A THESIS

Maternal and Neonatal Outcomes of Planned Primary Cesarean versus Vaginal Delivery for Low Risk Primiparous Women at Term

By

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CERTIFICATE OF APPROVAL

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List of Abbreviations

CNS..... Central Nervous System

CS..... Cesarean Section Delivery

ICD-9 ..... International Classification of Disease codes (9th edition)

L&D ..... Labor and delivery

NICU .....Neonatal Intensive Care Unit

OSHPD ..... Office of Statewide Health Planning and Development (California)

PPC ..... Planned Primary Cesarean Delivery

RDS.....Respiratory Distress Syndrome

TTN.....Transient Tachypnea of the Newborn

URHHT ..... Uterine rupture, Hysterectomy, Hemorrhage or Transfusion

List of Definitions

Planned Cesarean.....cesarean that is scheduled in advance

Primary Cesarean ..... cesarean in a woman with no history of a previous cesarean

Primiparous..... a woman who has given birth to only one child

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"In art nothing worth doing can be done without genius, in science even a very moderate capacity can contribute something to a supreme achievement."

- Betrand Russell

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Abstract

Objective: To compare maternal and neonatal outcomes of planned primary cesarean (PPC), with and without labor, to vaginal delivery in low risk primiparous women at term. **Methods:** Retrospective cohort study consisting of hospital delivery discharges for low risk primiparous women who delivered a term singleton infant in California in 2002. Multivariate logistic regression was used to assess the effect of delivery route (PPC with labor, PPC without labor, vaginal delivery) on maternal and neonatal morbidity. Maternal outcomes: hemorrhage, transfusion, uterine rupture, hysterectomy, cardiac complications, anesthetic complications, and major infection. Neonatal outcomes: transient tachypnea of newborn (TTN), respiratory distress syndrome (RDS), NICU admission, sepsis, intracranial hemorrhage, and central nervous system (CNS) complications. **Results**: 122,578 primiparous women met eligibility criteria: 111,486 vaginal; 5,603 PPC with labor; 5,489 PPC without labor. Among mothers, higher rates of cardiac complications, anesthetic complications and major infection were associated with PPC, regardless of labor. For mothers, lower rates of hemorrhage and transfusion were associated with PPC, regardless of labor. For infants, a higher rate of TTN was associated with PPC, regardless of labor. Higher rates of neonatal morbidity for RDS, CNS complications, NICU admission and sepsis were associated with PPC in the presence of labor. We found no decreased neonatal morbidity associated with PPC. **Conclusion:** In this large population of low risk primiparous women at term, increased maternal and neonatal morbidity was associated with PPC; except for maternal hemorrhage and transfusion which was decreased. Clinicians should inform low risk primiparous women that, although maternal and neonatal morbidity is rare, there is an increased association with PPC compared to vaginal delivery.

CHAPTER 1: INTRODUCTION

The cesarean delivery rate has been rising steadily for the past decade. In 2006 it climbed to 31.1 percent of all births, a three percent increase from 2005 and a new record high marking a fifty percent increase in cesarean delivery over the last decade. [1] Furthermore, the rate of primary cesarean among low-risk women having a first birth increased one-third between 1996 and 2003 to a rate of 23.6 percent of all primiparous births. [1] In response to growing concerns about the rising cesarean rate, the U.S. Department of Health and Human Services established decreasing the cesarean rate as one of the Healthy People Year 2000 objectives. [2] When objectives were evaluated for Healthy People 2010 (HP 2010), lowering the cesarean rate was again a top priority. [2] However, for HP 2010, the focus was shifted from decreasing cesarean delivery in all women giving birth to decreasing cesarean specifically among low-risk women; with a target rate of 15 percent for cesarean delivery in this low-risk population, a 36 percent drop from the current rate. [1, 2] Despite this objective by HP 2010, the trend in the rate for low-risk women continues to parallel the rising trend for all women. The discrepancy from HP 2010 goals to actual rates begs us to ask the question if the objectives established are logical and realistic to achieve and, if so, what may be done to reach the HP 2010 goal. Consequently, it has become increasingly important to better understand the role and appropriateness of cesarean in the low-risk population.

The issues central to the debate relate to maternal and neonatal morbidities associated with route of delivery—with some favoring planned primary cesarean (PPC) because of fear of childbirth or convenience, [3] risk of urinary and fecal incontinence, [4] breech presentation, [5] and unexplained fetal death at term; [3, 5] while others favor

vaginal birth because of the reduced risk of maternal death, [6] decreased neonatal respiratory problems, [6-9] shortened hospital stay, [10] and fewer unexplained fetal deaths in subsequent pregnancies. [11] In an attempt to reduce the cesarean rate, there has been an emphasis on avoiding primary cesarean deliveries. [12] Primary cesarean delivery refers to cesareans among women with no history of a previous cesarean. Of the approximate 150,000 annual cesarean deliveries in California, the primary cesarean rate was nearly 17% in 2002 and rose to 19.1% in 2003. [13, 14] A significant contributor to the escalating primary cesarean rate is *planned* primary cesarean (PPC), also referred to as *elective* primary cesarean delivery. [15-17] It has been estimated that up to 25% of primary cesareans are planned, varying by geographic region and hospital. [18]

The high rate of cesarean deliveries may be attributed to a variety of factors, some medically necessary and others due to maternal request without medical indication. [19, 20] Medical factors most frequently influencing the primary cesarean rate include pre-eclampsia and placental issues, while fetal indications most often influencing the cesarean rate include malpresentation and birth defects. [16, 17, 20] A U.S. National Institutes of Health (NIH) State of-the-Science Conference on "Cesarean Delivery by Maternal Request," in March 2006 commissioned an evidence report that restructured the question to focus on a comparison of what they defined as planned cesarean delivery. [21] The report found little research which compared outcomes based upon mode of delivery, and the NIH panel concluded there was a need for research that explicitly compared planned cesarean, with and without labor, and vaginal births. [16] There are a few detailed illustrations of the rates of specific complications, while comparisons of outcomes by route of delivery matched for clinical condition, age, and week of gestation

are often lacking, specifically with respect to planned cesarean delivery. [22] Our study was conducted to shed light on maternal and neonatal outcomes of planned primary cesarean compared to vaginal delivery among low-risk primiparous women.

