

Study of 2014 birth data confirms risk factors for cesarean birth for nulliparous women at term carrying a singleton baby in vertex presentation

Gustavo San Román, M.D., F.A.C.O.G.
5225-70 Route 347
Port Jefferson Station, New York 11776

Objective

To confirm risk factors for cesarean birth in nulliparous women.

Methods

United States birth certificate records from 1.1 million nulliparous women who labored with a singleton pregnancy in vertex presentation and gave birth at term in 2014 were obtained and analyzed for previously proven risk factors for cesarean birth. An example patient is created and followed through five stages in order to demonstrate the impact of induction of labor, maternal age, prepregnancy body mass index, maternal weight gain and newborn weight on outcome.

Results

Induction of labor, maternal age, prepregnancy body mass index, maternal weight gain, newborn weight, maternal height and gestational age all had a significant impact on outcome for nulliparous women who labored with a term singleton pregnancy in vertex presentation.

Conclusion

Seven previously proven risk factors are confirmed in this study.

Introduction

The concern over the rapid increase in cesarean birth rates from 1996 to 2011 in the United States has prompted the American College of Obstetricians and Gynecologist (ACOG) and the Society for Maternal-Fetal Medicine to publish an obstetric care consensus on the safe prevention of the primary cesarean delivery (1). The focus of the consensus is to address changes that can be made by the obstetrical care provider and includes the statement that “Before 41 0/7 weeks of gestation, induction of labor generally should be performed based on maternal and fetal medical indications”.

The consensus also addresses one change that can be made by the patient and that is to avoid excessive maternal weight gain. The consensus references prior studies that suggest that women who gain more weight than recommended have an increased risk of cesarean birth (2, 3).

The current study is a retrospective analysis which seeks to confirm that there are other maternal physical characteristics in addition to maternal weight gain that affect the rate of cesarean birth. The current analysis is limited to nulliparous women who give birth at term with a singleton pregnancy in vertex presentation (commonly referred to as NTSV births). Other maternal physical characteristics have been previously reported to affect the risk of cesarean birth (4-15). Of these previously reported physical characteristics, maternal age, prepregnancy body mass index (BMI), maternal weight gain, newborn weight, maternal height and gestational age were chosen for this study because they are all objective and are typically recorded for every pregnancy. This study confirms the significant impact on outcome that maternal physical characteristics, newborn weight and induction of labor have on the risk of cesarean birth for women who labor with an NTSV pregnancy.

Materials and methods

The publicly available 2014 Natality Public Use File was downloaded from the National Center for Health Statistics website for the purpose of statistical reporting and analysis and was exempt from Institutional Review Board review (16). United States birth data available in this file represent all births registered in the 50 States, the District of Columbia, and New York City. The Centers for Disease Control and Prevention’s National Center for Health Statistics (NCHS) receives these data as electronic files, prepared from individual records processed by each registration area, through the Vital Statistics Cooperative Program. The file contains non-identifiable birth data for 3,998,175 births that occurred in 2014.

In order to study the effect of women's physical characteristics on the risk of cesarean birth for first time mothers who gave birth at term with a single baby in vertex presentation the birth records that did not meet these criteria were removed from the dataset using the fields for Live Birth Order, Obstetric Estimated Gestational Age, Plurality and Fetal Presentation. This resulted in 1,299,954 birth records that met the criteria for being nulliparous, term, singleton and vertex (NTSV births). Of the 1,299,954 NTSV birth records there were 98,838 birth records that were missing one or more of the characteristics required for analysis. This resulted in 1,201,116 complete NTSV birth records for analysis. The cesarean birth rate for these records as well as the cesarean birth rate by maternal age group for these records was compared to the results published in the National Vital Statistics Final Report for 2014.

