivery in Comparison to Those without Cesarean Delivery.....	39
4.2.3 Mean Differences of Maternal Characteristics	42

4.2.4 Characteristics of Maternal Age	44
4.3 Potential Risk Factors for Cesarean Delivery among Different Maternal Age Groups	53
4.3.1 Difference in Maternal Characteristics of Cesarean Delivery among Different Age Groups	53
4.3.2 Unadjusted Odds Ratios of Cesarean Delivery among Different Age Groups	60
4.3.3 Logistic Regression Analysis for Cesarean Delivery among Different Age Groups	63
4.4 Potential Risk Factors for Cesarean Delivery in Spontaneous and Induced Labour Groups	66
4.4.1 Difference in Maternal Characteristics of Cesarean Delivery between Spontaneous and Induced Labour Groups	66
4.4.2 Unadjusted Odds Ratios of Cesarean Delivery Comparing Spontaneous and Induced Labour Groups	69
4.4.3 Logistic Regression Analysis of Cesarean Delivery for Induced Labour and Spontaneous Labour Groups	71
Chapter Five: Discussion	75
5.1 Discussion of the Results	75
5.1.1 CD rates from 1997 to 2002 in Alberta	75
5.1.2 The Impact of Maternal Age on Cesarean Delivery	76
5.1.3 Predictors of Cesarean Delivery among Different Maternal Age Groups ..	77
5.1.4 Predictors of Cesarean Delivery in Spontaneous and Induced Labour Groups	79
5.2 Strengths and Weakness of the Study	80
5.2.1 Study Strengths	80
5.2.2 Study Weakness	81
5.3 Summary of the Study Results and Conclusion	84
5.4 Suggestions for Further Research	88
Reference	91
Appendix A: Figures For the Tables Presented in the Results	100

List of Tables

Table 1. Number and rate of overall annual cesarean delivery (CD) among live births, Alberta, 1997-2002	26
Table 2. Annual age-specific cesarean delivery rates among live births, Alberta, 1997- 2002.....	27
Table 3. Annual cesarean delivery rates among live births in spontaneous labour and induced labour groups, Alberta, 1997-2002	29
Table 4. Cesarean delivery (CD) rates among live births within region where mothers lived, Alberta, 1997-2002 combined	32
Table 5. Cesarean delivery (CD) rates among live births within region where mothers delivered babies, Alberta, 1997-2002 combined	33
Table 6. Number and percentage of cesarean delivery (CD) occurred in regions outside the mothers region of residence, Alberta, 1997-2002 combined	34
Table 7. Baseline characteristics of Alberta mothers who delivered between 1997 and 2002 in Alberta	37
Table 7. Baseline characteristics of Alberta mothers who delivered between 1997 and 2002 in Alberta (continued)	38
Table 8. Characteristics of mothers with cesarean delivery (CD) in comparison to those without CD, Alberta, 1997-2002 combined	40
Table 8. Characteristics of mothers with cesarean delivery (CD) in comparison to those without CD, Alberta, 1997-2002 combined (continued).....	41
Table 9. Mean differences of maternal and infant characteristics between cesarean delivery and not cesarean delivery (CD), Alberta, 1997-2002 combined	43
Table 10. Percentage of different maternal age groups, Alberta, 1997-2002	45
Table 11. Mean maternal age by region of residence, Alberta, 1997-2002combined.....	47

Table 12. Maternal age group by region of residence, Alberta, 1997-2002 combined	49
Table 13. Maternal characteristics for mothers within different age groups, Alberta, 1997-2002 combined	51
Table 13. Maternal characteristics for mothers within different age groups, Alberta, 1997-2002 combined (continued).....	52
Table 14. Maternal characteristics of cesarean delivery (CD) among women aged less than or equal to 19 years group, Alberta, 1997-2002 combined.....	54
Table 14. Maternal characteristics of cesarean delivery (CD) among women aged less than or equal to 19 years group, Alberta, 1997-2002 combined (continued)	55
Table 15. Maternal characteristics of cesarean delivery (CD) among women aged 20 to 34 years group, Alberta, 1997-2002 combined.....	56
Table 15. Maternal characteristics of cesarean delivery (CD) among women aged 20 to 24 years age, Alberta, 1997-2002 combined (continued)	57
Table 16. Maternal characteristics of cesarean delivery (CD) among women aged 35 and older group, Alberta, 1997-2002 combined	58
Table 16. Maternal characteristics of cesarean delivery (CD) among women aged 35 and older group, Alberta, 1997-2002 combined (continued).....	59
Table 17. Unadjusted odds ratio (OR) for cesarean delivery among mothers with liveborn singletons within different age groups, Alberta, 1997-2002 combined	62
Table 18. Adjusted odds ratio (OR) for cesarean delivery among mothers with liveborn singletons within different age groups, Alberta, 1997-2002 combined	65
Table 19. Comparison of maternal characteristics of mothers with cesarean delivery (CD) between spontaneous and induced labour, Alberta, 1997-2002	67

Table 19. Comparison of maternal characteristics of mothers with cesarean delivery (CD) between spontaneous and induced labour, Alberta, 1997-2002 (continued)...	68
Table 20. Unadjusted odds ratio (OR) for cesarean delivery among mother with liveborn singletons who underwent spontaneous in comparison with induced labour, 1997-2002 combined	70
Table 21. Adjusted odds ratio (OR) for cesarean delivery among mother with liveborn singletons who underwent spontaneous in comparison with induced labour, 1997-2002 combined	74

Chapter One: Introduction

1.1 Research Questions

This study was designed to describe the epidemiology of cesarean delivery (CD) in Alberta and four research questions were investigated:

- 1) Did the CD rate change from 1997 to 2002 and did the regional CD rates differ by health regions during this six-year period in the province of Alberta?
- 2) Were the characteristics of mothers, who underwent CD different from those who did not?
- 3) What were the risk factors for CD among women within defined age cohorts (age less than or equal to 19, 20 to 34, and greater than or equal to 35)?
- 4) Did maternal risk factors for CD differ in cases of spontaneous and induced labour?

1.2 Research Hypotheses

It is hypothesized that CD is more likely to occur in the presence of the following twelve putative risk factors: advancing maternal age, nulliparity, induced labour, preterm delivery, low birth weight, multiple birth, smoking, alcohol consumption, illicit drug use, less than four prenatal visits, unmarried status and more than one previous abortion.

1.3 Study Rationale

Although CD is generally safe and advantageous to the mother and baby, it is not without medical risks. Canadian CD rate reached 20% (1) and has exceeded World Health Organization (WHO) recommended an optimal CD rate of 10-15%(2) . Furthermore, there are associated consequences with respect to use of scarce health care resources. Therefore, the potential relationships between CD and advancing maternal age, nulliparity, induced labour, preterm delivery, low birth weight, multiple birth, smoking, alcohol consumption, illicit drug use, less than four prenatal visits, unmarried status, history of previous abortion and region of residence during pregnancy are of tremendous public health and scientific interest. However, limited provincial research exists to describe the relationship between these risk factors and CD in Alberta. To our knowledge, this study is the first to evaluate these hypothesized associations from a Canadian population-based data set.

From the 1960s to the early 1980s, CD rates increased from approximately 5% to almost 20% in Canada and the United States (1), and similar trends were noted worldwide (1-5) . More recently, in Canada, the CD rates rose from 17.8% in 1994 to 19.1% in 1997(3). Similarly, in the United States the CD rates rose from 20.7% in 1996 to 22.9% in 2000(3). By comparison, the CD rate in England and Wales is currently 21.5% which has increased from 4% in 1973 (4). Rates in Italy have also increased from 11.2% in 1980 to 33.2% in 2000 (5). In Alberta, 20% (n=8000) of the approximate 40,000 births per year are delivered by CD(6).

CD increased medical risks including: iatrogenic infections (20%) as a consequence of major abdominal surgical procedures and increased risk of respiratory

distress syndrome (RDS) among infants (7). Maternal consequences of a CD include increased hospital stay to 4 days compared to 2 days for an uncomplicated vaginal delivery, also resulting in direct increases in health care costs (8-11). The escalation in CD rates has not been associated with any additional benefits in terms of maternal and perinatal outcomes(11); on the contrary, CD rates higher than 15% have resulted in increased risks to pregnant women and also increased infant morbidity and mortality(7) , so the World Health Organization (WHO) has recommended a CD rate of 10-15% as an optimal rate(2). Therefore, with present concerns about health care improvement and appropriate allocation of health care resources, it becomes important to understand the characteristics of women who are at high risk of undergoing CD and to determine strategies to optimize provincial CD. This study describes the relationship between maternal risk factors and CD in order to provide health care professionals with information that would improve identification of women at risk of CD and to develop strategies to reduce the risk.

Chapter Two: Review of the Literature

2.1 Indications of Cesarean Delivery

CD is the surgical delivery of an infant through an incision in the mother's abdomen and the uterus. The indications for CD as listed in the *International Classification of Diseases, Ninth Revision* (ICD-9) codes are previous cesarean (654.2), breech presentation (652.2), dystocia including disproportion (653.0,653.1,653.2,653.3,653.4,653.9), obstructed labour (660.1,660.6,660.7,660.8,660.9), abnormality of forces of labour (661.0,661.1,661.2,661.9), long labour (662.0,662.1,662.2), malpresentation (660.0,650.2,652.5,652.8,652.9), and fetal distress (656.3). Previous CD, dystocia, breech presentation and fetal distress are noted as the most important indications by Health Canada(1).

Other specific medical indications include failure of labour to progress, failed induction, failed forceps or vacuum extraction, preeclampsia, gestational diabetes, syphilis, Crohn's disease, high lumbar radiculopathy, degenerative back disease, deep transverse arrest, macrosomia, abruptio placentae, umbilical cord prolapse, intrauterine growth retardation, polyhydramnios and suspected chorioamnionitis(12).

2.2 Potential Risk Factors of Cesarean Delivery

Numerous studies have attempted to determine the reasons for the increased and increasing CD rate. These studies have used various designs and differ with respect to the number and type of risk factors considered. Identified risk factors of CD

include advancing maternal age, nulliparity, induced labour, preterm delivery, low birth weight, multiple birth, smoking, alcohol consumption, illicit drug use, prenatal visits, unmarried status, and history of previous abortion, geographic region of residence, pregnant weight and height (12-23) . Apart from these medical and obstetrical factors, several non-medical factors including physician practice patterns(24), type of birth attendant, women's socio-economic status, race and education, financial incentives and patient preferences(7;25-36); have been noted, however, these non-medical factors were unable to be addressed in this study. Literature review was restricted to those factors that were included in this analysis.

2.2.1 Maternal Age

The mean age of the maternity population has increased globally since 1970, largely as a consequence of women choosing delay childbearing until completion of advanced education and achievement of financial stability (32;37;38). Among the childbearing population in the United States, the proportion of women 30 years of age or older increased from 17.7% in 1970 to 30.2% in 1990(29). In Alberta, the proportion of women aged 35 and older increased from 8.4% in 1990 to 16.8% in 2001(39). Some studies have suggested that older maternal age increases the risk of neonatal and perinatal complications (34;40-42); however, others have reported no such relationship(43;44).

From 1999 to 2000, the primary CD rate (i.e., the number of CD to women who have not previously had a CD expressed as a percentage of all deliveries to women who have not had a CD previously) in Canada for women was highest among women

aged 35 years or greater at 19.4%, compared to 15.6% for women 25 to 34 years of age, and 13.4% for women less than 25 years of age (1). Some epidemiological studies have shown a statistically significant association between CD and advancing maternal age; maternal age was considered to be an independent risk factor for CD(16;23;30;32;33;35;45;46). The reasons for this statistically significant and clinically important increased risk were unclear, but might be due to high risk of medical complication or physician and patient concern over pregnancy outcomes among older age groups.

2.2.2 Parity

The association between CD and parity (i.e. birth order), which is defined as the number of previous live births and stillbirths, indicate an increased risk among nulliparous women (1;23;35;47-55) . The *Canadian Perinatal Health Report* (1) documented that nulliparous women were more likely to deliver by cesarean than women having their second or subsequent babies with no history of prior CD. Bailit and Garrett (49) found that nulliparous patients were almost three times more likely to have CD than multiparous patients, a finding similar to Horrigan (50). A retrospective case record analysis from Mesleh et al. (53), however, revealed that the CD rate among nulliparous women was similar to the rate in other obstetric populations. The reason for these conflicting findings is not well understood, however, the studies were conducted in different countries, and differing prenatal care patterns may have contributed to the differing results.

2.2.3 Induced labour

Research on the relationship between induced labour and CD has been inconsistent, however, the *Canadian Perinatal Health Report* notes a positive association between induction of labour and an increased risk of CD (1). Labour induction was suggested as a significant risk factor for CD in numerous studies(27;46;56-66). Delaney and Young (56) reported that induced labour was related to an increased CD rate and the adjusted odds ratio of CD for induced labour compared with spontaneous labour was 1.84 (95% CI 1.51,2.25). Similarly, Friesen et al.(57) concluded that induced labour, rather than spontaneous labour was associated with an increased CD rate (24% vs. 10%) among infants weighing more than 4000 grams. However, Horrigan conducted a retrospective analysis of the relationship between labour induction and CD among infants with birth weights more than 4000 grams and reported that no correlation was found between the rate of labour induction and the rate of CD. In addition, some other studies found induction lowered the CD rate (11;47;50;67-69). Mathews(50) who concluded that the risk of CD was lower among women with induced compared to spontaneous labour. Few studies have been undertaken to distinguish risk factors of CD between induced and spontaneous labour groups, despite the possibility that the risk factors could differ for the two conditions.

2.2.4 Birth Weight and Gestational Age

High birth weight and gestational age of more than 42 weeks have been identified as risk factors for CD (25-27;40;58;67;70). An Australian study(27), which analyzed a population based data set of 616,303 live, singleton term births

occurring between 1990 and 1997, found that women with infants weighing more than 4500grams and with a gestational age of greater than 42 weeks were more likely to be delivered by CD. Similarly, Horrigan(67) reported that deliveries occurring after 40 weeks were more likely to delivery by CD and Gonen (58) found that macrosomia, defined as birth weight exceeding 4000grams, was associated with an increased risk of CD. Although the reasons are complex, it might because the incidence of dystocia increases with birth weight(71) and failure to progress in labour increases with gestational age(69).

Low birth weight and gestational age less than 37 weeks have also been reported as risk factors for CD (23;49;72;73⁶). A study conducted by Bailit and Garrett (72) showed that gestational age of 24-30 weeks was a significant predictor, after analyzing 123,850 deliveries from Washington State Birth Events Record Data between 1997 and 1998.

2.2.5 Multiple Birth

The rate of multiple birth has increased recently in Canada, from 2.1% in 1991 to 2.7% in 2000 (1). United States data is similar between 1980 and 1996. The twin gestation rate increased by 47%, also the triplet and higher-order gestation rate increased four fold, reaching 20% in 1996(74). Many studies showed that multiple births was highly associated with an elevated CD rate (22;49;74;75). Conde-Agudelo et al. (74) analyzed Perinatal Information System database in Montevideo, Uruguay and reported that the CD rate was 48.7% for women with multiple gestation compared

to 17.7% for women with singleton gestation, yielding an adjusted odds ratio of CD of 2.5(95% CI 2.5, 2.6).

2.2.6 Smoking

The prevalence of smoking among pregnant women in Canada from 1996 to 1997 ranged from 25.2% in Atlantic Provinces to 18.6% in British Columbia (8). In New Zealand, approximately 30% of women quit smoking during pregnancy, compared to an Alberta smoking cessation rate of only 8.4%(6). Maternal smoking during pregnancy has been associated with preterm birth, low birth weight, intrauterine growth retardation, a small head circumference, a low Apgar score at 5 minutes, stillbirths and neonatal deaths (76;76-79), but its relevance to CD is not well described. Turcot et al. (80)carried out a prospective cohort study in 11 North American university-affiliated teaching hospitals. Data from 935 nulliparous women in spontaneous term labour with a single foetus in cephalic presentation demonstrated that cigarette smoking was associated with a reduction in the risk of operative delivery. Although the underlying mechanism is unclear, authors hypothesized that the effect might be mediated by a reduction of birth weight.