CHAPTER 2: METHODS

The institutional review boards at Oregon Health & Science University (IRB00002945) and the Cedars-Sinai Medical Center (Pro00007240/CR00001958) approved our study protocol. The study population consisted of all patients who were delivered in 2002 in the State of California, as reported to the California Office of Statewide Health Planning and Development (OSHPD). These data included up to 25 clinical conditions per woman and infant as identified by International Classification Disease (ICD-9) codes. It was our goal to have a study population of low risk primiparous women who delivered a term (≥ 37 weeks) singleton viable infant. We excluded women who had a previous delivery, preterm delivery or multiple gestations. In addition, we excluded women with pre-existing medical conditions: cardiovascular disease (codes 648.5, 648.6), diabetes (code 648), liver disorders (code 646.7), renal disease (code 646.2), lung disease (codes 519.9, 496) and seizure disorders (codes 345.x, 780.3x). Women were also excluded if the fetus was identified as having intrauterine growth retardation (code 656.5) or intrauterine fetal demise (code 656.4).

After the exclusion criteria were applied, we classified our study population by route of delivery and labor status. The challenge was that there are no ICD-9 codes for planned cesarean delivery or the presence of labor. Consequently, we utilized several different algorithms to accomplish our goal. For classifying women by route of delivery,

we selected a previously validated methodology developed by Gregory et al. to identify women who underwent planned cesarean. [15] According to the Gregory method the potential indications for planned cesarean include genital herpes (HSV), other viral diseases, malpresentation, unengaged fetal head, antepartum bleeding, placental conditions, eclampsia, severe pre-eclampsia, macrosomia, congenital fetal CNS anomaly and chromosomal abnormalities. [15, 18] However, to further insure we captured a low risk population we modified the Gregory method and omitted conditions which would preclude women from being low risk; in other words, we excluded from the algorithm conditions associated with adverse outcomes. Specifically, we excluded placental conditions, eclampsia, severe pre-eclampsia, antepartum bleeding and other viral illnesses. The modified algorithm was aimed at identifying low risk women who underwent planned cesarean, so that we could focus specifically on the impact of route of delivery on morbidity, rather than confounding the analysis with the presence of maternal co-morbidities.

Table 1: Modified Method for Potential Indications for PPC delivery by ICD-9 code. [15, 18]

	Indication	ICD-9
a.	Malpresentation	652.x*
b.	Genital Herpes (HSV)	054.x
c.	Macrosomia	656.6
d.	Unengaged fetal head	652.5
e.	Chromosomal abnormality	655.1
f.	Congenital fetal CNS anomaly	655.0

*(except 652.1 and 652.5)

We also utilized a validated algorithm to identify women who labored based upon ICD-9 and DRG codes which indicated a vaginal delivery, fetal distress, labor abnormalities, cord prolapse, or breeches converted to vertex presentation (codes 653.x, 660.x, 661.x, 662.x, 652.1, 659.1, 656.3, 663.0). [15, 23, 24] Although some define elective or planned cesarean as a cesarean delivery in the absence of labor, many women with an indication for planned cesarean go into labor prior to their scheduled cesarean. As we cannot predict when a woman will go into labor, or if labor will occur prior to a planned cesarean, we felt it was important to assess the role labor plays in the context of PPC so that clinicians and patients will be better informed for the decision making process on choosing route of delivery. The result of applying these standardized methodologies was dividing our low risk population into three groups by route of delivery and labor status: PPC with labor, PPC without labor, and vaginal delivery.

Outcomes

Outcomes were identified by using ICD-9 codes as reported to OSHPD. Maternal outcomes examined included: hemorrhage, transfusion, uterine rupture, emergent hysterectomy, cardiac complications, anesthetic complications, major infection, pulmonary embolism, shock and death. Specifically, anesthetic complications were defined as complications from anesthetic administration or other sedation during labor and delivery (L&D) (code 668.x). Cardiac complications were defined as cardiac arrest or failure or acute myocardial infarction which occurred during L&D or immediately following (codes 668.1x, 669.4x, 410.x). Major infections were defined as major puerperal infection following delivery: endometritis, myometritis, pelvic cellulitis/sepsis,

peritonitis, pyemia, salpingitis, and septicemia; also included in this outcome were wound complications such as dehiscence or disruption of cesarean or perineal wounds (codes 670.x, 615.x, 674.1x, 674.2x, 674.3x). Uterine rupture was defined as before or during onset of labor (codes 665.0x, 665.1x); and emergent hysterectomy included subtotal abdominal, total abdominal, vaginal, and radical forms of hysterectomy (codes 683.x-689.x). Hemorrhage and transfusion were treated as a composite outcome and included postpartum hemorrhage, either immediate or delayed secondary, and third stage associated with uterine atony or retained placenta, in addition to the transfusion of blood products (codes 666.x, 990.x). Pulmonary embolism included air, amniotic, blood-clot and septic emboli (code 673.x). Shock was defined as occurring during or following L&D (code 669.1x). Death was identified by ICD-9 codes 674.9, 668.9 and 669.9. See Appendix 1 for details on maternal outcome definitions and associated ICD-9 codes.