The effect of physical characteristics as well as the effect of induction of labor can be distorted by birth records from women who did not attempt labor. Therefore, the analysis was limited to only complete NTSV birth records from women who labored. There were 87,993 birth records from women who had a cesarean birth but did not attempt labor as noted in the fields for Trial of Labor Attempted, Induction of Labor and Augmentation of Labor. This resulted in 1,113,123 complete NTSV birth records from women who attempted labor. Statistical analysis was performed using IBM SPSS Statistics for Windows version 23 (IBM Corporation, Armonk, NY, United States). Risk factors were analyzed using multivariate logistic regression analysis.

Analysis included the creation of an example patient. Cesarean birth rates were analyzed with the example patient being older, heavier, having increased weight gain and increased newborn weight. Spontaneous and induced labors were analyzed separately.

Results

Characteristics of the original data file are displayed in table 1. Analysis of the 1,201,116 complete NTSV birth records revealed a cesarean birth rate of 25.8%. Table 2 demonstrates that both the total cesarean birth rate and the cesarean birth rates by age groups were similar to the cesarean birth rates published by the National Center for Health Statistics (NCHS) for 2014 (17). The overall cesarean birth rate for the 1,113,123 complete NTSV birth records with labor attempted was 19.9%. The cesarean birth rate for complete NTSV birth records that had spontaneous onset of labor was 14.5%. Induction of labor more than doubled that rate to 30.5% as shown in table 3

($p = <0.001$). The effect of each risk factor on the rate of cesarean birth for the 1,113,123 complete NTSV birth records with labor attempted is illustrated in figures 1 through 6 and table 4.

Both newborn weight and maternal weight gain did not exhibit a linear progression throughout the reported ranges. However, when the other covariates were included in the analysis of birth records where the maternal weight gain was less than 25 pounds the result was that increasing maternal weight gain increased the risk of a cesarean birth but with less effect than when the maternal weight gain was over 25 pounds as shown in table 4. Induction of labor, increasing maternal age, increasing prepregnancy BMI, increasing maternal weight gain, decreasing newborn weight when less than 2800 grams, increasing newborn weight when greater than 2800 grams, decreasing maternal height and longer gestations significantly affected the risk of a cesarean birth.

Table 5 represents an example patient as the example patient gets older, heavier, has increased maternal weight gain and with an increase in newborn weight. At each stage the rate of cesarean birth was significantly greater if the patient was induced ($p = < 0.001$). For this example patient the increase in the rate of cesarean birth from stage to stage for both spontaneous and induced onset of labor was significant ($p = <0.001$). Table 5 demonstrates that if the example patient delays her first birth from around age 22 (Stage 1) to around age 32 (Stage 2) that the risk of cesarean birth increases by almost 50% from 8.76% to 12.87% when the onset of labor was spontaneous. The risk of a cesarean birth increases by an additional 35% to 17.33% if the example patient increases her prepregnancy BMI by gaining around 28 pounds from age 22 to age 32 (Stage 3). The risk of a cesarean birth increases to 20.36% if she gains an additional 20 pounds during pregnancy (Stage 4) and the risk increases further to 26.17% with a one pound increase in newborn weight (Stage 5). Induction of labor increases the risk of a cesarean birth significantly further reaching 43.82% (Stage 5). The Stage 5 example patient's physical characteristics have an average of 5 foot 5 inches in height, 32 years of age, 170 pounds in prepregnancy weight, 45 pound weight gain during pregnancy, a newborn weight of 8 pounds 3 ounces and birth between 39 and 40 weeks.

Table 1 – Data File Characteristics

Total Birth Records	3,998,175
Unknown Parity	21,574
Multiparous	2,423,144
Unknown Weeks	784

< 37 or > 42 Weeks	141,461
Multiple Gestation	12,823
Unknown Presentation	31,317
Non-Vertex Presentation	67,118
Total NTSV Birth Records	1,299,954
Missing Induction Yes/No	376
Missing Maternal Height	64,355
Missing Maternal Prepregnancy Weight	22,744
Missing Maternal Weight at Birth	10,926
Missing Newborn Weight	257
Missing Route of Birth	180
Complete NTSV Birth Records	1,201,116
Number of Cesarean Births	309,431
Cesarean Birth Rate	25.8%
Birth records without labor attempt	87,993
Complete NTSV Birth Records with Labor Attempted	1,113,123