2.2.7 Alcohol and Drug Use

In Alberta, 7.5% of women were recorded to have consumed alcohol during pregnancy according to the Physician Notice of Live Birth and Stillbirth Record(6). Excessive consumption of alcohol during pregnancy has been associated with a group of adverse fetal outcomes including decreased body weight, malformations, cognitive

and behavioural impairments which fall under the diagnostic umbrella of fetal alcohol spectrum disorder (81). Moreover, the combination of smoking and alcohol has been reported to have exacerbated adverse effects on birth outcome(6). However, few researchers have explored the relationship between CD and maternal alcohol consumption.

No definitive reports describing the association between illicit drug use and CD rate were found. This is an important problem to investigate since roughly 1.4% of pregnant women were reported to use illicit drugs in Alberta between 1994 and 1996(6) .

2.2.8 Prenatal Care and Marital Status

The relationships between prenatal care, marital status and CD have been inconsistent (12;23;29;41;69;70;72;74;82-85). The effect of prenatal care and marital status on CD was examined by Bailit et al., but no significant relationship was found (72). Furthermore, McDuffie and colleagues (83) conducted a clinical trial, in which 2764 pregnant women were randomly assigned either to a study group who received 9 prenatal visits or a control group with 14 prenatal visits. Although the study group was observed to receive an average of 2.7 fewer total prenatal visits per pregnancy than the control group ($p < 0.001$), there was no significant difference in the incidence rates for CD between the two groups (RR, 1.04; 95% CI 0.78, 1.14). In the United States, CD rates appear to be slightly higher among married women (23).

2.2.9 History of Previous Abortion

The relationship between a prior history of abortion and an increased risk of CD is controversial. A slightly increased risk of CD (OR=1.8, $p=0.04$), if there was a history of previous abortion, was documented by Trujillo et al.(86). On the other hand, Harlow and colleagues (12) conducted a multi-centre, randomized, clinical trial to assess maternal risk factors for CD in a cohort of 6393 low-risk nulliparous patients between 18 and 34 years old. Both the bivariate and logistic regression analyses showed that a prior history of abortion had little impact on the risk of CD. Maternal and fetal characteristics such as maternal age, race, education and gender of neonate, as well as prenatal examination data, were considered in the multivariate model.

2.2.10 Geographic Differences

CD rates are noted to vary by geographic region(12;74;87;88). A multi-centre study conducted in the United States (12) demonstrated that the observed CD rates were lower in the Boston and Indianapolis than in rural Missouri and Iowa. Although differences in spontaneous labour were noted throughout Alberta between 1994-1996(6), the investigation of regional variation in CD rates remains incomplete for the province.

In summary, although many of the risk factors for CD identified above have been described in previous reports, only a few studies have attempted to estimate the cumulative influence of these risk factors on CD rates(80). The identification of risk

factors related to CD is greatly needed to guide the development of prevention programs and defrayed human and health care costs.

Chapter Three: Methodology

The discussion of the research and analysis methodology follows the definitions of the variables.

3.1 Operational Definitions

Live birth – In the WHO's definition, a live birth is the complete expulsion or extraction from the mother, irrespective of the duration of the pregnancy, of a foetus in which, after expulsion or extraction there is breathing, beating of the heart, pulsation of the umbilical cord or unmistakable movement of voluntary muscle, whether or not the umbilical cord has been cut or the placenta attached.

Stillbirth – In the WHO's definition, a stillbirth is the complete expulsion or the extraction from the mother after at least 20 weeks' pregnancy, or after attaining a weight of 500 grams or more, of a foetus in which, after the expulsion or extraction there is no breathing, beating of the heart, pulsation of the umbilical cord or unmistakable movement of voluntary muscle.

CD rate - The number of deliveries by CD expressed as a percentage of the total number of deliveries (in a given place and time), including both primary and repeat rates (1). This is the primary outcome of this study.

Maternal age - The age of the mother at the time of delivery. It is calculated as the integer of the difference between the delivery date and the mother's date of birth. For these analyses, maternal age has been categorized as:

Younger age – younger than 19 years of age

Intermediate age - 20 to 34 years of age

Older age - 35 years of age or older

Nulliparous women (nulliparas) – Women who are bearing or having borne one child (including this delivery)

Multiparous women (multiparas) – Women who are having or had two or more pregnancies, which resulted in viable fetuses (6).

Induced labour- labour brought on by mechanical or other extraneous means, including

medical and surgical induction(89).

Gestational age - The duration of gestation is measured from the first day of the last normal menstrual period. Gestational age is expressed in completed days or completed weeks.

Preterm - Less than 37 full weeks of gestation or less than 259 full days.

Term - 37 to 42 full weeks of gestation or between 259 and 293 full days.

Postterm - More than 42 full weeks of gestation or 294 full days or more.

Birth weight: The first weight of the foetus or new-born obtained after birth, preferably within the first hour after birth, before the significant post-natal loss has occurred.

Low birth weight - Birth weight of less than 2500 grams.

Normal infant - Birth weight between 2500 and 4000 grams.

High Birth weight - Birth weight more than 4000 grams.

Multiple birth - Pregnancy in which two or more fetuses exist simultaneously(89).

Smoking status - Whether or not the expectant mother smoked during pregnancy.

Responses were dichotomized into Yes and No.

Alcohol consumption - If the expected mother drank any alcoholic beverages during this pregnancy. Responses were dichotomized into Yes and No.

Illicit drug use - If the expected mother used illicit drugs, including marijuana and hashish during this pregnancy. Responses were dichotomized into Yes and No.

Prenatal visits: the number of times the expectant mother visited a physician prior to delivery, classified into two categories: less than four prenatal visits and greater than or equal to four prenatal visits.

Marital Status: If the expected mother was married when she delivered her baby. Responses were dichotomized into Yes and No. Yes included mothers who were married and the husband is the natural father of the child, legally married and the husband is not the natural father of the child, as well not legally married. No included mothers who were never married, widowed and divorced.

Aborted pregnancies: The number of times that expected mother experience abortion regardless of cause or procedure, and was recorded into three categories: no, one abortion, and two or more abortion.

Geographic region – Two definitions were used: the health region of residence of the mother based on the usual address provided by the mother and the health region where the birth occurred. Both were considered in this analysis. When the second

definition was used, the analysis was not specific to Alberta residents, but included all deliveries occurring in this province. The province of Alberta is divided administratively into nine regional health authorities.

3.2 Design Type and Rationale

This research project was a population-based, cross-sectional analysis of data routinely collected through the Notice of Live Birth or Stillbirth (PNOB) from 1997 to 2002. The cross-sectional analysis enabled the identification of current relationships between exposure(s) such as maternal age and smoking and CD (81).

There were three reasons why this type of study design was chosen. First of all, compared to case-control studies, this cross-sectional analysis was based on the complete population, and consequently the ability to generalize the findings may be considered a strength. Second, this study design was appropriate in view of the current level of knowledge, since no causal relationships were found between the variables of interest in previous reports. Lastly, the study was cost effective. If a prospective cohort study were done, it would be very expensive and time consuming to gather a sufficient number of subjects(90;91).

3.3 Target Population

The target population for the project comprised all women who delivered a live born infant in the province of Alberta during the six-year study period from January 1, 1997 to December 31, 2002. Approximately 227,034 births were obtained from the PNOB database, which is the basis for legal registration of birth, was

completed on all births in the province. Therefore, this was a population-based analysis in that it included all women delivering babies in Alberta during the six-year period. The 1,473 stillbirths during this period were excluded since the dependent variable CD and most independent variables of interest were absent in the stillbirth registration data.

Presence or absence of exposure (i.e., risk factors) was recorded on the PNOB form for each woman. In addition, presence or absence of the outcome (CD) was identified by physicians in the hospital and recorded in this database.

3.4 Data Source and Location for the Study

The data set included the 1997-2002 Alberta Vital Statistic Birth Registration data and Maternal Risk Factor Surveillance System data. This study made use of secondary data; which refers to data that have been collected for purposes other than a specific research project(92). The period from 1997 to 2002 represents the most recent six-year period for which CD data were available for analysis for both presence and absence of all the risk factors of interest. The data were managed and analyzed using SPSS/PC version 12.0(SPSS Inc, Chicago, Ill) and STATA version 7.0.

3.5 Access to the Research Setting

Data were obtained from Alberta Health and Wellness, and was stored in a computer file, protected with a personal password.

Data collection variables included:

- Birth date of mother

- Birth date of newborn baby
- Mode of delivery
- Number of live births and stillbirths that mother has ever had, including the current birth
- Type of labour
- Gestational age
- Birth weight
- Multiple or singleton births
- Smoking status during pregnancy
- Alcohol consumption during pregnancy
- Use of street drugs during pregnancy
- Prenatal visits
- Marital status
- Aborted pregnancies, and
- Health region where birth occurred and where mother lived

3.6 Data Analysis Procedures

3.6.1 Study Variables

The primary dichotomous outcome variable of this study was CD versus non-CD. The independent variables included maternal age, nulliparity, induced labour, preterm delivery, low birth weight, multiple birth, smoking, alcohol consumption, illicit drug use, less than four prenatal visits, unmarried status, and history of previous

abortion. Maternal age was regarded as both a continuous and categorical variable, while all other variables were categorical variables.

3.6.2 Data Cleaning

The quality of the data was checked in the initial stage of analysis. For example, missing values, out of range values (outliers) were checked using computer software. The observations with missing values or outliers were eliminated prior to data analysis.

The variable parity was computed by calculating live birth plus stillbirth, which was recorded in the data set. Other variables of interest were categorized for the analysis.

3.6.3 Data Analysis

Primary analysis included rate calculations, univariate analysis, bivariate analysis and multivariate analysis. Rate calculations, univariate and bivariate analysis were carried out with the use of the merged data set, which included all live births occurring in Alberta. Since most variables of interest, including type of delivery, were absent in the Stillbirth Registration Data, stillbirths were excluded in this analysis. Multivariate analysis was restricted to live and singleton births during the six-year period.

3.6.3.1 Rate Calculations

The annual provincial CD rates over the study period and across regions within Alberta were estimated using the data set, which included all live births in Alberta. Age -specific and labour-specific CD rates were also compared to determine if there were significant differences between the rates during the study period. All annual trends over time were estimated by chi square test and $p < 0.05$ was used to determine statistical significance.

CD rates for different regions as well as corresponding 95% confidence intervals were calculated to assess the significance of the differences, or any overlap, in the estimated CD rates across regions within Alberta. The nine regional health authorities (RHAs) examined included Chinook, Palliser, Calgary, David Thompson, East Central, Capital, Aspen, Peace Country and Northern Lights.

3.6.3.2 Univariate Analysis

Univariate statistics and graphical analysis were used to describe three characteristics of maternal age: the shape of distribution by using a histogram, central tendency and variability by calculating mean, standard deviation, median, and range(93). In addition, univariate statistical analysis was conducted to describe the frequency and percentages of each exposure level, i.e., each category of risk factors.

3.6.3.3 Bivariate Analysis

Bivariate analysis was carried out to describe the association between the risk factors and the primary outcome variable (CD). Continuous variables were

compared using the 2-tailed student t test. $P < 0.05$ was used to determine a statistically significant association between two variables. If statistically significant results were obtained the observed variation exceeded the expected random variation, assuming a normal distribution of this variable(94;95). Pearson Chi Square tests were performed for categorical variables to estimate the association between two variables. In most cases, the sample size from PNOB database was so large that even differences that were trivial from a clinical perspective could still achieve statistical significance ($p < 0.001$), so the interpretations also considered the literature and clinical relevance.

Linear trend test was used to determine the significant of the change overtime.

In addition, for all categorical variables the estimates of crude odds ratios were calculated with p-values and the corresponding 95% confidence intervals (95% CI) comparing women who did and did not have CD (reference category). For example, the odds ratio of women who smoked compared to women who did not, was calculated. If the 95% CI around the odds ratio was greater than 1, but did not include 1, the observed rate of CD was considered significantly above the expected value. On the other hand, if the 95% CI around the odds ratio was less than 1 and also did not include 1, the observed rate of CD was significantly below the predicted value. In order to simultaneously control for known potential confounding factors, which can cause or prevent the outcome of interest, not in the causal pathway, but are independently related to factors under investigation (96), the bivariate relationships were further examined using multivariate logistic regression analysis.

3.6.3.4 Multivariate Logistic Regression Analysis

Unconditional logistic regression was performed to develop models for independent risk factors of CD. Potential risk factors were chosen in this study based on characteristics shown to be important in previous research, statistical significance and the availability of those data from PNOB data source. All covariates were entered into the initial models if the data elements were completed in over 80% of records and were statistically significant ($p < 0.05$) in the bivariate analysis. In addition, records were excluded if data were missing on any variable in the specific model under consideration. Adjusted odds ratios and 95% confidence intervals were calculated from the regression coefficients and standard errors of the factors retained in each model.

A full assessment of effect modification was made. Hypothesized effect modifiers are factors that modify the effect of the causal factor under study(96). Although a large number of interactions might be created from the variables in the model, only those which we had chosen *a priori* or those that made biological sense were examined. In this analysis, the interaction terms of age with all other independent variables, and the interaction of smoking and alcohol consumption were investigated. In the model-building process, we were interested in assessing the inclusion of the interaction term, which would change the coefficients of the main effects by comparing two models, so the likelihood ratio test was used as a means of screening. Generally, the interactions with biological as well as statistical significance were maintained in the model and final models for CD were developed that included all statistically significant independent variables and interaction terms.

Live, singleton births were analyzed to examine the risk factors of CD with the use of multivariate logistic regression analysis. There were two reasons why multiple births were excluded. Firstly, multiple gestations had substantial relationship with labour induction, preterm birth, maternal age and other factors that were tested in our analysis(1;3) , therefore our analysis was restricted to singleton births to reduce bias due to co- linearity. Secondly, many researchers have reported that the risk factors for CD are considerably different for women who have had multiple gestations than for the obstetric population generally, so we focused on studying singleton births to be consistent with previous studies that have been conducted in this field(82). Similarly, since birth weight and preterm birth could have a co-linearity relationship, (23) we did not put both variables in the same models. Gestational age rather than birth weight could be identified by obstetricians at admission to the hospital; this factor has been used to predict CD by many researchers, therefore this variable was used in our multivariate model to concur with literature(80).

Advancing maternal age is a key independent risk factor and is an established risk factor for CD; therefore, it was first regarded as a continuous variable to estimate the rate of change of the log of odds of CD per year change of age, irrespective of other risk factors. It is recognized that some information may be lost when continuous variables are replaced by categorical variables. Therefore, by using age as a continuous variable in the model, it was easier to assess potential confounders and effect modifiers than using a model in which age was treated as a categorical variable. Since the statistically significant interactions between age and other factors such as parity, gestational age and prenatal visits were found in the first model and then

maternal age was reclassified into three categories to compare the odds ratios of CD in three different age groups in the logistic regression models. By developing three separate logistic models for each age group, it is easier to interpret the regression parameters.

Additionally, to distinguish the difference in maternal risk factors for CD in cases of spontaneous and induced labour in women in Alberta, two separate regression models were developed. The ORs of CD in the spontaneous and induced labour groups were then compared to identify the maternal risk factor disparities between these two groups.

3.7 Ethical Considerations

The database was installed on an office computer and was password protected. The PNOB database did not contain nominal information, so no individuals could be identified and only aggregate data would be published. The proposal of this study was approved by the Conjoint Health Research Ethics Board.

Chapter Four: Results

The total number of mothers who delivered babies between 1997 and 2002 in Alberta was 228,507, including 227,034(99.4%) live births and 1473(0.6%) stillbirths. Only live births were included in this analysis.

This chapter presents the results of analysis in the following order:

- 1) CD rates in Alberta, 1997 to 2002
- 2) Characteristics of mothers who underwent CD in comparison with those who did not
- 3) Risk factors of CD within defined age cohorts (age less than or equal to 19, 20 to 34, and greater than or equal to 35)
- 4) Risk factors of CD within spontaneous and induced labour groups

Each part of the results sections addresses one research question of this project.