Neonatal outcomes of interest included: transient tachypnea of newborn (TTN), respiratory distress syndrome (RDS), other respiratory problems, NICU admission, sepsis, intracranial hemorrhage, other hemorrhage, congenital central nervous system (CNS) problems and death. TTN is associated with code 770.6 and RDS code 769. The other neonatal respiratory problems we examined included congenital pneumonia, aspiration, interstitial emphysema, atelectasis, apnea and hypoxemia which were treated as a composite outcome (codes 770.x, except 770.6). Congenital CNS problems were also examined as a composite outcome and included convulsions of newborn, cerebral irritability and depression, coma and other abnormal cerebral signs (codes 779.x). Intracranial hemorrhage was defined as subdural and cerebral hemorrhage, intraventricular hemorrhage and subarachnoid hemorrhage (codes 767.0, 7721.x and

772.2). NICU admission was derived from hospital records and not associated with an ICD-9 code. Sepsis included septicemia and bacteremia (codes 771.8x). Death was identified by codes 768.1, 779.9 and 798.x. See Appendix 2 for details.

Statistical Analysis

We used multivariable logistic regression analyses to assess the relation between PPC and our outcomes of interest, controlling for maternal demographic characteristics (age, race, and education) as well as insurance payer. We did not analyze rare outcomes (neonatal death; and maternal shock, pulmonary embolism and death). We reduced the categorical variables to dichotomous variables: race/ethnicity (Caucasian, Black, Hispanic, Asian, and Native American) and insurance payer status at time of delivery (Kaiser, MediCal, no coverage, other). Maternal age and level of education were left as continuous variables. We selected vaginal delivery route as the reference variable, and Caucasian as the reference population for race/ethnicity. We implemented fixed effects for hospital ID to control for unobserved heterogeneity at the hospital level. We then calculated adjusted odds ratios for the outcomes and nominal two-tailed *P* values were reported with statistical significance considered as a *P* value of < 0.05. We also conducted tests of differences of demographic characteristics, insurance payer and hospital length stay and charges for the PPC group as a whole compared to the vaginal group: t-tests for age, education, gestation length; chi-square tests for race and insurance payer; and Mann-Whitney test of differences for hospital stay and charges. We utilized Pseudo R-squared values as a measure of goodness of fit of the model. All analyses were completed using SPSS (version 15.0; SPSS Inc, Chicago, IL) and SAS/STAT software.

Chapter 3: Results

Cesarean delivery rates

The use of these criteria yielded a study population consisting of 146,387 low risk primiparous women who delivered a term singleton viable infant. The overall primary cesarean rate in this group of low risk primiparous women was 23.84% (34,901/146,387). Of the 146,387 women, our study population consisted of 122,578 who met the eligibility criteria: 111,486 vaginal deliveries; 5,603 PPC with labor; 5,489 PPC without labor. The remaining 23,809 primary cesareans were classified as unplanned cesareans and will not be addressed in our results.

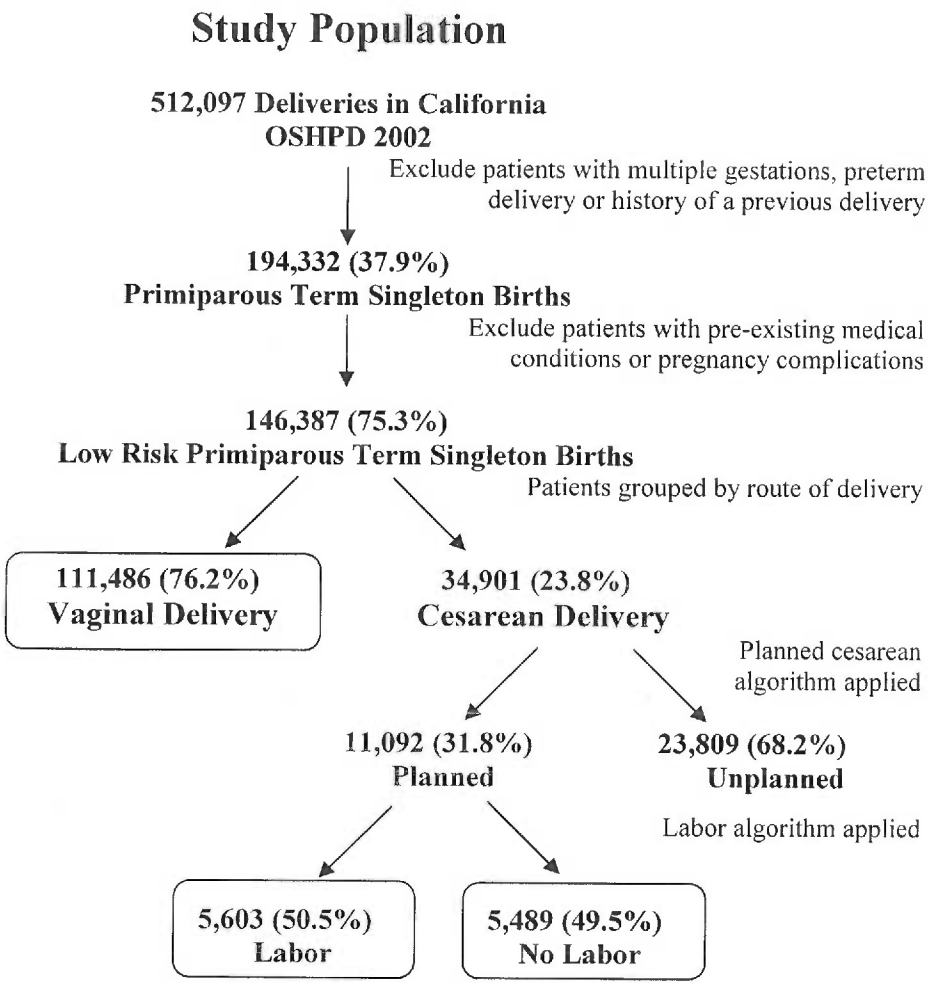

Fig 1. Derivation of study population.