Table 2 – Comparison of Complete NTSV Birth Records to National Vital Statistics Final Published Report

	This Study	Final Published Results for 2014
Cesarean Birth Rate	25.8%	26.0%
Cesarean Birth Rate by Maternal Age		
Age < 20	17.4%	17.4%
20-24	22.5%	22.6%
25-29	25.8%	25.9%
30-34	30.1%	30.4%
35-39	39.1%	39.4%
40 and Over	52.3%	52.7%

Table 3 – Cesarean birth rate by onset of labor

Complete NTSV Birth Records with Labor Attempted	1,113,123
Number of Cesarean Births	221,438
Overall Cesarean Birth Rate	19.9%
Complete NTSV Birth Records with Spontaneous onset of Labor	738,048
Number of Cesarean Births	106,864
Cesarean Birth Rate	14.5%
Complete NTSV Birth Records with Induced onset of labor	375,075
Number of Cesarean Births	114,574
Cesarean Birth Rate	30.5%

Table 4 - Adjusted odds ratio progression of cesarean birth for nulliparous women

Physical characteristic	Step Size	Induced Labor Odds Ratio (95% CI)	Spontaneous Labor Odds Ratio (95% CI)
Onset of labor		2.324 (2.301-2.348)	0.430 (0.426-0.435)
Maternal age	Every 3 years older	1.181 (1.177-1.186)	1.181 (1.177-1.186)
Prepregnancy body mass index (BMI)	Every 3 kg/m ² increase	1.212 (1.208-1.216)	1.215 (1.211-1.219)
Maternal weight gain when > 25 lbs.	Every 5 lbs. more	1.071 (1.067-1.074)	1.081 (1.078-1.085)
Maternal weight gain when <= 25 lbs.	Every 5 lbs. more	1.047 (1.038-1.057)	1.032 (1.024-1.041)
Newborn weight when <= 2800 g	Every 200 g smaller	1.217 (1.190-1.242)	1.193 (1.168-1.221)
Newborn weight when > 2800 g	Every 200 g larger	1.149 (1.144-1.154)	1.192 (1.188-1.197)
Maternal height	Every inch shorter	1.138 (1.134-1.140)	1.153 (1.151-1.157)
Gestational age	Every week longer	1.049 (1.041-1.056)	1.094 (1.086-1.101)

Table 5 – Example Patient

Example Patient	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
	Younger	Older	Older and heavier	Older, heavier with increased weight gain	Older, heavier with increased weight gain and increased newborn weight
	Range (Average Spont./Induced)	Range (Average Spont./Induced)	Range (Average Spont./Induced)	Range (Average Spont./Induced)	Range (Average Spont./Induced)
Maternal Age in years	Between 20 and 25 (22.4/22.4)	Between 30 and 35 (32.0/32.0)	Between 30 and 35 (32.0/32.0)	Between 30 and 35 (32.0/32.0)	Between 30 and 35 (31.9/32.0)
Prepregnancy BMI in kg/m ²	Between 20 and 30 (23.7/24.3)	Between 20 and 30 (23.3/23.8)	Between 25 and 35 (28.1/28.7)	Between 25 and 35 (27.7/28.2)	Between 25 and 35 (27.7/28.2)
Maternal Weight Gain in pounds	Between 20 and 30 (25.5/25.6)	Between 20 and 30 (25.7/25.7)	Between 20 and 30 (25.3/25.4)	Between 35 and 75 (44.5/45.8)	Between 35 and 75 (45.4/46.5)
Infant Weight in grams	Between 3000 and 3500 (3242/3254)	Between 3000 and 3500 (3250/3257)	Between 3000 and 3500 (3258/3264)	Between 3000 and 3500 (3273/3278)	Between 3500 and 4000 (3724/3729)
Height in inches	ALL (63.6/63.8)	ALL (64.3/64.2)	ALL (64.2/64.2)	ALL (64.7/64.7)	ALL (65.4/65.2)
Gestational Age in weeks	ALL (39.1/39.5)	ALL (39.2/39.5)	ALL (39.1/39.4)	ALL (39.2/39.3)	ALL (39.5/39.8)
Number of birth records with spontaneous labor	25,950	19,593	7,294	7,950	7,353
Cesarean Birth Rate	8.76%	12.87%	17.33%	20.36%	26.17%
Number of birth records with induced labor	9,867	6,747	3,537	4,934	4,968
Cesarean Birth Rate	20.19%	27.27%	34.24%	38.35%	43.82%
Number of birth records for all labors	35,817	26,340	10,831	12,884	12,321
Cesarean Birth Rate	11.90%	16.56%	22.85%	27.25%	33.28%