4.1 Cesarean Delivery Rate in Alberta

Q 1. Did the CD rate change from 1997 to 2002 and did the regional CD rates differ by health regions during this six-year period in the province of Alberta?

The results of provincial CD rates (section 4.1.1), age-specific CD rates (section 4.1.2), labour-specific CD rates (section 4.1.3) and regional CD rates (section 4.1.4) for each year are reported in this section.

4.1.1 Annual Provincial Cesarean Delivery Rate

In Table 1, the delivery data for each year are summarized. The number of CDs ranged from 5,823 in 1997 to 8,531 in 2002; the number of all deliveries also exhibited an upward trend during this period, from 36,026 to 37,506. The annual provincial CD rate rose steadily from 16.3% to 22.9% ($p < 0.001$), representing a 40% increase over 6 years. The overall provincial average CD rate was 19.5% for this time period.

Table 1. Number and rate of overall annual cesarean delivery (CD) among live births, Alberta, 1997-2002

Year of Birth	Number of CDs	Number of Deliveries	CD per 100 Deliveries
1997	5823	35768	16.3
1998	6255	36635	17.1
1999	6937	36900	18.8
2000	7113	35778	19.9
2001	8076	36464	22.1
2002	8531	37250	22.9
Total	42735	218795	19.5
Linear-by-Linear Association $p < 0.001$ trend			

4.1.2 Annual Age-Specific Cesarean Delivery Rate

The delivery data were subdivided by maternal age group, and the percentage of CD deliveries for each group is presented in Table 2. All age-specific CD rates consistently increased with time (from 1997 to 2002) and this trend was more pronounced among older women. In 2002, 31.1% of CD deliveries in Alberta were to women aged 35 and older, an absolute increase 8.9% since 1997. Additionally, the rate increased 6.3% among women aged 20 to 34 and 3.4% among those aged 19 and younger. When these rates were compared, the pattern of increasing CD rates with each year remained the same (Figure 1).

Table 2. Annual age- specific cesarean delivery rates among live births, Alberta, 1997-2002

Year	Age Group (Years)			Total
	<=19	20-34	>=35	
1997	11.0	15.7	22.2	16.3
1998	11.0	16.3	24.7	17.1
1999	11.6	18.2	25.9	18.8
2000	13.8	18.9	27.9	19.9
2001	14.3	21.1	30.9	22.1
2002	14.4	22.0	31.1	22.9
Total	12.6	18.7	27.2	19.5

Linear-by-Linear Association $p < 0.001$ trend

4.1.3 Annual Cesarean Delivery Rates in Spontaneous and Induced Labour Groups

The delivery data were subdivided into spontaneous and induced labour groups, and the percentage of CD deliveries for each group is presented in Table 3. From 1997 to 2002, CD rates increased gradually over time in both spontaneous and induced labour groups ($p < 0.001$ trend). The CD rate among those with induced labour increased approximately 3%, which was similar to those with spontaneous labour (3.3%) over the six-year period in Alberta (Table 3). Additionally, the CD rate in the induced labour group was higher than the spontaneous labour group each year. The provincial average CD rate in the induced group (16.1%) was higher than the rate in the spontaneous group (9.9%).

Table 3. Annual cesarean delivery rates among live births in spontaneous labour and induced labour groups, Alberta, 1997-2002

Year of Birth	Induced Labour			Spontaneous Labour		
	Number of CDs	Number of deliveries	CD per 100 deliveries	Number of CDs	Number of deliveries	CD per 100 deliveries
1997	1204	8279	14.5	1963	23351	8.4
1998	1261	8689	14.5	2047	23400	8.7
1999	1394	9059	15.4	2217	22862	9.7
2000	1419	8740	16.2	2219	21990	10.1
2001	1694	9257	18.3	2431	21700	11.2
2002	1664	9527	17.5	2564	21951	11.7
Total	8636	44933	16.1	13441	121813	9.9

Linear-by-Linear Association $p < 0.001$ trend

4.1.4 Regional Variations of Cesarean Delivery Rate

The regional data were compiled in two ways – by region of the mother's residence, and by region in which the CD was performed. Table 4 presents the CD rate of each region where the mother lived and Table 5 presents where the mother delivered the baby, respectively. Table 6 shows the number and percentage of CD, which occurred within regions outside the mothers region of residence.

Analysis indicated important variation according to geographic area. The East Central region had the highest CD rates both for the region of residence (24.1%) and the region of birth (23.7%); the Palliser Region had the lowest rates (12.6% and 10.7% respectively). However, some regional rates must be interpreted with caution due to the low number of cases involved.

The provincial average (19.5%) was the same for both analysis of region of residence and region of birth; however each regional CD rate was different. When data from 1997 to 2002 were combined and analyzed by maternal residence (in a health region), CD rates were higher than the provincial average in Calgary, David Thompson, East Central, Peace Country region and Northern Lights (Table 4). When data for the period 1997 to 2002 were combined and analyzed by health region in which the birth occurred, the CD rate of Capital was higher than the provincial average, but the rate of Northern Lights was no longer higher than average, and the rate of David Thompson was the same as provincial average rate (Table 5). Other regions remained in the same position, although the absolute value changed. In all,

38.1% of all CD deliveries in Alberta occurred in the Calgary region, 32.7% occurred in Capital region and 29.2% in the remaining seven regions (Table 6).

Table 4. Cesarean delivery (CD) rates among live births within region where mothers lived, Alberta, 1997-2002 combined

Region of Residence	Number of CDs	Number of Deliveries	CD per 100 Deliveries	95% CI
Chinook	2110	11787	17.9	17.2,18.6
Palliser	842	6701	12.6	11.8,13.4
Calgary	15801	76862	20.6	20.3,20.8
David Thompson	4238	20497	20.7	20.1,21.2
East Central	1328	5503	24.1	23.0,25.2
Capital	11555	62528	18.5	18.2,18.8
Aspen	2678	14267	18.8	18.1,19.4
Peace Country	2223	11071	20.1	19.3,20.8
Northern Lights	1313	6651	19.7	18.8,20.7
Total	42088	215867	19.5	19.2,20.0

CI=Confidence Interval

Table 5. Cesarean delivery (CD) rates among live births within region where mothers delivered babies, Alberta, 1997-2002 combined

Region of Birth	Number of CDs	Number of Deliveries	CD per 100 Deliveries	95% CI
Chinook	2220	12265	18.1	17.4,18.8
Palliser	708	6642	10.7	9.9,11.4
Calgary	16193	77854	20.8	20.5,21.1
David Thompson	3740	19171	19.5	18.9,20.1
East Central	968	4087	23.7	22.4,25.0
Capital	13887	70519	19.7	19.4,20.0
Aspen	1764	11484	15.4	14.7,16.0
Peace Country	2098	10349	20.3	19.5,20.0
Northern Lights	1157	6424	18.0	17.1,19.0
Total	42735	218795	19.5	19.4,20.2

CI=Confidence Interval

Table 6. Number and percentage of cesarean delivery (CD) occurred in regions outside the mother's region of residence, Alberta, 1997-2002 combined

Region of Residence	Region of Birth (n, % with region of residence)			Total number of CD in region of residence
	Calgary	Capital	Other regions	
	51 (2.4%)	4 (0.2%)	11 (0.4%)	2110
Chinook	113 (13.4%)	6 (0.7%)	70 (8.3%)	842
Palliser	15585 (98.6%)	43 (0.3%)	171 (1.1%)	15801
Calgary	250 (5.9%)	341 (8.0%)	74 (1.6%)	4238
David Thompson	3 (0.2%)	452 (34.0%)	32 (2.4%)	1328
East Central	12 (0.1%)	11496 (99.5%)	47 (0.4%)	11555
Capital	10 (0.4%)	1028 (38.4%)	30 (1%)	2678
Aspen	9 (0.4%)	185 (8.3%)	92 (3.4%)	2223
Peace Country	6 (0.5%)	102 (7.8%)	103 (0.8%)	1313
Northern Lights	16039	13657	12392	42088
Total	(38.1%)	(32.7%)	(29.2%)	(100%)

4.2 Characteristics of Mothers Who Underwent CD in Comparison to Those Who Did Not

Q2. Were the characteristics of mothers, who underwent CD different from those who did not?

This section used univariate and bivariate analysis to describe maternal characteristics including advancing maternal age, nulliparity, induced labour, preterm delivery, low birth weight, multiple birth, smoking, alcohol consumption, illicit drug use, less than four prenatal visits, unmarried status, history of previous abortion and geographic regions.

4.2.1 Baseline Characteristics of Cesarean Delivery

The characteristics of mothers who delivered babies from 1997 to 2002 are described in Table 7. The total number of cases in each variable differed due to missing cases. A large amount of the data (79.9%) for quantity smoked by the expectant mother during the current pregnancy, which was recorded in the data source, was missing; thus this variable was excluded in the analysis. In addition, the variable, 'Onset of labour', which recorded women undergoing spontaneous labour or induced labour, had the highest missing value (14.8%) in the analysis. The level of completeness exceeded 85% for each variable included in the analysis.

Among the whole study population, mean maternal age was 28.2 years (SD=5.7 years); the median was 28.0 years (a range of 12 to 60 years). Mean gestational age was 39.0 weeks (SD=2.2 weeks) and median was 39.0 weeks. Mean birth weight was 3378.96 grams (SD=597.52 grams). Mean number of prenatal visits

was 8.5 (SD=3.3) and median was 9. Both mean and median of parity was 2.00 (SD=1.3).

Table 7. Baseline characteristics of Alberta mothers who delivered between 1997 and 2002 in Alberta

Maternal Characteristics	n	%	Total N*
Type of delivery			
CD	42735	19.5	218795
Maternal age group			
12-19	15082	6.6	
35- 60	32036	14.1	227034
Parity			
2 or more	133776	58.9	227034
Type of labour			
Induced labour	54968	28.4	193329
Gestational age (week)			
<37	18541	8.2	
>42	130	0.1	227034
Birth weight (g)			
<2500	14319	6.3	
>4000	27607	12.2	227034
Type of birth			
Multiple birth	6639	2.9	227034

Table 7. Baseline characteristics of Alberta mothers who delivered between 1997 and 2002 in Alberta (continued)

Maternal Characteristics	n	%	Total N*
Smoking	49889	23.2	214916
Alcohol use	9399	4.3	216782
Street drug use	3821	1.8	213683
Prenatal visits <4	27993	12.3	227031
Unmarried	40489	17.8	226890
Aborted Pregnancies			
1	44987	20.4	
2 or more	37952	17.2	220395

*Subgroup totals may not add up to total number of women because of missing data.

4.2.2 Characteristics of Mother with Cesarean Delivery in Comparison to Those without Cesarean Delivery

The characteristics of mothers with CD and without CD are listed in Table 8.

The total number of mothers with CD was 42,735 from 1997 to 2002 in Alberta representing 19.5% of all live births, which were delivered in hospital, at home, at nursing homes, in auxiliary hospital and en route.

Table 8 reveals that with respect to maternal characteristics, women who underwent CD were significantly more likely to a) be 35 years or older, b) be nulliparous, c) have had labour induction , d) have babies with gestational age less than 37 weeks or more than 42 weeks, e) have low birth weight or heavy infants, f) have multiple births, h) be non-smokers, i) not consuming alcohol, j) not use illicit drugs, k) have had less than four times prenatal visits , l) be married and g) have aborted one or more pregnancies (all $p < 0.001$).

Table 8. Characteristics of mothers with cesarean delivery (CD) in comparison to those without CD, Alberta, 1997-2002 combined

Characteristics	CD	No CD			OR	95% CI
	n	% within	n	%within		
		CD		not CD		
Maternal age group						
<=19	1826	4.3	12676	7.2	0.63*	0.59,0.66
20-34(ref)	32484	76.0	140885	80.0	1.00	
>=35	8425	19.7	22499	12.8	1.62*	1.58,1.67
Parity						
1	20172	47.2	69513	39.5	1.37*	1.40,1.34
2 or more (ref)	22563	52.8	106547	60.5	1.00	
Type of labour						
Spontaneous labour (ref)	13441	60.9	121813	73.1	1.00	
Induced labour	8636	39.1	44933	26.9	1.74*	1.69,1.79
Gestational age (wks)						
<37	6003	14.0	11846	6.7	2.27*	2.19,2.34
37-42(ref)	36703	85.9	164114	93.2	1.00	
>42	29	0.1	100	0.1	1.30	0.86,1.96
Birth weight (g)						
<2500	5064	11.8	8721	5.0	1.33*	1.29,1.37
2500-4000(ref)	31746	74.3	146696	83.3	1.00	
>4000	5925	13.9	20643	11.7	2.68*	2.59,2.78
Type of birth						
Singleton (ref)	39579	92.6	172834	98.2	1.00	
Multiple	3156	7.4	3226	1.8	4.27*	4.06,4.49

CI= confidence interval, OR= odds ratio, Reference category (ref),* Significant at p<0.05

Table 8. Characteristics of mothers with cesarean delivery (CD) in comparison to those without CD, Alberta, 1997-2002 combined (continued)

Characteristics	CD		No CD		OR	95% CI
	n	% within CD	n	%within not CD		n
Smoking						
No (ref)	31522	78.6	128210	76.4	1.00	
Yes	8562	21.4	39647	23.6	0.88*	0.86,0.90
Alcohol use						
No (ref)	38952	96.1	161839	95.5	1.00	
Yes	1566	3.9	7545	4.5	0.86*	0.82,0.91
Street drug use						
No (ref)	39343	98.4	163923	98.2	1.00	
Yes	627	1.6	3052	1.8	0.86*	0.79,0.93
Prenatal visits						
<4 (ref)	5088	11.9	22276	12.7	1.00	
>=4	37647	88.1	153784	87.3	1.07*	1.04,1.11
Marital status						
Yes (ref)	36235	84.9	143378	81.5	1.00	
No	6467	15.1	32591	18.5	0.79*	0.76,0.81
Aborted Pregnancies						
No (ref)	25971	60.8	110573	62.8	1.00	
1	9170	21.5	35783	20.3	1.09*	1.06,1.12
2 or more	7594	17.8	29704	16.9	1.09*	1.06,1.12

CI= confidence interval, OR= odds ratio, Reference category (ref),* Significant at p<0.05

4.2.3 Mean Differences of Maternal Characteristics

Table 9 contains a comparison of mean difference of maternal age, parity, gestational age, infant birth weight and prenatal visits of women with or without CD. The standard deviations (SD), which describe the sample variation, are also presented.

Mothers with CD had significantly higher mean maternal age, lower gestational age, birth weight and parity than mothers without CD. However, no statistically significant differences were found for the mean prenatal visits at the $p < 0.05$ level.

Mean maternal age was 1.6 years higher in mothers with CD compared with mothers without CD ($p < 0.001$). Mean gestational age for those who experienced CD was 0.7 weeks shorter than those who did not experienced CD ($p < 0.001$). Additionally, mean infant birth weight was 100 grams lower and the average parity was also slightly lower in CD group compared to non-CD group ($p < 0.001$). However, the difference for prenatal visits was not significant ($p > 0.05$) between the two groups.

Table 9. Mean differences of maternal and infant characteristics between cesarean delivery and not cesarean delivery (CD), Alberta, 1997-2002 combined

	CD		Not CD		Significance
	Mean	SD	Mean	SD	p
Maternal age (years)	29.5	5.64	27.9	5.62	<0.001
Parity	1.8	1.85	2.0	1.24	<0.001
Gestational age (wks)	38.4	2.59	39.1	2.04	<0.001
Birth weight (gms)	3297.9	732.67	3397.9	558.30	<0.001
Prenatal visits	8.50	3.24	8.50	3.24	0.982

SD= standard deviation

4.2.4 Characteristics of Maternal Age

Since advancing maternal age is a key predictor of CD, this section provides an overview of the annual change, regional variation and other characteristics of maternal age.

4.2.4.1 The Distribution of Maternal Age

The distribution of maternal age of the childbearing population in Alberta from 1997 to 2002 is illustrated in Figure 2. When the maternal age was regarded as a continuous variable, the distribution was close to normal.