Population characteristics

A summary of the maternal demographic characteristics by route of delivery (PPC with labor, PPC no labor, vaginal delivery) is provided in Table 2. The test of differences comparing the PPC group as a whole to vaginal delivery demonstrated that the two groups are statistically significantly different with regards to maternal demographic characteristics (age, race, and education level), insurance payer, hospital stay length and hospital charges. We found that women undergoing vaginal delivery were more likely to have a shorter hospital stay, be younger, Hispanic and have MediCal for medical insurance when compared to women undergoing PPC. These same maternal characteristics were controlled for in our model.

Goodness of Fit

Pseudo R-squared values for maternal and neonatal morbidity exceeded ninety percent for all outcomes, signifying a high level of goodness of fit for our model in explaining the association between route of delivery and the outcomes of interest.

Table 2: Maternal Characteristics in 122,578 Low Risk Primiparous Women at Term According to Route of Delivery

	PPC with labor (n = 5,603)	PPC no labor (n = 5,489)	Vaginal* (n = 111,486)	P-value
Characteristic	*mean (range)*	*mean (range)*	*mean (range)*	
Age (yrs)	27.42 (13-49)	28.11 (13-51)	24.82 (13-51)	<0.001[a]
Education (yrs)	13.25 (4-32)	13.45 (4-30)	12.75 (2-33)	<0.001[a]
Race				<0.001[b]
Asian	12.24%	13.84%	12.74%	
Black	3.71%	4.07%	4.87%	
Hispanic	37.66%	36.15%	44.00%	
Native American	0.39%	0.42%	0.41%	
White	44.00%	40.13%	36.97%	
Other	2.00%	5.39%	1.01%	
Insurance Payer				<0.001[b]
Kaiser	9.65%	11.03%	12.21%	
MediCal	36.57%	32.90%	43.13%	
No Coverage	2.01%	2.43%	2.47%	
Other Insurance	51.77%	53.64%	42.19%	
Length of gestation (days)	279.65	276.16	278.42	<0.001[a]
Days hospital stay, infant	3.4 (1.0-241.0)	3.27 (1.0-230.0)	1.88 (1.0-189.0)	<0.001[c]
Days hospital stay, mom	3.77 (1.0 - 90.0)	3.31 (1.0-94.0)	2.14 (1.0-62.0)	<0.001[c]
Hospital charges, infant (US$)	5,416 (103-407,291)	4,457 (68-431,008)	3,149 (110-2,537,995)	<0.001[c]
Hospital charges, mom (US$)	18,701 (1,209-252,625)	15,136 (2,539-181,847)	9,741 (1,183-339,394)	<0.001[c]

**Vaginal is the reference group.*

[a] *T-test to compare all PPC to vaginal group.*

[b] *Chi-square to compare all PPC to vaginal group.*

[c] *Mann Whitney to compare all PPC to vaginal group.*

Maternal Outcomes

Maternal outcomes by route of delivery are shown below in Table 3. See appendix 1 for definition of maternal outcomes and associated ICD-9 codes.

Table 3: Maternal Outcomes According to Route of Delivery

	Number of cases	Absolute risk by route* (%)	Adjusted OR** (CI 95%)	P-value
Cardiac complications (n=87)				
PPC with labor	35	0.62	17.47 (10.96, 27.86)	< 0.001
PPC no labor	15	0.27	7.64 (4.07, 13.66)	< 0.001
Vaginal (reference)	37	0.03	1	
Major infection (n=523)				
PPC with labor	130	2.32	8.87 (7.21, 10.91)	< 0.001
PPC no labor	72	1.31	5.01 (3.86, 6.49)	< 0.001
Vaginal (reference)	321	0.29	1	
Uterine rupture (n=8)				
PPC with labor	3	0.05	9.22 (3.75, 410.92)	0.153
PPC no labor	1	0.02	4.17 (0.56, 322.5)	0.432
Vaginal (reference)	4	< 0.001	1	
Hysterectomy (n=9)				
PPC with labor	3	0.05	8.82 (2.37, 382.43)	0.052
PPC no labor	2	0.04	3.38 (0.42, 290.6)	0.363
Vaginal (reference)	4	< 0.001	1	
Anesthetic complications (n=222)				
PPC with labor	23	0.41	2.70 (1.74, 4.19)	< 0.001
PPC no labor	28	0.51	3.29 (2.19, 4.92)	< 0.001
Vaginal (reference)	171	0.15	1	
Hemorrhage & Tranfusion (n=2699)				
PPC with labor	91	1.62	0.69 (0.56, 0.85)	< 0.001
PPC no labor	42	0.77	0.32 (0.23, 0.43)	< 0.001
Vaginal (reference)	2566	2.30	1	

** Derived from route of delivery groups: PPC with labor=5,603;PPC no labor=5,486;Vaginal=111,486.*
***Controlling for age, education, race and insurance payer.*

Cardiac Complications

The prevalence of cardiac complications such as cardiac arrest, cardiac failure or acute myocardial infarction in our low risk study population was 0.071% (87/122,578). Higher maternal morbidity for cardiac complications was associated with PPC, regardless

of labor, compared to vaginal delivery when controlling for age, race, education level and insurance (PPC no labor OR: 7.64; 4.07–13.66; PPC with labor OR: 17.47; 10.96–27.86).