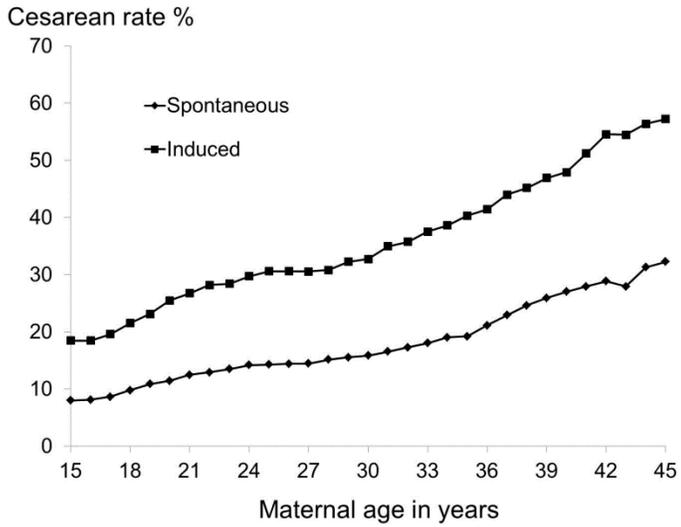


Figure 1 – Effect of maternal age

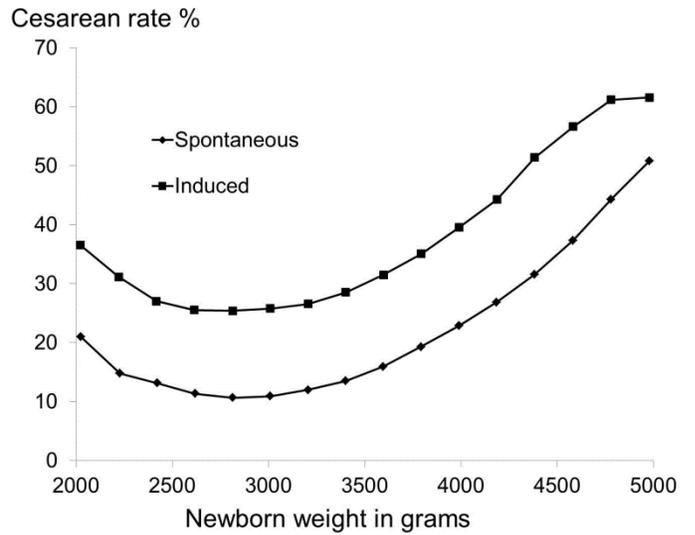


Figure 4 – Effect of Newborn weight

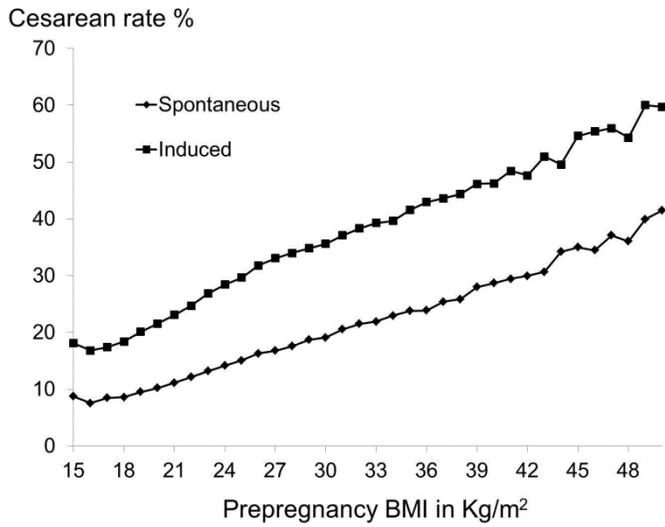


Figure 2 – Effect of prepregnancy body mass index

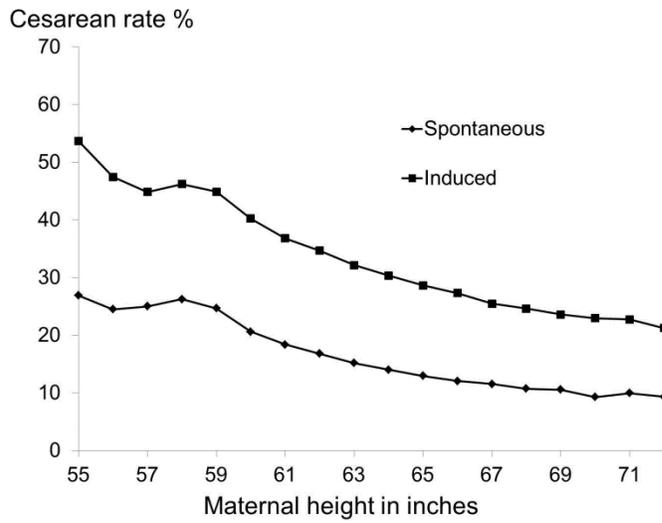


Figure 5 – Effect of maternal height