4.2.4.2 Annual Changes of Maternal Age

Table 10 and Figure 3 show that patterns of childbearing age in Alberta have changed with time. The proportion of women aged 19 or less gradually declined from 1997 to 2002 while the proportion of women aged 35 and greater slightly increased, reaching a peak at year 2000, after which the percentage gradually decreased. The percentage of women aged 20 to 34 only slightly changed.

Table 10. Percentage of different maternal age groups, Alberta, 1997-2002

Year of Birth	Age Group (Years)						Total
	<=19		20-34		>=35		
	n	%	n	%	n	%	N
	within		within		within		
	Year		Year		Year		
1997	2618	7.1	29456	79.5	4977	13.4	37051
1998	2676	7.0	30265	79.6	5066	13.3	38007
1999	2667	7.0	30216	79.8	5432	14.2	38315
2000	2486	6.7	29220	78.6	5454	14.7	37160
2001	2374	6.3	29876	79.1	5502	14.6	37752
2002	2261	5.8	30833	79.7	5605	14.5	38749
Total	15082	6.6	179916	79.2	32036	14.1	227034

Linear-by-Linear Association $p < 0.001$ trend

4.2.4.3. Regional Variations of Maternal Age

4.2.4.3.1 Mean Maternal Age Comparison

When comparing residence of health regions (Table 11), the highest mean age was 29.4 years (95% CI 29.3, 29.4) in Calgary and the lowest mean age was 26.3 years (95% CI 26.2, 26.4) in Northern Lights. The mean age of Capital region was 28.5 (95% CI 28.5, 28.6).

Table 11. Mean maternal age by region of residence, Alberta, 1997-2002 combined

Region of Residence	Number	Mean	95% CI
Chinook	12090	27.06	26.96,27.16
Palliser	7337	27.01	26.89,27.13
Calgary	78082	29.35	29.31,29.39
David Thompson	21319	27.01	26.93,27.08
East Central	5696	27.95	27.81,28.09
Capital	66463	28.51	28.47,28.55
Aspen	14728	26.70	26.61,26.79
Peace Country	11358	26.45	26.35,26.55
Northern Lights	6878	26.30	26.17,26.43
Total	223951	28.23	28.20,28.25

CI= confidence interval

4.2.4.3.2 Regional Maternal Age Group Comparison

Based on location of delivery, in comparison with other regions in Alberta, Calgary had the lowest percentage (4.4%) among women aged 19 and younger and the highest percentage (18.1%) among women aged 35 and greater (Table 12).

**Table 12. Maternal age group by region of residence, Alberta, 1997-2002
combined**

Region of Birth	Maternal Age Groups						Total
	<=19		20-34		>=35		
	n	%	n	%	n	%	
Chinook	1061	8.8	9746	80.6	1284	10.6	12091
Palliser	548	7.5	6150	83.8	640	8.7	7338
Calgary	3463	4.4	60478	77.4	14147	18.1	78088
David Thompson	1902	8.9	17310	81.2	2107	9.9	21319
East Central	320	5.6	4700	82.5	676	11.9	5696
Capital	3935	6.9	52623	79.2	9909	14.9	66467
Aspen	1522	10.3	9195	80.9	962	8.5	11360
Peace Country	1203	10.6	9195	80.9	962	8.5	11360
Northern Lights	802	11.7	5484	79.7	593	8.6	6879
Total	14756	6.6	177549	79.3	31663	14.1	223968

4.2.4.4 Characteristics of different age groups

Table 13 contains a comparison of maternal characteristics in different age groups. We observed that the proportion of births delivered by CD, aborted pregnancies and two or more multiple births rose continuously with maternal age ($p < 0.001$ trend). We also found that the proportion of women who delivered their first baby, smoked, consumed alcohol, attended fewer than four prenatal visits and were unmarried decreased with advancing age ($p < 0.001$ trend). The prevalence of birth weight less than 2500 grams and gestational age less than 37 week were significantly higher both among women aged 19 or younger and women aged 35 or older compared to women aged 20 to 34 ($p < 0.001$).

Table 13. Maternal characteristics for mothers within different age groups, Alberta, 1997-2002 combined

Characteristics	Age Group (Years)						Total	
	<=19		20-34		>=35			
	n	%	n	%	n	%	N	%
Cesarean delivery								
No	12676	87.4	140885	80.3	22499	72.8	176060	80.5
Yes	1826	12.6	32484	18.7	8425	27.2	42735	19.5
Parity								
1	12352	81.9	73080	40.6	7826	24.4	93258	41.1
2 or more	2730	18.1	106836	59.4	24210	75.6	133776	58.9
Type of labour								
Spontaneous labour	9993	74.1	110117	71.5	18251	70.5	138361	71.6
Induced labour	3478	25.9	43840	28.5	7641	29.5	48313	30.2
Gestational age (wks)								
<37	1322	8.8	14093	7.8	3126	9.8	18541	8.2
37-42	13745	91.1	165724	92.1	28894	90.2	208363	91.8
>42	99	0.1	15	0.1	16	0.0	130	0.1
Birth weight (gms)								
<2500	1.93	7.2	10685	5.9	2541	7.9	14319	6.3
2500-4000	12445	82.5	147164	81.8	25499	79.6	185108	81.5
>4000	1544	10.2	22067	12.3	3996	12.5	27607	12.2
Type of birth								
Singleton	14885	97.2	174855	97.2	30655	95.7	220395	97.1
Multiple	197	1.3	5061	2.8	1381	4.3	6639	2.9

Table 13. Maternal characteristics for mothers within different age groups, Alberta, 1997-2002 combined (continued)

Characteristics	Age Group (Years)						Total	
	<=19		20-34		>=35			
	n	%	n	%	n	%	N	%
Smoking								
No	6081	44.8	132877	77.9	26069	84.6	165027	76.8
Yes	7482	55.2	37675	22.1	4732	15.4	49889	23.2
Alcohol use								
No	12668	90.1	165094	96.1	29621	96.1	207383	95.7
Yes	1399	9.9	6786	3.9	1214	3.9	9399	4.3
Street drug use								
No	12720	92.3	166953	98.5	30189	99.2	209862	98.2
Yes	1056	7.7	2535	1.5	203	0.8	3821	1.8
Prenatal visits (#)								
>=4	8331	87.6	131018	93.4	27395	94.3	166744	93.2
<4	1182	12.4	9308	6.6	1652	5.7	1652	6.8
Marital status								
Yes	6063	40.3	151153	84.1	29185	91.2	186401	82.2
No	8995	59.7	28663	15.9	2831	8.8	4.489	17.8
Aborted Pregnancies								
No	11173	74.1	113554	63.1	16675	52.1	141402	62.3
1	2017	13.4	36389	20.2	8066	25.2	46472	20.5
2 or more	1829	12.5	29973	16.7	7295	22.8	39160	17.2

4.3 Potential Risk Factors for Cesarean Delivery among Different Maternal Age Groups

Q3. What were the risk factors for CD among women within defined age cohorts (age less than or equal to 19, 20 to 34, and greater than or equal to 35)?

Data were analyzed from 227,034 deliveries and maternal age was categorized into three groups (age less than or equal to 19, 20 to 34, and greater than or equal to 35) according to the literature (35;68;97). The potential risk factors for CD within age groups were compared by using bivariate (section 4.3.1 and 4.3.2) as well as multivariate logistic regression analysis (section 4.3.3).

4.3.1 Difference in Maternal Characteristics of Cesarean Delivery among Different Age Groups

Table 14,15,16 compare the maternal characteristics of women who underwent CD within age groups (age less than or equal to 19, 20 to 34, and greater than or equal to 35).

Table 14. Maternal characteristics of cesarean delivery (CD) among women aged less than or equal to 19 years group, Alberta, 1997-2002 combined

Characteristics	<=19 Years Group			
	CD		Not CD	
	n	%	n	%
Parity				
1	1532	83.9	10335	81.5
2 or more	294	16.1	2341	18.5
Type of labour				
Spontaneous labour	735	69.1	8997	75.3
Induced labour	453	38.1	2944	24.7
Gestational age (wks)				
<37	281	15.4	993	7.8
37-42	1542	84.4	11671	92.1
>42	3	0.2	12	0.1
Birth weight (gms)				
<2500	263	14.4	793	6.3
2500-4000	1266	69.3	10694	84.4
>4000	297	16.3	1189	9.4
Type of birth				
Singleton	1759	96.3	12552	99.0
Multiple	67	3.7	124	1.0

Table 14. Maternal characteristics of cesarean delivery (CD) among women aged less than or equal to 19 years group, Alberta, 1997-2002 combined (continued)

Characteristics	<=19 Years Group			
	CD		Not CD	
	n	%	n	%
Smoking				
No	732	44.9	5137	44.8
Yes	899	55.1	6335	55.2
Alcohol use				
No	1525	89.9	10704	90.0
Yes	171	10.1	1192	10.0
Street drug use				
No	1541	92.9	10757	92.2
Yes	118	7.1	905	7.8
Prenatal visits (#)				
>=4	1551	84.9	10519	83.0
<4	275	15.1	2157	17.0
Marital status				
Yes	784	43.0	5026	39.7
No	1039	57.0	7632	60.3
Aborted Pregnancies				
No	1334	73.1	9450	74.6
1	235	12.9	1702	13.4
2 or more	257	14.1	1524	12.0

Table 15. Maternal characteristics of cesarean delivery (CD) among women aged 20 to 34 years group, Alberta, 1997-2002 combined

Characteristics	20-34 Years Group			
	CD		Not CD	
	n	%	n	%
Parity				
1	15712	48.4	54561	38.7
2 or more	16772	51.6	86324	61.3
Type of labour				
Spontaneous labour	10260	60.6	97390	73.0
Induced labour	6670	39.4	36027	27.0
Gestational age (wks)				
<37	4401	13.5	9148	6.5
37-42	28063	86.4	131659	93.5
>42	20	0.1	78	0.1
Birth weight (gms)				
<2500	3661	11.3	6609	4.7
2500-4000	24224	74.6	117647	83.6
>4000	4599	14.2	16629	11.8
Type of birth				
Singleton	30141	92.8	138376	98.2
Multiple	2343	7.2	2509	1.8

Table 15. Maternal characteristics of cesarean delivery (CD) among women aged 20 to 24 years age, Alberta, 1997-2002 combined (continued)

Characteristics	20-24 Years Group			
	CD		Not CD	
	n	%	n	%
Smoking				
No	24065	79.0	104539	77.7
Yes	6401	21.0	29996	22.3
Alcohol use				
No	29692	96.4	130156	96.0
Yes	1119	3.6	5456	4.0
Street drug use				
No	29961	98.5	131737	98.5
Yes	443	1.5	1992	1.5
Prenatal visits (#)				
≥4	28732	87.4	123852	87.9
<4	3752	11.6	17033	12.1
Marital status				
Yes	27804	85.7	117818	83.7
No	4465	14.3	23007	16.3
Aborted Pregnancies				
No	20285	62.4	89378	63.4
1	6762	20.8	28440	20.2
2 or more	5437	16.7	23067	16.4

Table 16. Maternal characteristics of cesarean delivery (CD) among women aged 35 and older group, Alberta, 1997-2002 combined

Characteristics	>=35 Years Group			
	CD		Not CD	
	n	%	n	%
Parity				
1	2928	34.8	4617	20.5
2 or more	5497	65.2	17882	79.5
Type of labour				
Spontaneous labour	2446	61.8	15426	72.1
Induced labour	1513	38.2	5962	27.9
Gestational age (wks)				
<37	1321	15.7	1705	7.6
37-42	7098	84.2	20784	92.4
>42	6	0.1	10	0.0
Birth weight (gms)				
<2500	1140	13.5	1319	5.9
2500-4000	6256	74.3	18355	81.6
>4000	1029	12.2	2825	12.6
Type of birth				
Singleton	7679	91.1	21906	97.4
Multiple	746	8.9	593	2.6

Table 16. Maternal characteristics of cesarean delivery (CD) among women aged 35 and older group, Alberta, 1997-2002 combined (continued)

Characteristics	>=35 Years Group			
	CD		Not CD	
	n	%	n	%
Smoking				
No	6725	84.2	18534	84.5
Yes	1262	15.8	3316	15.2
Alcohol use				
No	7735	96.6	20979	95.9
Yes	276	3.4	897	4.1
Street drug use				
No	7841	99.2	21492	99.3
Yes	66	0.8	155	0.7
Prenatal visits (#)				
>=4	7364	87.4	19413	86.3
<4	1061	12.6	3086	13.7
Marital status				
Yes	7647	90.8	20543	91.3
No	773	9.2	1952	8.7
Aborted Pregnancies				
No	4352	51.7	11745	52.2
1	2173	25.8	5641	25.1
2 or more	1900	22.6	5113	22.7

4.3.2 Unadjusted Odds Ratios of Cesarean Delivery among Different Age Groups

Table 17 presents the odds ratios and 95% confidence intervals for CD risk factors within each age group.

Among women aged 19 or younger, there was a 1.9-fold higher risk of CD when labour was induced and 1.2-fold of higher risk of CD for those having a first delivery. The OR of CD was 2.41 (95%CI 1.86,2.47) for preterm versus term delivery. Birth weight less than 2500 grams increased the risk of CD, with an OR of 2.8 (95%CI 2.41, 3.26). Similarly birth weight more than 4000 grams increased the risk of CD, with an OR of 2.11(95%CI 1.84, 2.43). CD was almost four times more frequent among women who delivered multiple births compared with a singleton birth. Women who underwent two or more abortions in the past had a 20% increase in the risk of CD compared with women who had never had an abortion. Unmarried women had a 13% reduction in the risk of CD compared with married women. No significant relationships were found between CD and gestational age more than 42 weeks, one aborted pregnancy, smoking, alcohol consumption and street drug use.

Among women aged 20 to 34, women undergoing induction of labour had a 76% increase in the risk of CD as compared to women undergoing spontaneous labour. For mothers delivering their first infants, there was a 48% increase in the risk of CD. Smokers were at less risk of CD than non-smokers (OR=0.93; 95% CI 0.90, 0.96). Similarly, mothers who consumed alcohol were at less risk than women who did not (OR=0.93; 95% CI 0.90, 0.96). No significant association was found between street drug use and CD in this group. CD was significantly increased in preterm birth but not postterm birth as compared to term birth. Both birth weight less than 2500

grams and more than 4000 grams were found to be associated with an increased risk of CD. CD was 4.3 times more frequent among women who delivered multiple births compared with a singleton birth. Unmarried women were less likely to have CD. Less than 4 prenatal visits and 2 or more previous abortions slightly increased the risk of CD.

Among women aged 35 or greater, there was a 1.6-fold higher risk of CD among mothers undergoing labour induction and two-fold increased risk of CD when mothers delivered first babies at age 35 years and older. Gestational age less than 37 weeks, birth weight less than 2500 grams and multiple births significantly increased the risk of CD. Statistically, only alcohol consumption had a protective effect on the risk of CD in the same group. A moderate difference was observed between prenatal visits more than or equal to four times and fewer than four times. Other factors did not show any statistical relationships with CD in this group.

Therefore, the bivariate analysis revealed that induced labour, nulliparity, gestational age less than 37 weeks, birth weight less than 2500 grams and multiple births were significantly associated with CD in all age groups.