Major Infection

The prevalence of major infections such as endometritis, myometritis, sepsis, and wound complications in our low risk study population was 0.427% (523/122,578). Higher maternal morbidity for major infection was associated with PPC, regardless of labor, compared to vaginal delivery when controlling for age, race, education level and insurance (PPC no labor OR: 5.01; 3.86–6.49; PPC with labor OR: 8.87; 7.21–10.91).

Anesthetic Complications

The prevalence of anesthetic complications in our low risk study population was 0.181% (222/122,578). Higher maternal morbidity for anesthetic complications was associated with PPC, regardless of labor, compared to vaginal delivery when controlling for age, race, education level and insurance (PPC no labor OR: 3.29; 2.19–4.92; PPC with labor OR: 2.70; 1.74–4.19).

Hemorrhage & Transfusion

The prevalence of the composite outcome of hemorrhage and transfusion in our low risk study population was 2.21% (2,699/122,578). Lower maternal morbidity for hemorrhage and transfusion was associated with PPC, regardless of labor, compared to vaginal delivery when controlling for age, race, education level and insurance (PPC no labor OR: 0.32; 0.23-0.43; PPC with labor OR: 0.69; 0.56-0.85).

Uterine rupture

The prevalence of uterine rupture in our low risk study population was 0.007% (8/122,578). No statistically significant association was found between uterine rupture and route of delivery.

Hysterectomy

The prevalence of emergent hysterectomy in our low risk study population was 0.007% (9/122,578). No statistically significant association was found between emergent hysterectomy and route of delivery.

Other morbidities

The following maternal outcomes were rare and did not undergo statistical analysis: pulmonary embolism (12 cases), shock (7 cases) and death (4 cases).

Neonatal Outcomes

Neonatal outcomes by route of delivery are shown below in Table 4. See appendix 2 for definition of neonatal outcomes and associated ICD-9 codes.

Table 4: Neonatal Outcomes According to Route of Delivery

	Number of cases	Absolute risk by route* (%)	Adjusted OR** (CI 95%)	P-value
CNS complications (n=201)				
PPC with labor	39	0.70	5.03 (3.52, 7.18)	< 0.001
PPC no labor	9	0.16	1.17 (0.6, 2.3)	0.646
Vaginal (reference)	153	0.14	1	
NICU admission (n=1632)				
PPC with labor	160	2.86	2.31 (1.96, 2.73)	< 0.001
PPC no labor	83	1.51	1.21 (0.97, 1.52)	0.095
Vaginal (reference)	1389	1.25	1	
Intracranial hemorrhage (n=38)				
PPC with labor	3	0.05	1.8 (0.55, 5.91)	0.332
PPC no labor	2	0.04	1.22 (0.29, 5.14)	0.782
Vaginal (reference)	33	0.03	1	
Sepsis (n=1738)				
PPC with labor	121	2.16	1.62 (1.35, 1.96)	< 0.001
PPC no labor	55	1.00	0.77 (0.59, 1.01)	0.059
Vaginal (reference)	1562	1.40	1	
All Respiratory Complications (n=5551)				
PPC with labor	424	7.57	1.75 (1.57, 1.97)	< 0.001
PPC no labor	297	5.41	1.23 (1.09, 1.4)	0.001
Vaginal (reference)	4830	4.33	1	
TTN (n=2155)				
PPC with labor	180	3.21	2.00 (1.71, 2.34)	< 0.001
PPC no labor	162	2.95	1.82 (1.55, 2.15)	< 0.001
Vaginal (reference)	1813	1.63	1	
RDS (n=263)				
PPC with labor	23	0.41	1.89 (1.23, 2.91)	0.004
PPC no labor	6	0.11	0.5 (0.22, 1.12)	0.092
Vaginal (reference)	234	0.21	1	
Other respiratory problems (n=3133)				
PPC with labor	221	3.94	1.56 (1.35, 1.79)	< 0.001
PPC no labor	129	2.35	0.9 (0.76, 1.08)	0.268
Vaginal (reference)	2783	2.50	1	

** Derived from route of delivery groups: PPC with labor=5,603;PPC no labor=5,486;Vaginal=111,486*
***Controlling for age, education, race and insurance payer.*

CNS complications

The prevalence of neonatal congenital CNS complications such as convulsions, cerebral irritability, coma and other abnormal cerebral signs in our low risk study population was 0.16% (201/122,578). Higher neonatal morbidity for CNS complications was associated with PPC in the presence of labor compared to vaginal delivery when controlling for age, race, education level and insurance (PPC with labor OR: 5.03; 3.52–7.18). However, no statistically significant association was found between CNS complications and PPC in the absence of labor.

NICU Admission

The prevalence of NICU admission in our low risk study population was 1.33% (1,632/122,578). Higher neonatal morbidity for NICU admission was associated with PPC in the presence of labor compared to vaginal delivery when controlling for age, race, education level and insurance (PPC with labor OR: 2.31; 1.96–2.73). However, no statistically significant association was found between NICU admission and PPC in the absence of labor.

Intracranial Hemorrhage

The prevalence of neonatal intracranial hemorrhage in our low risk study population was 0.031% (38/122,578). No statistically significant association was found between neonatal intracranial hemorrhage and route of delivery.

Sepsis

The prevalence of neonatal sepsis in our low risk study population was 1.42 % (1,738/122,578). Higher neonatal morbidity for sepsis was associated with PPC in the presence of labor compared to vaginal delivery when controlling for age, race, education level and insurance status (PPC with labor OR: 1.62; 1.35–1.96). No statistically significant association was found between neonatal sepsis and PPC in the absence of labor.

Respiratory Complications (all combined)

The prevalence of all respiratory complications combined (TTN, RDS, other respiratory problems) in our low risk study population was 4.53% (5,551/122,578). Higher neonatal morbidity for the composite outcome of all respiratory complications was associated with PPC, regardless of labor status, compared to vaginal delivery when controlling for age, race, education level and insurance status (PPC no labor OR: 1.23; 1.09-1.4; PPC with labor OR: 1.75; 1.57–1.97).