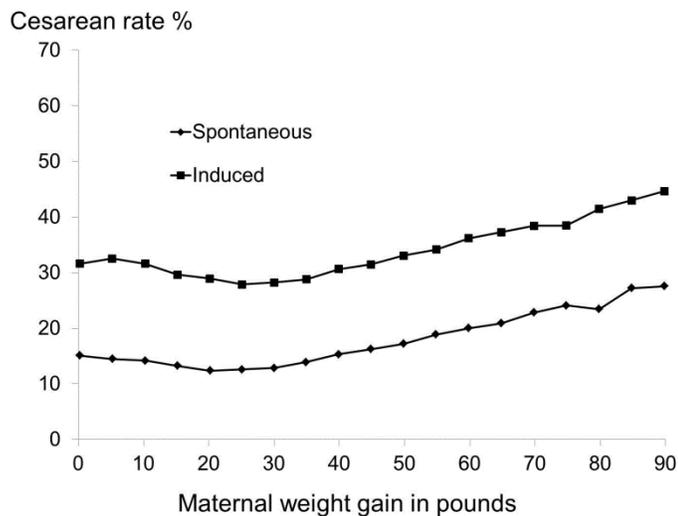


Figure 3 – Effect of maternal weight gain

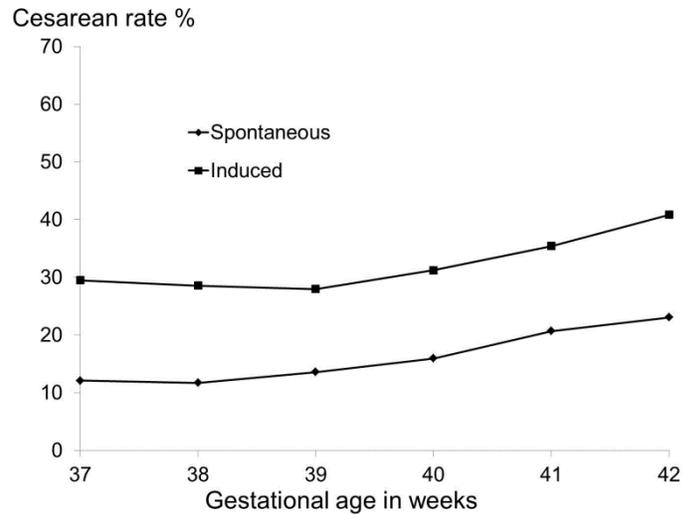


Figure 6 – Effect of gestational age

Discussion

This study confirms that maternal physical characteristics, newborn weight and induction of labor significantly affect the risk that labor will result in a cesarean birth for NTSV births.