Table 17. Unadjusted odds ratio (OR) for cesarean delivery among mothers with liveborn singletons within different age groups, Alberta, 1997-2002 combined

Variables	<=19		20-34		>=35	
	OR	95% CI	OR	95% CI	OR	95% CI
Parity						
1	1.18*	1.03,1.35	1.48*	1.45,1.52	2.06*	1.95,2.18
2 or more (ref)	1.00		1.00		1.00	
Type of labour						
Spontaneous (ref)	1.00		1.00		1.00	
Induced labour	1.88*	1.66,2.13	1.76*	1.70,1.82	1.60*	1.49,1.72
Gestational age (wks)						
<37	2.41*	1.86,2.47	2.26*	2.17,2.35	2.70*	2.10,2.45
37-42(ref)	1.00		1.00		1.00	
>42	1.89	0.53,6.71	1.20	0.74,1.97	1.76	0.64,4.84
Birth weight (gms)						
<2500	2.80*	2.41,3.26	1.34*	1.30,1.40	2.54*	2.33,2.76
2500-4000(ref)	1.00		1.00		1.00	
>4000	2.11*	1.84,2.43	2.70*	2.58,2.80	1.07	0.99,1.15
Type of birth						
Singleton (ref)	1.00		1.00		1.00	
Multiple	3.86*	2.85,5.21	4.29*	4.05,4.54	3.59*	3.21,4.01
Smoking						
No(ref)	1.00		1.00		1.00	
Yes	1.00	0.9,1.10	0.93*	0.90,0.96	1.05	0.98,1.13
Alcohol use						
No(ref)	1.00		1.00		1.00	
Yes	1.00	0.85,1.19	0.90*	0.84,0.96	0.84*	0.73,0.96
Street drug use						
No(ref)	1.00		1.00		1.00	
Yes	0.91	0.75,1.11	0.98	0.88,1.09	1.16	0.87,1.56
Prenatal visits (#)						
>=4 (ref)	1.00		1.00		1.00	
<4	1.16	1.00,1.33	1.05*	1.01,1.09	1.10*	1.02,1.20
Marital status						
Yes(ref)	1.00		1.00		1.00	
No	0.87*	0.79,0.96	0.86*	0.23,0.89	1.06	0.97,1.16
Aborted Pregnancies						
No(ref)	1.00		1.00		1.00	
1	0.98	0.84,1.03	1.04	1.00,1.07	1.04	0.98,1.11
2 or more	1.20*	1.03,1.38	1.05*	1.02,1.08	1.00	0.96,1.11

CI= confidence interval, OR= odds ratio, Reference category (ref),* Significant at p<0.05

4.3.3 Logistic Regression Analysis for Cesarean Delivery among Different Age Groups

In order to compare risk factor differences for each age group, the probability of CD as a function of all potential risk factors was modeled, separately for each age group. The results of three final logistic regression models according to maternal age are presented in Table 18.

11,038 women aged 19 and younger, 135,246 women aged 20 to 34 and 23,002 women aged 35 and older were included in each model, respectively, with no missing information on maternal characteristics. Nine independent variables including nulliparity, induced labour, preterm birth, smoking, alcohol consumption, illicit drug use, less than four prenatal visits, unmarried status, history of previous abortion and interaction between smoking and alcohol consumption were considered for inclusion in the first step. The interaction terms were found to be statistically non-significant ($p > 0.05$) in each model, so were not retained in these models. All other variables were included in the final models.

The multivariate logistic regression analysis showed the following three variables to be significant in all age categories: nulliparity, induced labour and gestational age < 37 weeks; however, odds ratios and confidence intervals varied. The most significant risk factor was nulliparity, with ORs of 3.65(95% CI 3.38, 3.94), 2.92(95% CI 2.82, 3.04) and 2.01(95% CI 1.62, 2.51) for mothers aged 35 and older, 20 to 34, and 19 and younger, respectively. Both labour induction and gestational age less than 37 weeks significantly increased the risk of CD in all age categories, although odds ratios varied. The positive effects of married and aborted pregnancies

on CD were only evident among women aged 20 to 34. Smoking was not statistically significant in the final models.

Table 18. Adjusted odds ratio (OR) for cesarean delivery among mothers with liveborn singletons within different age groups, Alberta, 1997-2002 combined

Variables	<=19		20-34		>=35	
	OR	95% CI	OR	95% CI	OR	95% CI
Type of labour						
Spontaneous(ref)	1.00		1.00		1.00	
Induced labour	1.93*	1.68,2.21	1.80*	1.74,1.87	1.52*	1.41,1.65
Parity						
1	2.01*	1.62,2.51	2.92*	2.82,3.04	3.65*	3.38,3.94
2 or more(ref)	1.00		1.00		1.00	
Gestational age (wks)						
<37	1.82*	1.47,2.26	1.78*	1.67,1.89	1.94*	1.72,2.20
37-42(ref)	1.00		1.00		1.00	
>42	2.87	0.77,10.78	1.23	0.63,2.42	1.96	0.57,6.78
Smoking						
No(ref)	1.00		1.00		1.00	
Yes	1.08	0.94,1.24	0.98	0.93,1.02	1.02	0.91,1.14
Alcohol use						
No(ref)	1.00		1.00		1.00	
Yes	0.93	0.72,1.19	0.94	0.85,1.03	0.81	0.66,1.00
Street drug use						
No(ref)	1.00		1.00		1.00	
Yes	1.02	0.78,1.34	1.08	0.93, 1.23	1.30	0.84,1.99
Prenatal visits (#)						
>=4 (ref)	1.00		1.00		1.00	
<4	1.11	0.93,1.34	0.98	0.93,1.04	1.02	0.91,1.14
Marital status						
Yes(ref)	1.00		1.00		1.00	
No	0.92	0.81,1.05	0.90*	0.85,0.95	1.12	0.98,1.27
Aborted Pregnancies						
No(ref)	1.00		1.00		1.00	
1	0.96	0.79,1.18	1.14*	1.09,1.19	1.06	0.97,1.17
2 or more	1.15	0.93,1.42	1.09*	1.03,0.95	1.08	0.98,1.19
Total n	11038		135246		23002	

CI= confidence interval, OR= odds ratio, Reference category (ref),* Significant at p<0.05

4.4 Potential Risk Factors for Cesarean Delivery in Spontaneous and Induced Labour Groups

Q4. Did maternal risk factors for CD differ in cases of spontaneous and induced labour?

To facilitate comparison of risk factors between those who had a spontaneous compared to an induced labour, both bivariate analysis (section 4.4.1 and 4.4.2) and multivariate logistic regression analysis (section 4.4.3) were undertaken.

4.4.1 Difference in Maternal Characteristics of Cesarean Delivery between Spontaneous and Induced Labour Groups

Table 19 shows maternal characteristics, separately for the spontaneous and induced labour subgroups. Prevalence of each risk factor in the presence and absence of CD groups were compared; the risk factors for CD were found to be consistent, regardless of labour type ($p < 0.001$).

Table 19. Comparison of maternal characteristics of mothers with cesarean delivery (CD) between spontaneous and induced labour, Alberta, 1997-2002

Characteristics	Induced Labour				Spontaneous Labour			
	CD		Not CD		CD		Not CD	
	n	%	n	%	n	%	n	%
Maternal age								
12-19	453	5.2	2944	6.6	735	5.5	8997	7.4
20-34	6670	77.2	36027	80.2	10260	76.3	97390	80.0
>=35	1513	17.5	5962	13.3	2446	18.2	15426	12.7
Parity								
1	6085	70.5	18253	40.8	7497	55.8	47341	38.9
2 or more	2551	29.5	26580	59.2	5944	44.2	74472	61.1
Gestational age								
<37	674	7.8	2891	6.4	2352	17.5	8911	6.7
37-42	7951	92.1	42011	93.5	11082	82.4	113550	93.2
>42	11	0.1	31	0.1	7	0.1	64	0.1
Birth weight								
<2500	659	7.6	2484	5.5	1868	13.9	5690	4.7
2500-4000	6222	72.0	35826	79.7	9795	72.9	103134	84.7
>4000	1755	20.3	6623	14.7	1778	13.2	12989	10.7
Type of birth								
Singleton	8273	95.8	43604	97.0	12418	92.4	120155	98.6
Multiple	363	4.2	1329	3.0	1023	7.6	1658	1.4

Table 19. Comparison of maternal characteristics of mothers with cesarean delivery (CD) between spontaneous and induced labour, Alberta, 1997-2002 (continued)

Characteristics	Induced Labour				Spontaneous Labour			
	CD		Not CD		CD		Not CD	
	n	%	n	%	n	%	n	%
Smoking								
No	6467	79.5	32646	76.1	9941	78.5	89025	76.5
Yes	1663	20.5	10290	23.9	2716	21.5	27218	23.5
Alcohol use								
No	8020	96.2	41790	95.6	12231	95.8	111875	95.5
Yes	315	3.8	1902	4.4	532	4.2	5244	4.5
Street drug use								
No	8111	98.4	42396	98.3	12365	98.0	113286	98.1
Yes	134	1.6	730	1.7	247	2.0	2194	1.9
Prenatal visits (#)								
>=4	7674	88.9	40000	89.0	11506	85.6	105233	86.4
<4	962	11.1	4933	11.0	1936	14.4	16580	13.6
Marital status								
Yes	7220	83.6	36769	81.9	11159	83.1	99088	81.4
No	1412	16.4	8145	18.1	2269	16.9	22655	18.6
Aborted								
No	5533	64.1	28195	62.7	8418	62.6	77032	63.2
1	1804	20.9	9391	20.9	2837	21.1	24610	20.2
2 or more	1299	15.0	7347	16.4	2186	16.3	20171	16.6

4.4.2 Unadjusted Odds Ratios of Cesarean Delivery Comparing Spontaneous and Induced Labour Groups

Table 20 contains crude odds ratios of CD for women who experienced spontaneous labour and induced labour. A total of 169,286 women with CD underwent a trial of labour. 121,382 (71.7%) women in spontaneous labour group were compared with 47,904 (28.3%) women in induced labour group.

The bivariate analysis revealed that CD was significantly related to maternal age less than or equal to 19, maternal age greater than or equal to 35, nulliparity, gestational age less than 37 weeks, birth weight less than 2500 grams and more than 4000 grams, smoking and unmarried status among those with either induced or spontaneous labour. Gestational age greater than 42 weeks, less than four prenatal visits and alcohol consumption were not significantly associated with CD in either those with induced or spontaneous labour.

Table 20. Unadjusted odds ratio (OR) for cesarean delivery among mother with liveborn singletons who underwent spontaneous in comparison with induced labour, 1997-2002 combined

Variables	Induced Labour		Spontaneous Labour	
	OR	95% CI	OR	95% CI
Maternal age				
12-19	0.85*	0.77,0.94	0.80*	0.74,0.86
20-34(ref)	1.00		1.00	
>=35	1.37*	1.28,1.46	1.51*	1.44,1.58
Parity				
1	3.63*	3.45,3.82	2.20*	2.12,2.84
2 or more (ref)	1.00		1.00	
Gestational age (wks)				
<37	1.19*	1.08,1.31	2.23*	2.09,2.37
37-42(ref)	1.00		1.00	
>42	1.89	0.95,3.76	1.08	0.46,2.52
Birth weight (gms)				
<2500	1.55*	1.46,1.64	1.48*	1.40,1.56
2500-4000(ref)	1.00		1.00	
>4000	1.56*	1.41,1.72	2.66*	2.48,2.84
Type of birth				
Singleton (ref)	1.00		1.00	
Multiple	1.44*	1.28,1.62	5.97*	5.51,6.47
Smoking				
No(ref)	1.00		1.00	
Yes	0.82*	0.77,0.87	0.92*	0.86,0.95
Alcohol use				
No(ref)	1.00		1.00	
Yes	0.88	0.78,1.00	0.95	0.87,1.05
Street drug use				
No(ref)	1.00		1.00	
Yes	0.95	0.78,1.15	1.03	0.89,1.18
Prenatal visits (#)				
>=4 (ref)	1.00		1.00	
<4	1.02	0.94, 1.10	1.05	1.00, 1.10
Marital status				
Yes(ref)	1.00		1.00	
No	0.89*	0.83,0.94	0.91*	0.86,0.95
Aborted Pregnancies				
No(ref)	1.00		1.00	
1	0.99	0.93,1.05	1.06*	1.01,1.11
2 or more	0.91*	0.85,0.97	0.99	0.94,1.04

CI= confidence interval, OR= odds ratio, Reference category (ref), * Significant at p<0.05

4.4.3 Logistic Regression Analysis of Cesarean Delivery for Induced Labour and Spontaneous Labour Groups

Table 21 presents the results of two separate logistic regression models. These models were developed to assess risk factor differences between those who underwent spontaneous versus induced labour. These models were restricted to singleton, live births. Among women in the induced labour subgroup, 47,904 cases (90.0%) were included in the multivariate analysis, 5,320 cases (10.0%) were missing, while among those in spontaneous group, 121,282 cases (89.5%) were included in the analysis and 14,236 cases (10.5%) were missing.

The following nine variables were included in the analysis: maternal age, parity, gestational age, smoking, alcohol consumption, street drug use, less than four prenatal visits, unmarried status, and history of previous abortion. In addition, the interactions of maternal age with other independent variables, smoking and alcohol interaction were evaluated in the first models. In the final models non-significant interaction terms were eliminated.

The analysis revealed that CD was significantly associated with nulliparity, maternal age greater than or equal to 35, gestational age less than 37 weeks, unmarried status, aborted pregnancy equal to one (all $p < 0.05$) among women with labour induction and those who entered labour spontaneously; however, the magnitude of odds ratios and confidence intervals varied. The most significant positive predictor of CD regardless of labour type was nulliparity, with other significant positive predictors including maternal age greater than or equal to 35 years,

gestational age less than 37 weeks and history of abortion. Unmarried women, compared to married women, were at lower risk of CD, regardless of labour type.

The characteristics associated with an increased risk of CD among those with induced labour also included maternal age less than or equal to 19, and a history of two or more of previous abortions. An interaction between maternal age greater than or equal to 35 and nulliparity was statistically significant in both induced and spontaneous labour groups. However, only the interaction terms of maternal age less than or equal to 19 with nulliparity and one abortion, respectively, were statistically significant in the induced labour group. The interaction between maternal age greater than or equal to 35 and unmarried status was significant in the spontaneous labour group.

Logistic regression models showed that in the induced labour group, nulliparas aged 19 and younger were 2.29 ($1.10 \times 3.92 \times 0.53 = 2.29$) times more likely to have a CD, also nulliparas aged 35 and older were 5.95 ($1.10 \times 3.92 \times 1.38 = 5.95$) times more likely to have CD compared with multiparas aged 20 to 34. Women who were 19 and younger and with a history of a previous abortion had 17% ($1.10 \times 1.14 \times 0.66 = 0.83$) reduction in risk of CD compared to women aged 20 to 34 and no abortion (See table for details).

The model of the spontaneous labour group revealed that nulliparas aged 35 and older were at 4.87-fold ($1.68 \times 2.48 \times 1.17 = 4.87$) higher risk of CD compared with multiparas aged 20 to 34. Unmarried women aged 35 and older had an almost 2-fold ($1.68 \times 0.90 \times 1.27 = 1.92$) higher risk of CD compared with married women aged 20 to 34.

To summarize, this analysis reveals that maternal age 35 and over, nulliparity, gestational age less than 37 weeks, unmarried status and one previous abortion were significant predictors of CD in both the spontaneous and the induced labour groups. Furthermore, we found significant interactions between maternal age and parity in two groups, maternal age and one previous abortion in the induced labour group and maternal age and unmarried status in the spontaneous labour group.