Transient Tachypnea of the Newborn (TTN)

The prevalence of TTN in our low risk study population was 1.76% (2,155/122,578). Higher neonatal morbidity for TTN was associated with PPC, regardless of labor status, compared to vaginal delivery when controlling for age, race, education level and insurance status (PPC no labor OR: 2.00; 1.71–2.34; PPC with labor OR: 1.82; 1.55–2.15).

Respiratory Distress Syndrome (RDS)

The prevalence of RDS in our low risk study population was 0.21% (263/122,578). Higher neonatal morbidity for RDS was associated with PPC in the presence of labor compared to vaginal delivery when controlling for age, race, education level and insurance status (PPC with labor OR: 1.89; 1.23–2.91). No statistically significant association was found between neonatal RDS and PPC in the absence of labor.

Other Respiratory Problems (ORP)

The prevalence of other respiratory complications such as congenital pneumonia, aspiration, interstitial emphysema, atelectasis and hypoxemia in our low risk study population was 2.56% (3,133/122,578). Higher neonatal morbidity for ORP was associated with PPC in the presence of labor compared to vaginal delivery when controlling for age, race, education level and insurance status (PPC with labor OR: 1.56; 1.35–1.79). No statistically significant association was found between neonatal ORP and PPC in the absence of labor.

Death

Neonatal death was rare and did not undergo statistical analysis (13 cases).

Chapter 4: Discussion

Our study of the morbidity of planned primary cesarean in a low risk primiparous population showed higher morbidity associated with planned primary cesarean when compared to vaginal delivery for nearly all maternal and neonatal outcomes examined. The absolute risk for all maternal morbidities combined was 7.99 percent for PPC versus 2.77 percent for vaginal delivery; the absolute risk for all neonatal morbidities combined was 21.45 percent for PPC versus 11.49 percent for vaginal delivery. The prevalence of maternal and neonatal morbidities in our low risk study population ranged from 0.007% for the rarest outcome of emergent hysterectomy to 4.5% for the most common outcome of neonatal respiratory problems. It is fortunate that maternal and neonatal morbidities are rare in labor and delivery, and even more so in our low risk population. [9, 16, 17, 22, 25-38] However, although adverse outcomes are rare, the higher maternal and neonatal morbidity associated with PPC is concerning and should guide clinicians in their counseling of low risk women to consider vaginal delivery over PPC.

Maternal Morbidity

Among our low risk primiparous women we found increased maternal morbidity for cardiac complications, major infections, and anesthetic complications associated with PPC regardless of labor. The current evidence regarding maternal anesthetic and cardiac complications in planned cesarean versus vaginal delivery is varied, although most support our findings of increased anesthetic and cardiac complications with planned cesarean over that of vaginal delivery. [16, 25, 26] It is alarming, however, that in a low risk population of women with no pre-existing cardiovascular disease that we found

marked increased morbidity for cardiac complications such as cardiac arrest, failure and acute myocardial infarction associated with PPC when compared to vaginal delivery. This finding warrants further research to better understand the association of PPC and cardiac complications.

We also found increased maternal morbidity for major infection associated with PPC, regardless of labor. Our results are consistent with the National Institutes of Health (NIH) review which found an increased risk of infection in the cesarean group, regardless of labor, over the vaginal group. [16] Furthermore, we found that PPC with labor has a greater association with infection when compared to PPC in the absence of labor. Consequently, in order to minimize infection risk, vaginal delivery is preferred; and should a PPC be necessitated, it is optimal to do so prior to the onset of labor.

Risk of uterine rupture and emergent hysterectomy were not statistically significant. The rarity of uterine rupture and emergent hysterectomy makes it challenging to draw firm conclusions regarding the risk of these outcomes associated with route of delivery. The absolute risk for uterine rupture or emergent hysterectomy is less than 0.05 percent irrespective of delivery route. This risk is so low that patients should be reassured that the probability of uterine rupture and emergent hysterectomy is rare. In addition, we would caution clinicians and patients in making decisions on preferred route of delivery based upon this outcome alone.

The exception to increased maternal morbidity associated with PPC was that of maternal hemorrhage and transfusion. We found lower morbidity for maternal hemorrhage and transfusion associated with PPC, regardless of labor. Postpartum hemorrhage (PPH) remains a leading cause of maternal mortality, with national statistics

suggesting that approximately 8% of pregnancy-related deaths are caused by PPH, ranking it in the top three causes of maternal mortality, along with embolism and hypertension. [39] In the past, most cases of intractable PPH followed vaginal delivery and were due to uterine atony; however, more recent case series and national databases have shown that more cases are now associated with cesarean delivery, with many patients having a diagnosis of placenta accreta. [40] However, these studies did not address planned cesarean, nor did they focus on low-risk women specifically. In the context of planned cesareans, nearly a dozen studies reviewed by the NIH are consistent with our findings and showed a lower risk of hemorrhage and transfusion among planned cesareans when compared to vaginal delivery; and also yielded evidence of lower risks of hemorrhage or transfusion in planned cesareans than in unplanned cesareans. [16, 17, 21]

Data from several sources indicate that the prevalence of PPH ranges from 1% to 13% depending upon labor management and population. [41, 42] In our study the prevalence of maternal hemorrhage and transfusion was 2.21%. Since we excluded women with placental abnormalities and hypertensive disorders, the lower prevalence is within expectations. [43] However, although the overall prevalence is decreased in our low risk population, hemorrhage and transfusion continue to pose the greatest absolute risk to the mother of all the maternal outcomes examined. Taken alone, these findings would suggest that we favor PPC in low risk primiparous women over vaginal delivery. However, when we consider the increased risk of other maternal outcomes in light of the decreased risk for hemorrhage and transfusion, we argue that any 'protective effect' that PPC may provide against hemorrhage and transfusion is overridden by the increased risks for cardiac and anesthetic complications, and major infection.