Other studies have demonstrated that the hospital and the obstetrical care provider can also have an effect on the risk of cesarean birth (7, 14, 15, 18-20). The results obtained for the example patient in table 5 of this study represent an averaging of the effect due to the hospital and the obstetrical care provider. In order to accurately assess the effect of the hospital or the obstetrical care provider on the risk of cesarean birth a study must provide risk adjustment for all seven risk factors confirmed in this study. For example, table 5 reveals that without risk adjustment, a hospital or obstetrical care provider who has older, heavier patients who give birth to babies with above average newborn weight and have more medical indications for induction of labor could have a cesarean birth rate that is more than 20 percentage points greater (33.28% vs. 11.90%) than a hospital or obstetrical care provider who has younger thinner patients who are giving birth to babies with average newborn weight even though the same average effect is being applied. Therefore, it is not possible for nulliparous women to interpret the effect of the hospital or obstetrical care provider using publically reported cesarean birth rates that do not provide risk adjustment.

Healthy People 2020 has set a target cesarean birth rate for NTSV births of 23.9% for the nation (21). Comparing their target to the current study is complicated by the fact that in the current study 87,993 (7.3%) birth records were removed before analysis because these births did not attempt labor whereas Healthy People 2020 uses all NTSV births for their target. If the records of women who did not attempt labor were included in the current study then the cesarean birth rates for the example patient (table 5) would be higher.

The Healthy People 2020 national target represents an average for the entire nation. Unfortunately some organizations have misinterpreted this national target as a target rate to be achieved by each and every hospital (22-24). The example patient in table 5 of this study reveals that a hospital or obstetrical care provider with a patient population similar to that found in table 5; stage 5 can have an NTSV cesarean birth rate of over 30% even though they are providing an average effect on the rate of cesarean birth. This is confirmed by the data published in the National Vital Statistics Report (table 2) which demonstrates that NTSV births to women over the age of 30 nationwide had a cesarean birth rate of over 30%. Therefore, it is not possible for nulliparous women to interpret the comparison of their hospital's or obstetrical care provider's unadjusted NTSV cesarean birth rate to the national target of 23.9%.

Furthermore, publically reported unadjusted NTSV cesarean birth rates can confuse nulliparous women into thinking that their risk of labor resulting in a cesarean birth is not at all related to their physical characteristics, the weight of their baby or whether or not the onset of labor is induced. Nulliparous women should be educated to understand that labor is a physical process and that this physical process is significantly affected by their physical characteristics, the weight of their baby and whether or not labor is induced.

The strength in this study is due to the large number of birth records representing births from across the United States. A weakness of this study could be the validity of the data obtained from birth certificates. However, this is a concern that was addressed in a National Vital Statistics Report from 2013 (25). That report compared the birth certificate data elements to the results found in the medical record in two states and found excellent agreement (> 90%) for parity, gestational age, vertex presentation, fetal birth weight and cesarean birth in both states. They found substantial agreement (75%-89.9%) for induction of labor and trial of labor. Many other data elements were found to have low or extremely low agreement but none of the elements with low or extremely low agreement were required for the current study. Unfortunately, there were 98,838 (7.6%) birth records that were missing data elements and were therefore removed from the dataset before analysis. The NCHS is currently working towards improving data collection and quality. The American College of Obstetricians and Gynecologists has a "revitalize" campaign that may improve the future quality of birth certificate obstetric data (26). Future studies will benefit from these efforts.

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