Table 21. Adjusted odds ratio (OR) for cesarean delivery among mother with liveborn singletons who underwent spontaneous in comparison with induced labour, 1997-2002 combined

Variables	Induced Labour		Spontaneous Labour	
	OR	95% CI	OR	95% CI
Maternal age				
12-19	1.10	0.75,1.63	0.66*	0.50,0.87
20-34(ref)	1.00		1.00	
>=35	1.40*	1.23,1.59	1.68*	1.54,1.84
Parity				
1	3.92*	3.68,4.17	2.48*	2.37,2.59
2 or more(ref)	1.00		1.00	
Gestational age (wks)				
<37	1.19*	1.09,1.32	2.23*	2.09,2.37
37-42(ref)	1.00		1.00	
>42	2.00	0.97,4.17	1.08	0.46,2.52
Smoking				
No(ref)	1.00		1.00	
Yes	0.97	0.90,1.03	1.00	0.95,1.06
Alcohol use				
No(ref)	1.00		1.00	
Yes	0.86	0.75,1.00	0.94	0.84,1.04
Street drug use				
No(ref)	1.00		1.00	
Yes	1.07	0.86,1.33	1.09	0.93,1.28
Prenatal visits (#)				
>=4 (ref)	1.00		1.00	
<4	1.05	0.97,1.14	0.98	0.92,1.04
Marital status				
Yes(ref)	1.00		1.00	
No	0.91*	0.84,0.98	0.90*	0.84,0.96
Aborted Pregnancies				
No(ref)	1.00		1.00	
1	1.14*	1.06,1.22	1.14*	1.08,1.21
2 or more	1.13*	1.04,1.23	1.06	1.00,1.14
Maternal age and parity				
12-19 and parity=1	0.53*	0.37,0.86	0.80	0.62,1.05
20-34 and parity>1(ref)	1.00		1.00	
>=35 and parity=1	1.38*	1.20,1.53	1.17*	1.05,1.31
Maternal age and abortion				
20-34 and no abortion(ref)	1.00		-	
12-19 and abortions=1	0.66*	0.46,0.92	-	
Maternal age and marital status				
20-34 and Married(ref)	-		1.00	
>=35 and Unmarried	-		1.27*	1.07,1.51
Total n	47904		121382	

CI= confidence interval, OR= odds ratio, Reference category (ref),* Significant at p<0.05

Chapter Five: Discussion

There are four sections in this chapter. Section 5.1 will discuss the interpretation of the study results. Section 5.2 will identify the strengths and weakness of the study. Section 5.3 will provide a summary and conclusion and the final section will provide suggestions for future research.

5.1 Discussion of the Results

5.1.1 CD rates from 1997 to 2002 in Alberta

As noted before, provincial CD rates and maternal age-specific CD rates increased steadily from 1997 to 2002 in Alberta (89); Regional CD rates from 1998 to 2000 reported by Alberta Health and Wellness revealed substantial differences between health regions. CD rates of induced and spontaneous labour groups were compared in a retrospective cohort study in a metropolitan area by Heffner et al. (69); however, no published literature has reported these data from Alberta.

The difference between CD rates according to region of residence compared to region of birth could be attributed to the practice of transferring high-risk mothers from other regions to larger centres (Edmonton and Calgary), which would result in CD rates based on region of birth being higher than region of residence. In total, 454 mothers who lived in other regions delivered in the Calgary Health Region, which represented 2.8% of all CD deliveries performed in this region. Moreover,

2161 mothers who lived in other regions delivered in Capital region, which represented 15.8% of all CD deliveries performed in this region (Table 6). The majority of women who lived in other regions and delivered in Calgary or Edmonton had characteristics of 'high risk'. The increased demand for level II and level III facilities (e.g., equipment and facilities to monitor fetal heart rates electronically, special care nurseries, obstetrical beds and neonatal intensive care area) associated with out-of-region patterns of service delivery needs to be properly accounted for and resourced.

5.1.2 The Impact of Maternal Age on Cesarean Delivery

As expected, the CD rate increased with advancing maternal age in the bivariate analysis (Table 8) (1;29;54;82;89;98-100). Although the underlying mechanism for a varying CD rate by maternal age is not well known, there is an age related increase in the incidence of CD risk factors, including medical complications such as hypertension, diabetes, preeclampsia and other antenatal complications. (3;25;29;38;40). Additionally, labour and delivery factors such as an increased duration of second stage labour, which has traditionally been defined as the period from full cervical dilation to the birth of the baby (11), is known to increase among older women (29;101). Unfortunately, we do not have the data to control for medical complications to assess the independent effect of age on CD as this data were unavailable(29). Similar to these findings, Poma (35) found that older women had a statistically significant higher CD rate (31.2%) than women aged 20 to 35years (20.3%) and aged 19 years or younger (14.0%), which he

attributed to increases in breech presentation and shoulder dystocia in older mothers.

5.1.3 Predictors of Cesarean Delivery among Different Maternal Age Groups

To understand how risk factors for CD varied by maternal age, both bivariate and logistic regression analysis were completed. Despite some variability in the bivariate analysis across age group, only nulliparity, gestational age less than 37 weeks and induced labour remained significant in the multivariate modeling (Table 17, Table 18).

The different results from the two types of analysis could be partially explained by the following: first, the multivariate analysis was restricted to singleton births, so the sample characteristics were somewhat changed between the bivariate and regression analysis. Second, the multivariate analysis controlled for potential confounders; therefore this would be a more reliable method of identification of key risk factors.

Although the methodology differed from other studies because our data were analyzed by age group and there was assessment of possible effect modifiers in our models, most of our findings confirmed the associations that have been shown in previous reports. Nulliparity was found to be a highly significant predictor of CD in this research. Although the finding cannot establish causation, it agreed with other studies (3;29;35;52;54;79;82;102). Joseph et al. (3) analyzed all deliveries (N=127,564) in Nova Scotia between January 1, 1998 and December 31, 2000 from the Nova Scotia Atlee Perinatal Database and found that reduced parity

was an increased risk factor of CD. Broster (55) also confirmed that nulliparity was a significant contributor to CD with the use of multiple regression analysis, although the reasons were less well described.

Moreover, this study and other studies confirmed gestational age less than 37 weeks as an important risk factor for CD (23;70;103-105). Schiff (23), who examined factors for CD among American Indian Women in New Mexico using birth certificate data from liveborn infants, reported that premature babies were twice as likely to be delivered by CD than term babies. Unfortunately, this study had a smaller sample size (N= 3645) and did not evaluate the interaction between maternal age and other variables in the multivariate model. A report from Vital and Health Statistics of the United States (23) demonstrated the highest CD rates occurred among infants with a gestational age less than 37 weeks and the peak rate of CD occurred between gestational ages of 28 to 31 weeks. The rationale for an increased number of CD in preterm infants relates to the high rate of antenatal and perinatal complications in this group, the attempts by caregivers to attain a neuroprotective effect through CD and possibly the association with multiple births.

The results of the current study were fairly consistent with the results of many previous studies in that induced labour was correlated with CD (23;27;56-63;106-108). Xenakis et al. (106) conducted a prospective study in the United States, excluding patients with either elective or emergency indications for CD and found that women who underwent labour induction were at least two times more likely to experience CD than women who entered labour spontaneously. Seyb et al. (108)

conducted a cohort study of 1562 term nulliparity deliveries in the United States between 1996 and 1997 and using stepwise multiple logistic regression they reported that elective and medical induction increased the risk of CD, with ORs of 1.89 (95% CI: 1.12, 3.18), and 1.69 (95% CI: 1.13, 2.54) respectively.

It may be possible to offer early CD to patients at highest risk, reducing the potential morbidity of a long labour or a failed operative vaginal delivery followed by a later CD. Therefore, studying indications for CD in each age group should be very useful for hospitals, clinicians, and researchers to identify women at risk.

5.1.4 Predictors of Cesarean Delivery in Spontaneous and Induced Labour Groups

To determine if risk factors for CD differed depending on the type of labour, both bivariate and multivariate analyses were undertaken. Both analyses demonstrated that maternal age greater than or equal to and 35 years, nulliparity, gestational age less than 37 weeks, and being unmarried were significant predictors of CD and only among women with spontaneous labour, maternal age less than 19 years old significantly decreased the risk of CD (Table 20, Table 21). As mentioned before, the associations found within the multivariate analysis had less bias compared to bivariate analysis, since multivariate analysis simultaneously controlled for all potential confounding variables.

Risk factor differences between induced and spontaneous labouring women, who go on to have CD, have rarely been studied. Although Delaney and Young (56) described indications for CD between women with spontaneous or induced labour, no analysis was undertaken. In another study, Seyb et al. (108) compared pregnancy

characteristics including mean maternal age, mean BMI, mean birth weight, race and premature rupture of membranes within subgroups of elective induction, medical induction and spontaneous labour, no multivariate analysis was performed. Neither study evaluated the interactions (or the statistical significance) between maternal age and parity, maternal age and previous abortions, and maternal age and marital status.

This study indicates that regardless of labour type, risk factors for CD were similar; however, the magnitude of the OR differed. For example (Table 21), gestational age less than 37 weeks was a stronger predictor of CD among spontaneously labouring women compared with induced labouring women (OR= 2.23 vs 1.19); in contrast, nulliparity was a stronger predictor of CD among induced compared to spontaneous labouring women (OR= 3.92 vs 2.48). However, further prospective studies are needed to confirm our findings.

5.2 Strengths and Weakness of the Study

It is important to examine and acknowledge the strengths and weaknesses of this study in order to appropriately interpret the findings and provide information for further research.

5.2.1 Study Strengths

The PNOB data is currently the best available large population-based data source for estimating CD rates and for this study evaluating the impact of maternal demographic characteristics on the risk of CD. Birth certificates are routinely recorded for every birth in Alberta, so high costs involved in

collecting data from patient charts in hospitals were avoided using these data. Secondly, this population-based data provided a large sample size and is less biased information on predicting the risk of CD (109). Also, the reliability and validity of the data has been determined. Research evidence demonstrated that the quality of data was relatively reliable and collection of information on type of delivery, maternal age, birth weight and multiple birth were valid (109). Furthermore, we are able to simultaneously control for potential confounding variables and assessed possible effect modifiers by means of multivariate logistic regression in this study.

5.2.2 Study Weakness

Several potential limitations are worthy of discussion. Some limitations are due to the study design and methods while others are associated with the data sources.

- i. It is not possible to determine a casual relationship between exposure and CD because of the cross-sectional nature of this study. Furthermore, since this was not a randomized or matched study, the possibility of unknown or unmeasured confounding always exists and may bias the results of the analysis.
- ii. The calculation of the CD rate included live births only. Temporal and regional variation of this number could contribute to the variation of both the denominator and numerator that was used to

calculate CD rates. Since the number of stillbirths was small, it is anticipated the effect on the CD rate was probably small.

- iii. Since the multivariate analysis was restricted to singleton, live born infants, the results could not be generalized to multiple births.
- iv. Missing data in the PNOB data set may bias the study results. Additionally, the possible presence of co-linearity relationships between covariates such as maternal age and parity or aborted pregnancies (Table 13), also might bias the results. Although the data was complete in greater than 85% of records and the estimated bias is likely small, this should be considered in interpretation of the odds ratios.
- v. Some information, which was of interest, was not possible to obtain from the PNOB data. For example, data were not available on the indications or reasons for CD such as elective and emergency CD, so the elective ones could not be excluded. Furthermore, some medical risk factors of pregnancy were associated with the risk of CD, i.e. the CD rate for eclampsia 52.3%, genital herpes 46.0%, pregnancy associated hypertension 41.6%, fetal distress 62.6%, diabetes 37.2%, oligohydramnios 45.6%(23). Since these factors could not be assessed in the analysis due to the dataset, therefore, the results could be biased. Similarly, information on medically and obstetrically indicated induction, or even elective induction were not recorded in this data

source, nor could we distinguish risk factors for different types of induction before CD. Lastly, we could not assess other potential cofounders such as Body Mass Index (BMI), pregnancy weight gain (52), medical complications including diabetes mellitus, or genital herpes as these types of information were absent from the PNOB database. Parrish et al (29) report that pregnancy and in-bour complication rates varied substantially by maternal age and parity. Therefore, medical complications may confound the relationship of maternal age or parity with CD.

- vi. Some underreported information might exist in the data. It has been founded in previous studies that women tend to underreport their induced abortions(48;56). Additionally, women could also underreport the information of smoking, consuming alcohol and using street drug during pregnancy.
- vii. Self-report data presents the problem of recall bias. Questions about alcohol intake, illicit drug use and smoking may be inconsistently reported for a variety of reasons. For example, women with CD could be more likely to report their adverse lifestyle (i.e. alcohol intake, illicit drug use and smoking) than women without CD. The differential misclassification bias can lead to an underestimate or overestimate of the strength of the association.

- viii. The data for this project were retrieved from a part of patient records in the hospitals of Alberta, which were designed predominantly to be used for direct patient care and follow-up, not for research. Accuracy may be compromised by the large number of professionals who recorded the information and misclassification bias may exist. For example, the nondifferential misclassification of exposure will produce a bias towards the null (towards an OR of 1.0), thus underestimating the strength of the association between the exposure and outcome.

5.3 Summary of the Study Results and Conclusion

To our knowledge, this is the first study to document maternal risk factors and the association with CD by analyzing a large population-based database in Alberta. Results confirmed the association between known risk factors and CD, and new relationships and interactions were examined.

Question 1. 1) Did the CD rate change from 1997 to 2002 and did the regional CD rates differ by health regions during this six-year period in the province of Alberta?

There were significant temporal increases in both the provincial CD rates and the age-specific CD rates ($p < 0.001$ trend). Overall, the annual provincial CD rate rose by 40%, from 16.3% in 1997 to 22.9% in 2002 and the provincial average CD rate for the six-year interval was 19.5%. The age-specific CD rate for women aged 35 or

older increased by 8.9%, which was the greatest increase in all age groups. The CD rate among women undergoing labour induction (16.1%) was higher than the rate in the spontaneous group (9.9%). Regional CD rates varied by health region, from a low of 10.7% (95% CI 9.9%, 11.4%) in Palliser Region to a high of 23.7% (95% CI 22.4%, 25.0%) in East Central region. Given the increasing CD rates in Alberta, and in alignment with the recommendations of the *Canadian Perinatal Health Report*, there is opportunity to establish clinical guidelines for CD and increase the rate of vaginal birth after CD to optimize the CD rate (1) in this province.

Question 2. Were the characteristics of mothers, who underwent CD different from those who did not?

Women who underwent CD were more likely to deliver babies with birth weight less than 2500 grams or more than 4000 grams and to deliver multiples. The mean maternal age, mean gestational age, mean birth weight and mean parity of the study population were found to be statistically significant predictors of CD; however, the number of prenatal visits was not.

The substantial increases in the percentages of mothers in the older age group may partially explain the increases of annual CD rates. In evidence of this, the Calgary and Capital regions had the highest mean age and proportions of women aged 35 or greater in the province and notably the CD rates were highest in these two regions.

In summary, this study confirms previous findings that advancing maternal age increased the risk of CD. Given the increased rate of delayed childbearing, and

the rising trend in elective CD(88;110) the provincial perinatal education programs have an opportunity to provide information on CD related risks in order that families can make informed decisions (10).

Q3. What were the risk factors for CD among women within defined age cohorts (age less than or equal to 19, 20 to 34, and greater than or equal to 35)?

Three separate multivariate logistic regression models were developed to investigate maternal risk factors of CD among pregnant women within different age groups. The results demonstrated that nulliparity, gestational age less than 37 weeks and labour induction significantly increased the risk of CD in all age groups when adjustment was made for smoking, alcohol consumption, illicit drug use, less than four prenatal visits, unmarried status, and history of previous abortion; however, the magnitude of adjusted odds ratios and 95% confidence interval differed. Parity was the strongest predictor in all age groups. The OR of CD for nulliparous women compared with multiparous women were 3.65 (95% CI 3.38, 3.94), 2.92 (95% CI 2.82, 3.04), 2.01(95% CI 1.62, 2.51) for mothers aged 35 years or greater, 20 to 34 years and 19 years or younger, respectively. Women who were married and who had one or two previous abortions had a significantly increased risk of CD only among those aged 20 to 34. Although advancing maternal age, birth weight less than 2500 grams and more than 4000 grams, and two or more multiple pregnancies played significant roles in determining risk for CD among the study population in the bivariate analysis, these relationships could not be confirmed with the use of the multivariate analysis.

Briefly, of all the risk factors we were able to assess, CD was significantly associated with nulliparity, gestational age less than 37 weeks and labour induction for women with singleton live births, after adjustment for smoking, alcohol consumption, illicit drug use, less than four prenatal visits, unmarried status, and history of previous abortion; however, OR differed between each age group. These results indicate that the key risk factors for CD are similar across maternal age groups; however, nulliparity elevates the risk of CD most significantly among older women. These results provide impetus for further research to understand the underlying mechanism, which drives the increased risk for nulliparous women. Furthermore, there is an opportunity to develop appropriate policies and guidelines for performing and monitoring CD in Alberta.

Question 4. Did maternal risk factors for CD differ in cases of spontaneous and induced labour?