Neonatal Morbidity

Similar to maternal outcomes, we observed higher neonatal morbidity for many outcomes associated with PPC, particularly PPC with labor. Higher neonatal morbidity for TTN was associated with PPC, regardless of labor; and increased neonatal morbidity for CNS complications, NICU admission, sepsis, RDS and other respiratory problems was associated with PPC with labor. The most widely documented short-term neonatal risks associated with cesarean delivery are respiratory disorders, specifically increased risks of TTN and RDS over that of vaginal delivery. [9, 44] The prevalence of TTN, RDS and other respiratory morbidities among term deliveries (> 37 weeks) ranges from 0.4% to 12.4% and is highly dependent upon route of delivery [7-9, 22, 29, 34, 45-47]. The evidence demonstrates an increasing risk of respiratory morbidity with cesarean delivery when compared to vaginal delivery. This holds true not only for cesareans of pre-term infants (less than 37 weeks gestation), but also for cesarean delivery of full-term infants. [44, 48] Most recently, a study by Zanardo et. al. demonstrated that the neonatal respiratory morbidity risk for RDS and TTN was significantly higher in the planned cesarean group than the vaginal delivery group. [9] Our findings of increased morbidity for TTN, RDS and other respiratory complications associated with PPC are consistent with literature to date.

Study Strengths

This was a very large population based study which provides important information characterizing the role and impact of PPC among low risk primiparous women. Few studies have defined the planned cesarean population, and even fewer have addressed outcomes for both mother and infant within the same study population. Additionally, we used a formal procedure developed by Gregory et al. to identify planned cesarean cases and labor status. [15, 18, 49] The Gregory model has been validated on a large study population and examined for clinical validity. We also focused our efforts specifically on a low risk population, which allowed us to more appropriately examine the association between delivery route and maternal and neonatal morbidity. Excluding women with pre-existing conditions and modifying the Gregory et al. method for identifying PPC cases allowed us to capture as healthy women as possible in our study population; thus we were able to focus on delivery route as the exposure and minimize potential confounders.

We also examined the role of labor in the context of primary cesarean to better model the actual sequelae of events a pregnant woman may experience. Perhaps one of the most important strengths of our study is the generalizability of the findings. The data was derived from hospital discharge information in California, an extremely diverse state, and one which accounts for over 15 percent of all the deliveries in the United States. This is perhaps one of the larger populations on which a PPC study has been conducted to date. Furthermore, the accuracy of the OSHPD data on discharge diagnoses has been continuously reviewed and validated. [50] Lastly, we defined our outcomes narrowly, which enabled us to more accurately interpret our findings and draw firmer conclusions.

Limitations

As with all studies which use administrative data, there may be a lack of sensitivity with administrative codes (e.g. ICD-9 and DRG) or inconsistencies with coding guidelines between hospitals. Another potential limitation is that there may be differences or co-morbidities in the groups that are not observable in the recorded data; and, if such differences do exist the estimates may be biased. However, our study is less vulnerable to such biases as our population consisted of low risk women with few co-morbid conditions, thereby minimizing the possibility for bias. Although our study population was large, many of our outcomes were rare events. There is some debate about the most appropriate procedure for modeling rare events, with some favoring multivariable logistic regression as we used; whereas others favoring rare event logistic regression which proponents argue is less likely to underestimate the probability of rare events. Lastly, instrumental vaginal delivery is associated with the highest rate of short-term maternal and neonatal complications, even when compared to planned cesarean section and cesarean section during labor. [22] Our study did not distinguish between instrumental vaginal delivery and unassisted vaginal delivery. However, with less than five percent of all births using forceps or vacuum, it is unlikely that this small sub-population significantly influenced our findings. [1]

Chapter 5: Conclusion

Lowering the cesarean rate in the United States has been a goal for the past several decades, with increased emphasis in the past decade by the National Institutes of Health and Healthy People 2000 and 2010 initiatives. In this large population of low risk primiparous women at term, the risks of maternal and neonatal morbidity were higher for planned cesarean delivery compared to vaginal delivery, with the exception of maternal hemorrhage and transfusion. Our findings suggest that vaginal delivery has lower maternal and neonatal morbidity among low risk primiparous women when compared to planned cesarean, regardless of labor. And for those women who do undergo PPC, maternal morbidities are increased when labor is present; however, labor provides both benefit and risk to the neonate in the context of PPC.

In view of these findings, it is concerning that the rate of planned primary cesarean continues to rise. It is well known that route of delivery has both short-term and long-term impacts for mother and infant; and although long-term outcomes were outside the scope of our study, the findings on short-term outcomes favor vaginal delivery for safety. It is important that patients and clinicians make decisions based on the evidence and not be driven by emotion or cultural values. Therefore, we emphasize limiting PPC within the low risk primiparous population to situations with proven benefit to mother and infant. Clinicians should take care in educating their low risk primiparous patients that increased maternal and neonatal morbidity is associated with PPC, and that vaginal delivery should be attempted when possible. When a PPC is chosen, the operation should be close to term as possible to minimize neonatal respiratory morbidity, and because the benefits and/or risks of labor in the context of PPC remain unclear.

There are many opportunities to build upon the growing breadth of literature on PPC. Specifically, future studies which further elucidated the role of labor in maternal and neonatal morbidities would be helpful in determining the timing of performing a planned cesarean. We must better understand the trade-off of earlier intervention of PPC to avoid the risks of labor, yet as delayed intervention as possible to allow for fetal lung maturity.