Two separate regression models were developed to distinguish risk differences between spontaneous and induced labour groups. The analyses demonstrated that maternal age greater than or equal to 35, nulliparity, gestational age less than 37 weeks, unmarried status and one previous abortion were associated with increasing risk for CD in both spontaneous and induced labour groups, after controlling for smoking, alcohol consumption, illicit drug use and less than four prenatal visits. Maternal age 19 years or younger reduced the risk of CD by 24% in the spontaneous group, while two or more abortions increased the risk of CD by 13% only in women undergoing labour induction. Additionally,

birth weight less than 2500 grams and more than 4000 grams, as well as multiple pregnancies, showed statistically significant relationships with CD only in the bivariate analysis, since these two variables were excluded from the multivariate analysis.

In summary, risk factors that distinguish between risk for induced versus spontaneous labour were difficult to determine from routine data collection. More detailed data such as the Discharge Abstract Database (DAD) from the Canadian Institute for Health Information (CIHI) should be analyzed to better identify additional risk factors, which characterize women at risk of CD. Furthermore, labour induction could reduce the risk of CD among women with gestational age less than 37 weeks; however, any adverse maternal and neonatal outcomes associated with the use of induction require investigation.

In conclusion, the potential risk factors for CD identified in this study not only provides an opportunity for clinicians to consider the profiles of their patients and choose an appropriate guideline for their practice, but also offer opportunities for women and their family to develop appropriate plans for birth.

5.4 Suggestions for Further Research

1. ICD diagnosis codes and other hospital information are coded on the CIHI's DAD; further analysis could link the provincial data with the DAD to better understand risk factors associated with CD.

2. Since adjusted CD rates (e.g., CD rate simultaneously adjusted for age and parity, and CD rates adjusted for birth weight), overcome the problems of temporal or regional variation, they provide more accurate information in estimating the changes and trends in CD rates. Therefore, further studies should present these rates when comparing CD rates over time and across populations.
3. Mixed effect model or hierarchical model analysis could be conducted in future analyses, since the PNOB data are hierarchically structured, with patient nested within hospital, and then nested within health region. The analyses conducted in this project ignored the hierarchical structure of data, possibly leading to biased results.
4. A multi-center perspective cohort study could be conducted to confirm the observed associations shown in the current study. Women with no *a priori* medical indication of CD would be eligible for the study and more detailed demographic, psychosocial (e.g. abuse, stress), medical (e.g. history of miscarriages) and lifestyle (e.g. fitness, work habits) data could be collected.
5. CD may result in increased utilization of services such as prenatal scans, amniocentesis, and antenatal admission to hospital, infant resuscitation, and admission to the neonatal unit. Further research could investigate maternal service utilization associated with CD in Alberta.
6. Since multiple births may have substantially different risk factors than singleton births, multivariate logistic regression analysis could be done only on multiple births.

7. The establishment of a perinatal surveillance database in Alberta such as the Nova Scotia Atlee Perinatal Database and the Aberdeen Maternity and Neonatal Databank in the UK(111;112) would provide more detailed information for research in this field.

Reference

- (1) Health Canada. Canadian Perinatal Health Report, 2003. Ottawa: Minister of Public Works and Government Services Canada. 2003. [http:// www.hc-sc.gc.ca/hpb/lcdc/brch/reprod.html](http://www.hc-sc.gc.ca/hpb/lcdc/brch/reprod.html)
- (2) Matthews TG, Crowley P, Chong A, McKenna P, McGarvey C, O'Regan M. Rising caesarean section rates: a cause for concern?[see comment]. *BJOG: an International Journal of Obstetrics and Gynaecology* 2003; 110(4):346-349.
- (3) Joseph KS, Young DC, Dodds L, O'Connell CM, Allen VM, Chandra S et al. Changes in maternal characteristics and obstetric practice and recent increases in primary cesarean delivery. *Obstetrics and Gynecology* 2003; 102(4):791-800.
- (4) Dobson R. Caesarean section rate in England and Wales hits 21. *BMJ* 2001; 323(7319):951.
- (5) Donati S, Grandolfo ME, Andreozzi S. Do Italian mothers prefer cesarean delivery? *Birth* 2003; 30(2):89-93.
- (6) Tough SC, Svenson L, Schopflocher D. Maternal Risk Factors In Relationship To Birth Outcome. 1999. Alberta Health and Wellness. Health Surveillance ISBN 0-7785-0207-4.
- (7) Wagner M. Choosing caesarean section. *Midwifery Today with International Midwife* 2001;(57):26-29.
- (8) Health Canada. Canadian Perinatal Health Report, 2000. Ottawa: Minister of Public Works and Government Services Canada. 2000. [http:// www.hc-sc.gc.ca/hpb/lcdc/brch/reprod.html](http://www.hc-sc.gc.ca/hpb/lcdc/brch/reprod.html)
- (9) Bost BW. Cesarean delivery on demand: what will it cost? *American Journal of Obstetrics and Gynecology* 188(6):1418-21; discussion 1421-3, 2003.
- (10) What is the right number of caesarean sections? *Lancet* 349(9055):815, 1997.
- (11) Family-Centred Maternity and Newborn Care. 2000. Health Canada.
- (12) Harlow BL, Frigoletto FD, Cramer DW, Evans JK, Bain RP, Ewigman B et al. Epidemiologic predictors of cesarean section in nulliparous patients at

low risk. RADIUS Study Group. Routine Antenatal Diagnostic Imaging with Ultrasound Study. *American Journal of Obstetrics and Gynecology* 172(1 Pt 1):156-62, 1995.

- (13) Braveman P, Egerter S, Edmonston F, Verdon M. Racial/ethnic differences in the likelihood of cesarean delivery, California. *American Journal of Public Health* 85(5):625-30, 1995.
- (14) Parsons MT, Winegar A, Siefert L, Spellacy WN. Pregnancy outcomes in short women. *Journal of Reproductive Medicine* 34(5):357-61, 1989.
- (15) Gould JB, Davey B, Stafford RS. Socioeconomic differences in rates of cesarean section. *New England Journal of Medicine* 321(4):233-9, 1989.
- (16) Cnattingius R, Cnattingius S, Notzon FC. Obstacles to reducing cesarean rates in a low-cesarean setting: the effect of maternal age, height, and weight. *Obstetrics and Gynecology* 92(4 Pt 1):501-6, 1998.
- (17) Garbacia JA, Jr., Richter M, Miller S, Barton JJ. Maternal weight and pregnancy complications. *American Journal of Obstetrics and Gynecology* 152(2):238-45, 1985.
- (18) Kanadys WM, Oleszczuk J. [Obesity as an obstetric risk factor]. [Review] [72 refs] [Polish]. *Ginekologia Polska* 70(6):464-71, 1999.
- (19) Ahern JK, Goodlin RC. Cesarean section in the massively obese. *Obstetrics and Gynecology* 51(4):509-10, 1978.
- (20) Sicuranza BJ, Tisdall LH. Cesarean section in the massively obese. *Journal of Reproductive Medicine* 14(1):10-1, 1975.
- (21) Molloy WB. Labor in short women. *Obstetrics and Gynecology* 34(3):330-4, 1969.
- (22) Weiss JL, Malone FD, Vidaver J, Ball RH, Nyberg DA, Comstock CH et al. Threatened abortion: A risk factor for poor pregnancy outcome, a population-based screening study. *American Journal of Obstetrics and Gynecology* 190;(3):745-750.
- (23) Taffel SM. Cesarean delivery in the United States, 1990. *Vital and Health Statistics Series 21, Data on Natality, Marriage, and Divorce* (51):1-24, 1994.
- (24) Goyert GL, Bottoms SF, Treadwell MC, Nehra PC. The physician factor in cesarean birth rates. *New England Journal of Medicine* 320(11):706-9, 1989.
- (25) Vercellini P, Zuliani G, Rognoni MT, Trespidi L, Oldani S, Cardinale A. Pregnancy at forty and over: a case-control study. *European Journal of Obstetrics, Gynecology, and Reproductive Biology* 1993; 48(3):191-195.

- (26) Guihard P, Blondel B. [Factors associated with cesarean section in France. Results from the 1995 National Perinatal Survey]. [French]. *Journal de Gynecologie, Obstetrique et Biologie de la Reproduction* 2001; 30(5):444-543.
- (27) Roberts CL, Algert CS, Carnegie M, Peat B. Operative delivery during labour: trends and predictive factors. *Paediatric and Perinatal Epidemiology* 2002; 16(2):115-123.
- (28) Sack RA. The effect of utilization on health care costs. *American Journal of Obstetrics and Gynecology* 1980; 137(2):270-275.
- (29) Parrish KM, Holt VL, Easterling TR, Connell FA, LoGerfo JP. Effect of changes in maternal age, parity, and birth weight distribution on primary cesarean delivery rates.[see comment]. *JAMA* 1994; 271(6):443-447.
- (30) Yuan W, Steffensen FH, Nielsen GL, Moller M, Olsen J, Sorensen HT. A population-based cohort study of birth and neonatal outcome in older primipara. *International Journal of Gynaecology and Obstetrics* 2000; 68(2):113-118.
- (31) Irwin DE, Savitz DA, Hertz-Picciotto I, St Andre KA. The risk of pregnancy-induced hypertension: black and white differences in a military population. *American Journal of Public Health* 1994; 84(9):1508-1510.
- (32) Lialios G, Kaponis A, Adonakis G. Maternal age as an independent risk factor for cesarean delivery. *International Journal of Gynaecology and Obstetrics* 1999; 67(3):187-188.
- (33) Peipert JF, Bracken MB. Maternal age: an independent risk factor for cesarean delivery. *Obstetrics and Gynecology* 1993; 81(2):200-205.
- (34) Ecker JL, Chen KT, Cohen AP, Riley LE, Lieberman ES. Increased risk of cesarean delivery with advancing maternal age: indications and associated factors in nulliparous women. *American Journal of Obstetrics and Gynecology* 2001; 185(4):883-887.
- (35) Poma PA. Effect of decreasing cesarean births on maternal age-, parity- and ethnicity-associated cesarean rates. *Journal of Reproductive Medicine* 2000; 45(3):213-218.
- (36) Kabra SG, Narayanan R, Chaturvedi M, Anand P, Mathur G. What is happening to caesarean section rates? *Lancet* 343(8890):179-80, 1994.
- (37) Tough SC, Newburn-Cook C, Johnston DW, Svenson LW, Rose S, Belik J. Delayed childbearing and its impact on population rate changes in lower birth weight, multiple birth, and preterm delivery. *Pediatrics* 109(3):399-403, 2002.

- (38) Dulitzki M, Soriano D, Schiff E, Chetrit A, Mashiach S, Seidman DS. Effect of very advanced maternal age on pregnancy outcome and rate of cesarean delivery. *Obstetrics and Gynecology* 1998; 92(6):935-939.
- (39) Tough S, Tofflemire K. Maternal risk factors in relationship to birth outcome, Alberta 1997-2001. 2003. Department of Pediatrics and Community Health Sciences.
- (40) Melchor JC, Rodriguez-Alarcon J, Fernandez-Llebrez L, Benito JA, Linares A, Aranguren G. Delayed childbearing and pregnancy outcome. *Zentralblatt fur Gynakologie* 1994; 116(10):566-570.
- (41) Prysak M, Lorenz RP, Kisly A. Pregnancy outcome in nulliparous women 35 years and older. *Obstetrics and Gynecology* 85(1):65-70, 1995.
- (42) Special Report on Maternal Mortality and Severe Morbidity in Canada - Enhanced Surveillance: The Path to Prevention. 2004. Ottawa: Minister of Public Works and Government Services Canada, Health Canada.
- (43) Kirz DS, Dorchester W, Freeman RK. Advanced maternal age: the mature gravida. *American Journal of Obstetrics and Gynecology* 152(1):7-12, 1985.
- (44) Kessler I, Lancet M, Borenstein R, Steinmetz A. The problem of the older primipara. *Obstetrics and Gynecology* 56(2):165-9, 1980.
- (45) Leung GM, Lam TH, Thach TQ, Wan S, Ho LM. Rates of cesarean births in Hong Kong: 1987-1999. *Birth* 2001; 28(3):166-172.
- (46) Martel M, Wacholder S, Lippman A, Brohan J, Hamilton E. Maternal age and primary cesarean section rates: a multivariate analysis. *American Journal of Obstetrics and Gynecology* 156(2):305-8, 1987.
- (47) Grobman WA, Dooley SL, Peaceman AM. Risk factors for cesarean delivery in twin gestations near term. *Obstetrics and Gynecology* 1998; 92(6):940-944.
- (48) Williams KP, Galerneau F. Intrapartum influences on cesarean delivery in multiple gestation. *Acta Obstetrica et Gynecologica Scandinavica* 2003; 82(3):241-245.
- (49) Bailit J, Garrett J. Comparison of risk-adjustment methodologies for cesarean delivery rates. *Obstetrics and Gynecology* 2003; 102(1):45-51.
- (50) Mathews TJ. Trends in stimulation and induction of labor 1989-1995. *Statistical Bulletin - Metropolitan Insurance Companies* 1997; 78(4):20-26.

- (51) Prysak M, Castronova FC. Elective induction versus spontaneous labor: a case-control analysis of safety and efficacy. *Obstetrics and Gynecology* 1998; 92(1):47-52.
- (52) Babinszki A, Kerenyi T, Torok O, Grazi V, Lapinski RH, Berkowitz RL. Perinatal outcome in grand and great-grand multiparity: effects of parity on obstetric risk factors. *American Journal of Obstetrics and Gynecology* 1999; 181(3):669-674.
- (53) Mesleh RA, Asiri F, Al Naim MF. Cesarean section in the primigravid. *Saudi Medical Journal* 21(10):957-9, 2000.
- (54) Mor-Yosef S, Samueloff A, Modan B, Navot D, Schenker JG. Ranking the risk factors for cesarean: logistic regression analysis of a nationwide study. *Obstetrics and Gynecology* 75(6):944-7, 1990.
- (55) Brost BC, Goldenberg RL, Mercer BM, Iams JD, Meis PJ, Moawad AH et al. The Preterm Prediction Study: association of cesarean delivery with increases in maternal weight and body mass index. *American Journal of Obstetrics and Gynecology* 177(2):333-7; discussion 337-41, 1997.
- (56) Delaney T, Young DC. Spontaneous versus induced labor after a previous cesarean delivery. *Obstetrics and Gynecology* 2003; 102(1):39-44.
- (57) Friesen CD, Miller AM, Rayburn WF. Influence of spontaneous or induced labor on delivering the macrosomic fetus. *American Journal of Perinatology* 1995; 12(1):63-66.
- (58) Gonen O, Rosen DJ, Dolfin Z, Tepper R, Markov S, Fejgin MD. Induction of labor versus expectant management in macrosomia: a randomized study. *Obstetrics and Gynecology* 1997; 89(6):913-917.
- (59) Shin KS, Brubaker KL, Ackerson LM. Risk of cesarean delivery in nulliparous women at greater than 41 weeks' gestational age with an unengaged vertex. *American Journal of Obstetrics and Gynecology* 2004; 190(1):129-134.
- (60) van Gemund N, Hardeman A, Scherjon SA, Kanhai HH. Intervention rates after elective induction of labor compared to labor with a spontaneous onset. A matched cohort study. *Gynecologic and Obstetric Investigation* 56(3):133-8, 2003.
- (61) Dublin S, Lydon-Rochelle M, Kaplan RC, Watts DH, Critchlow CW. Maternal and neonatal outcomes after induction of labor without an identified indication. *American Journal of Obstetrics and Gynecology* 183(4):986-94, 2000.

- (62) Friesen CD, Miller AM, Rayburn WF. Influence of spontaneous or induced labor on delivering the macrosomic fetus. *American Journal of Perinatology* 12(1):63-6, 1995.
- (63) Smith LP, Nagourney BA, McLean FH, Usher RH. Hazards and benefits of elective induction of labor. *American Journal of Obstetrics and Gynecology* 148(5):579-85, 1984.
- (64) Rayburn WF, Zhang J. Rising rates of labor induction: present concerns and future strategies. [Review] [11 refs]. *Obstetrics and Gynecology* 100(1):164-7, 2002.
- (65) Yeast JD, Jones A, Poskin M. Induction of labor and the relationship to cesarean delivery: A review of 7001 consecutive inductions.[see comment]. *American Journal of Obstetrics and Gynecology* 180(3 Pt 1):628-33, 1999.
- (66) Smith LP, Nagourney BA, McLean FH, Usher RH. Hazards and benefits of elective induction of labor. *American Journal of Obstetrics and Gynecology* 148(5):579-85, 1984.
- (67) Horrigan TJ. Physicians who induce labor for fetal macrosomia do not reduce cesarean delivery rates. *Journal of Perinatology* 2001; 21(2):93-96.
- (68) Using active management of labor and vaginal birth after previous cesarean delivery to lower cesarean delivery rates: A 10-year experience. *American Journal of Obstetrics and Gynecology* 2001; 184.
- (69) Heffner LJ, Elkin E, Fretts RC. Impact of labor induction, gestational age, and maternal age on cesarean delivery rates. *Obstetrics and Gynecology* 102(2):287-93, 2003.
- (70) Wilkes PT, Wolf DM, Kronbach DW, Kunze M, Gibbs RS. Risk factors for cesarean delivery at presentation of nulliparous patients in labor. *Obstetrics and Gynecology* 2003; 102(6):1352-1357.
- (71) Turner MJ, Rasmussen MJ, Turner JE, Boylan PC, MacDonald D, Stronge JM. The influence of birth weight on labor in nulliparas. *Obstetrics and Gynecology* 76(2):159-63, 1990.
- (72) Bailit JL, Garrett JM, Miller WC, McMahon MJ, Cefalo RC. Hospital primary cesarean delivery rates and the risk of poor neonatal outcomes. *American Journal of Obstetrics and Gynecology* 2002; 187(3):721-727.
- (73) Schiff M, Rogers C. Factors predicting cesarean delivery for American Indian women in New Mexico. *Birth* 26(4):226-31, 1999.

- (74) Conde-Agudelo A, Belizan JM, Lindmark G. Maternal morbidity and mortality associated with multiple gestations. *Obstetrics and Gynecology* 95(6 Pt 1):899-904, 2000.
- (75) Lieberman E, Lang JM, Heffner LJ, Cohen A. Assessing the role of case mix in cesarean delivery rates. *Obstetrics and Gynecology* 1998; 92(1):1-7.
- (76) Kallen K. The impact of maternal smoking during pregnancy on delivery outcome. *European Journal of Public Health* 2001; 11(3):329-333.
- (77) Abel EL. Smoking during pregnancy: a review of effects on growth and development of offspring. [Review] [113 refs]. *Human Biology* 52(4):593-625, 1980.
- (78) Bailey RR. The effect of maternal smoking on the infant birth weight. *New Zealand Medical Journal* 71(456):293-4, 1970.
- (79) Cnattingius S, Forman MR, Berendes HW, Graubard BI, Isotalo L. Effect of age, parity, and smoking on pregnancy outcome: a population-based study. *American Journal of Obstetrics and Gynecology* 168(1 Pt 1):16-21, 1993.
- (80) Turcot L, Marcoux S, Fraser WD. Multivariate analysis of risk factors for operative delivery in nulliparous women. Canadian Early Amniotomy Study Group. *American Journal of Obstetrics and Gynecology* 176(2):395-402, 1997.
- (81) Kesmodel U, Wisborg K, Olsen SF, Henriksen TB, Secher NJ. Moderate alcohol intake during pregnancy and the risk of stillbirth and death in the first year of life. *American Journal of Epidemiology* 2002; 155(4):305-312.
- (82) Sims CJ, Meyn L, Caruana R, Rao RB, Mitchell T, Krohn M. Predicting cesarean delivery with decision tree models. *American Journal of Obstetrics and Gynecology* 183(5):1198-206, 2000.
- (83) McDuffie RS, Jr., Beck A, Bischoff K, Cross J, Orleans M. Effect of frequency of prenatal care visits on perinatal outcome among low-risk women. A randomized controlled trial.[see comment]. *JAMA* 275(11):847-51, 1996.
- (84) Butler J, Abrams B, Parker J, Roberts JM, Laros RK, Jr. Supportive nurse-midwife care is associated with a reduced incidence of cesarean section.[see comment]. *American Journal of Obstetrics and Gynecology* 168(5):1407-13, 1993.
- (85) Binstock MA, Wolde-Tsadik G. Alternative prenatal care. Impact of reduced visit frequency, focused visits and continuity of care. *Journal of Reproductive Medicine* 40(7):507-12, 1995.

- (86) Trujillo HB, Tene Perez CE, Rios SM. [Risk factors for cesarean section: epidemiologic approach]. [Spanish]. *Ginecologia y Obstetricia de Mexico* 68:306-11, 2000.
- (87) Scott-Wright AO, Flanagan TM, Wrona RM. Predictors of cesarean section delivery among college-educated black and white women, Davidson County, Tennessee, 1990-1994. *Journal of the National Medical Association* 1999; 91(5):273-277.
- (88) Poma PA. Effects of obstetrician characteristics on cesarean delivery rates. A community hospital experience. *American Journal of Obstetrics and Gynecology* 1999; 180(6:Pt 1):t-72.
- (89) Alberta Health and Wellness. Alberta Reproductive Health: Pregnancies Births. 2002.
- (90) Gordis L. *Epidemiology*. 2000.
- (91) Charles H.Hennekens. *Epidemiology in Medicine*. 1987.
- (92) Kleinbaum D, Kupper L, Morgenstern H. *Epidemiological Research*. New York: 1982.
- (93) Denise F.Polot. *Nursing Research Principle and Methods*. 1999.
- (94) Bernard Rosner. *Fundamentals of Biostatistics*. 5th ed. 2000.
- (95) Hamilton LC. *Regression With Graphics: A Second Course in Applied Statistic*. 1992.
- (96) Kelsey J WAEATW. *Methods in Observational Epidemiology*. 2nd ed. ed. New York: Oxford University Press, 1996.
- (97) Schiff M, Rogers C. Factors predicting cesarean delivery for American Indian women in New Mexico. *Birth* 1999; 26(4):226-231.
- (98) Hansen JP. Older maternal age and pregnancy outcome: a review of the literature. [Review] [91 refs]. *Obstetrical and Gynecological Survey* 41(11):726-42, 1986.
- (99) Clarke SC, Taffel S. Changes in cesarean delivery in the United States, 1988 and 1993. *Birth* 22(2):63-7, 1995.
- (100) Adashek JA, Peaceman AM, Lopez-Zeno JA, Minogue JP, Socol ML. Factors contributing to the increased cesarean birth rate in older parturient women. *American Journal of Obstetrics and Gynecology* 169(4):936-40, 1993.

- (101) Berkowitz GS, Skovron ML, Lapinski RH, Berkowitz RL. Delayed childbearing and the outcome of pregnancy. *New England Journal of Medicine* 322(10):659-64, 1990.
- (102) Bai J, Wong FW, Bauman A, Mohsin M. Parity and pregnancy outcomes. *American Journal of Obstetrics and Gynecology* 2002; 186(2):274-278.
- (103) Babinszki A, Kerenyi T, Torok O, Grazi V, Lapinski RH, Berkowitz RL. Perinatal outcome in grand and great-grand multiparity: effects of parity on obstetric risk factors. *American Journal of Obstetrics and Gynecology* 181(3):669-74, 1999.
- (104) Joseph KS, Demissie K, Kramer MS. Obstetric intervention, stillbirth, and preterm birth. *Seminars in Perinatology* 26(4):250-9, 2002.
- (105) Maslow AS, Sweeny AL. Elective induction of labor as a risk factor for cesarean delivery among low-risk women at term. *Obstetrics and Gynecology* 95(6 Pt 1):917-22, 2000.
- (106) Zeidenstein L. Induction of labor in the nineties: conquering the unfavorable cervix. *Journal of Nurse-Midwifery* 43(2):124-5, 1998;-Apr.
- (107) Xenakis EM, Piper JM, Conway DL, Langer O. Induction of labor in the nineties: conquering the unfavorable cervix. *Obstetrics and Gynecology* 90(2):235-9, 1997.
- (108) Seyb ST, Berka RJ, Socol ML, Dooley SL. Risk of cesarean delivery with elective induction of labor at term in nulliparous women. *Obstetrics and Gynecology* 94(4):600-7, 1999.
- (109) Tough SC, Svenson LW, Johnston DW, Schopflocher D. Characteristics of preterm delivery and low birthweight among 113,994 infants in Alberta: 1994-1996. *Canadian Journal of Public Health Revue Canadienne de Sante Publique* 92(4):276-80, 2001;-Aug.
- (110) Krebs L, Langhoff-Roos J. Elective cesarean delivery for term breech. *Obstetrics and Gynecology* 101(4):690-6, 2003.
- (111) Bell JS. Can obstetric complications explain the high levels of obstetric interventions and maternity service use among older women? A retrospective analysis of routinely collected data. *BJOG* 2001 Sep;108(9):910-8 2001.
- (112) Jacqueline S Bell. Do obstetric complications explain high caesarean section rates among women over 30? A retrospective analysis. *BMJ*. 322(7291):894-5, 2001 Apr 14.

Appendix A: Figures For the Tables Presented in the Results

Figure 1. Cesarean section rate among livebirths, Alberta, 1997-2002

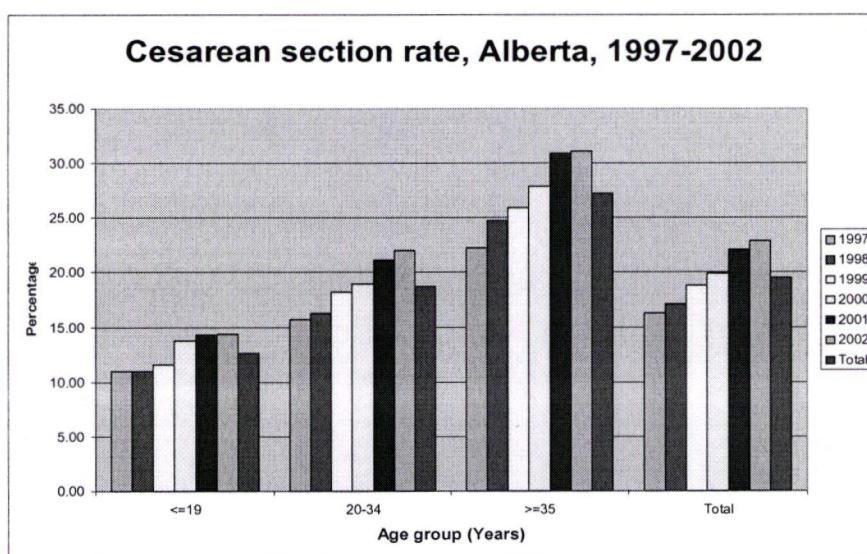


Figure 2. Distribution of maternal age, Alberta, 1997-2002combined

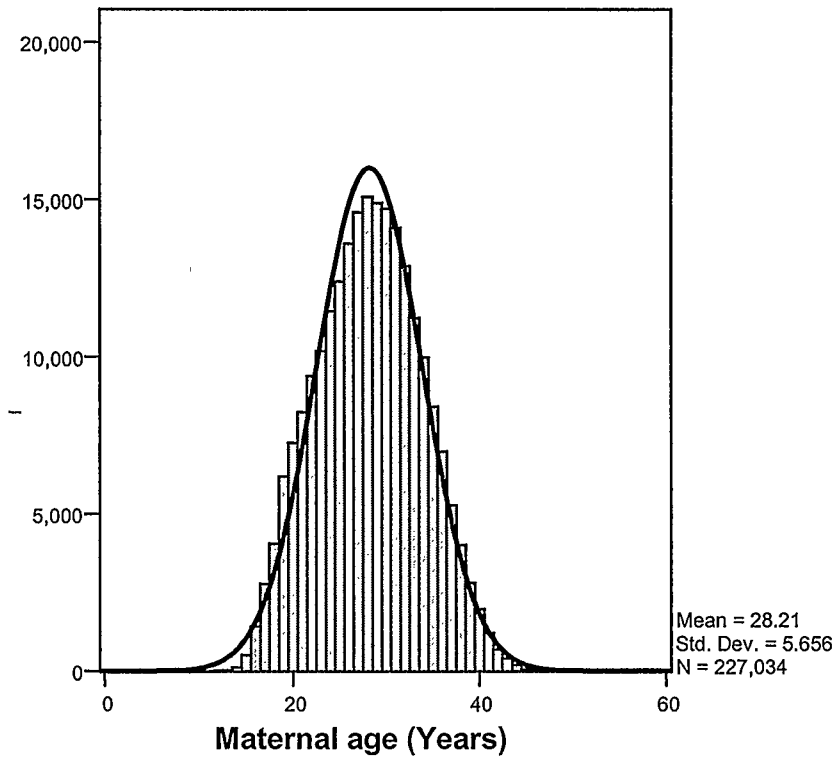


Figure 3. Maternal age group by year of birth, Alberta, 1997-2002

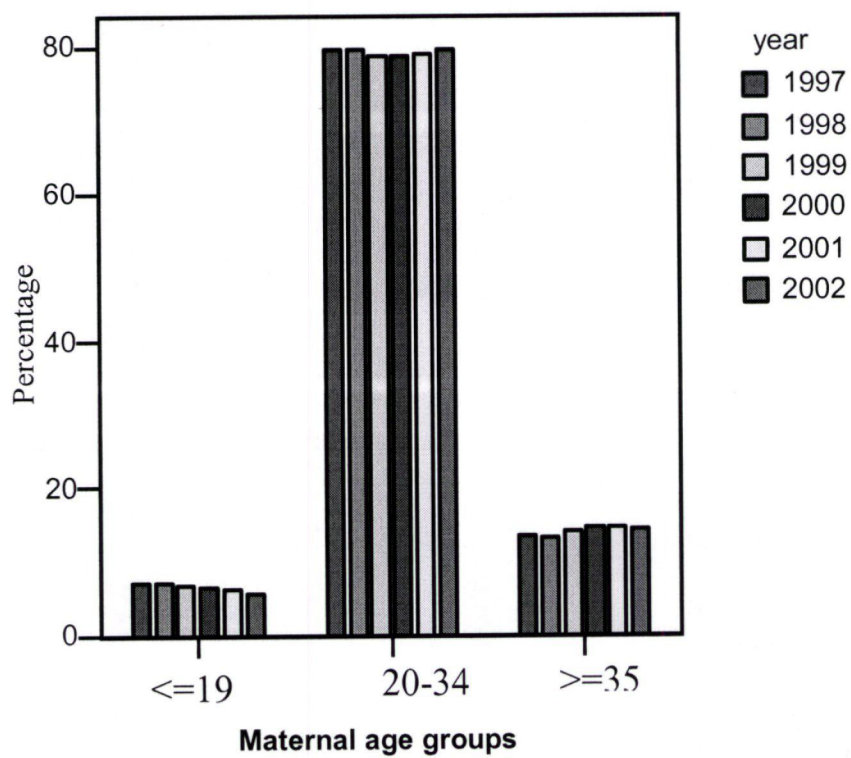
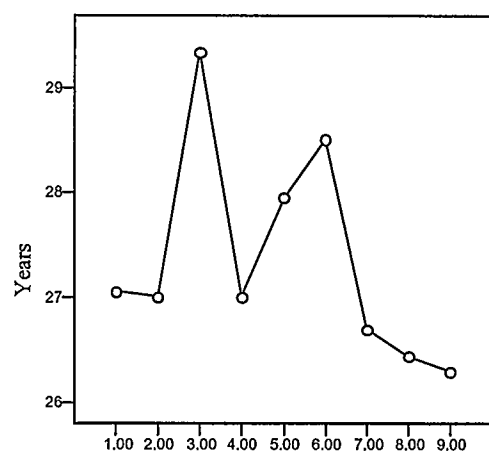


Figure 4. Mean maternal age by Region of residence, Alberta, 1997-2002
combined



Region of residence

1--Chinook 2--Palliser 3--Calgary 4--David Thompson

5--East Central 6--Capital 7--Aspen 8--Peace Country

9--Northern Lights