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Appendix 1: Maternal outcomes as defined by grouping of ICD-9 codes

MATERNAL Outcomes & ICD-9 Codes	Explanation of ICD-9 Codes
Cardiac complications	
6681 (includes 66810-66814)	cardiac complications (arrest or failure following anesthesia or in L&D)
6694 (includes 66940-66944)	other complications of obstetrical surgery and procedures: arrest following c/s or obstetrical surgery or delivery, failure following c/s or obstetrical surgery or delivery, NOS cardiac complication
410 (includes 4100-4110)	acute myocardial infarction (different codes designate varying areas of heart, e.g. anterolateral wall)
Major Infection	
670 (6700-6704; 67000-67004)	major puerperal infection following delivery: endometritis, fever (septic), pelvic cellulitis/sepsis, peritonitis, pyemia, salpingitis, septicemia
615	Inflammatory diseases of uterus, except cervix
6150	acute
6159	unspecified inflammatory disease of uterus: endometritis, endomyometritis, metritis, myometritis, perimetritis, pyometra, uterine abscess
6741 (67410, 67412, 67414)	disruption of cesarean wound: dehiscence or disruption of uterine wound
6742	disruption of perineal wound
67420	breakdown of perineum
67422	disruption of wound of: episotomy, perineal laceration
67424	secondary perineal tear
6743	other complications of obstetrical surgical wounds
67430	hematoma of c/s wound or perineal wound
67432	hemorrhage of c/s wound or perineal wound
67434	infection of c/s or perineal wound
Uterine Rupture	
6650 (includes 66500-66503)	rupture of uterus before onset of labor
6651 (includes 66510, 66511)	rupture of uterus during labor
Hysterectomy	
683 (includes 6831, 6839)	subtotal abdominal hysterectomy
684 (includes 6841, 6849)	Total abdominal hysterectomy
685 (includes 6851, 6859)	vaginal hysterectomy
686 (includes 6861, 6869)	radical abdominal hysterectomy
687 (includes 6871, 6879)	radical vaginal hysterectomy
689 (includes 6891, 6899)	other and unspecified hysterectomy
Anesthetic complications	
668	complications of administration of anesthetic or other sedation during L&D
6680 (includes 66800-66814)	pulmonary complications: aspiration, medelson's syndrome, pressure collapse of lung, etc.
6682 (includes 66820-66824)	central nervous system complications: cerebral anoxia
6688 (includes 66880-66884)	other complications of anesthesia or other sedation in L&D
6689 (includes 66890-66894)	unspecified complications of anesthesia and other sedation
Hemorrhage & Transfusion	
666	postpartum hemorrhage
6660 (includes 66600-66604)	third stage: associated with retained or trapped placenta, atonic
6661 (includes 66610-66614)	other immediate postpartum hemorrhage
6662 (includes 66620-66624)	delayed secondary postpartum hemorrhage
990 (includes 9900-9909)	Transfusion of blood and blood components
Pulmonary embolism	
673	Obstetrical pulmonary embolism: in pregnancy, childbirth, puerperium
6730 (includes 67301-67304)	obstetrical air embolism
6731 (includes 67311-67314)	amniotic fluid embolism
6732 (includes 67321-67324)	obstetrical blood-clot embolism
6733 (includes 67331-67334)	obstetrical pyemic and septic embolism
6738 (includes 67381-67384)	fat embolsim
Shock	
6691 (includes 66910-66914)	shock during or following labor and delivery
Death	
6749 (includes 67490, 67492, 67494)	sudden death of unknown cause during the pueriperium
6689	unspecified complication of anesthesia: death
6699	unspecified complication of labor and delivery: death

Appendix 2: Infant outcomes as defined by grouping of ICD-9 codes

INFANT Outcomes & ICD-9 Codes	Explanation of ICD-9 Codes
CNS problems	
7790	convulsions of newborn
7791	other and unspecified cerebral irritability of newborn
7792	cerebral depression, coma, and other abnormal cerebral signs
Intracranial Hemorrhage	
7670	subdural and cerebral hemorrhage
772	fetal and neonatal hemorrhage
7721	intraventricular hemorrahge
77210	unspecified grade
77211- 77214	grade I, grade II, grade III, grade IV
7722	subarachnoid hemorrhage
Sepsis	
7718	other infections specific to the perinatal period
77181	septicemia of newborn
77182	urinary tract infection of newborn
77183	bacteremia of newborn
77189	other infections specific to the perinatal period
All Respiratory Problems	includes codes from TTN, RDS and other categories
TTN	
7706	Transitory tachypnea of newborn
RDS	
769	Respiratory distress syndrome
Other respiratory problems	
770	other respiratory conditions of fetus and newborn
7700	congenital pneumonia
7701	fetal and newborn aspiration
77010	fetal and newborn aspiration, unspecified
77012	meconium aspiration with respiratory symptoms
77014	aspiration of clear amniotic fluid with respiratory symptoms
77016	aspiration of blood with respiratory symptoms
77018	other fetal and newborn aspiration with respiratory symptoms
7702	interstitial emphysema and related conditions
7704	primary atelectasis
7705	other and unspecified atelectasis
7708	other respiratory problems after birth
77081	primary apnea of newborn
77082	other apnea of newborn
77083	cyanotic attacks of newborn
77084	Respiratory failure of newborn
77086	aspiration of postnatal stomach contents with respiratory symptoms
77087	Respiratory arrest of newborn
77088	hypoxemia of newborn
77089	other respiratory problems after birth
Death	
7681	fetal death from asphyxia or anoxia during labor
7799	neonatal death
798	sudden death, cause unknown
7981	instantaneous death
7982	death occurring less than 24 hrs onset symptoms
7989	unattended death