

Can nulliparous women who labor decrease their risk of a cesarean birth?

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

Background

Labor is a physical process and the risk that this physical process will result in a cesarean birth is significantly affected by a woman's physical characteristics, the size of her baby as well as the labor management strategies used by her obstetrical care provider.

Objective

To discover risk factors that can be changed in order to decrease the risk that labor will result in a cesarean birth.

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 maternal age, prepregnancy body mass index, maternal weight gain, newborn weight and induction of labor on outcome.

Results

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

Conclusion

Of the seven risk factors confirmed in this study, all except maternal height and gestational age can be changed to some extent. Nulliparous women can decrease their risk of a cesarean birth by planning to give birth at a younger age and by maintaining a normal prepregnancy body mass index. Once nulliparous women are pregnant they can decrease their risk of a cesarean birth by limiting maternal weight gain, by avoiding induction of labor and by obtaining early prenatal care for the screening and treatment of conditions like hypertension and diabetes which can affect newborn weight.

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 delivery¹. The focus of the consensus is to address changes that can be made by the obstetrical care provider and includes a strong recommendation with a high quality of evidence that "Before 41 0/7 weeks of gestation, induction of labor generally should be performed based on maternal and fetal medical indications". The consensus addresses one change that can be made by the patient and that is to avoid excessive maternal weight gain. The consensus references prior studies^{2,3} that suggest that women who gain more weight than recommended have an increased risk of cesarean birth.

Due to the concern that induction of labor has erroneously been compared to spontaneous labor in the past the consensus makes reference to studies⁴⁻¹¹ that compare induction of labor to expectant management. Unfortunately, most of the retrospective studies referenced did not address Bishop score or maternal physical characteristics and therefore may suffer from bias due to the possibility that obstetrical care providers are more likely to induce women who have a favorable Bishop score or women that have favorable physical characteristics but would be more likely to select expectant management for women with unfavorable Bishop scores or less favorable physical characteristics.

A recent randomized trial by Walker et al,¹² that was limited to 619 nulliparous women over the age of 35 claims that "induction of labor at 39 weeks of gestation, as compared with expectant management, had no significant effect on the rate of cesarean section". In order to come to this conclusion the authors used an "intention-to-treat analysis" because 20% of the patients in the induction group went into spontaneous labor prior to being induced. It is concerning that the authors failed to provide the cesarean birth rate for the 80% of patients that were actually induced. Also of concern is that 49% of the patients in the expectant

management group were induced. Having such a high induction rate in the expectant management group and limiting the study to only women over the age of 35 makes it difficult to generalize the results of this study to other obstetrical care providers or to younger mothers.

However, a recent small randomized controlled trial by Miller et al,¹³ comparing induction of labor with expectant management of nulliparous women at 39 weeks gestation with a Bishop score of less than 5 revealed a cesarean birth rate of 17.7% for the expectant management group and a 30.5% rate for the induced group. These results were very similar to that of Osmundson et al,⁹ but neither study reached a statistically significant difference due to their small sample sizes (N=161 and N= 204).

The current study is a retrospective analysis which seeks to discover if there are other physical characteristics in addition to maternal weight gain that can be changed in order to decrease the risk that labor will result in a cesarean birth. The current analysis is limited to nulliparous women who labor and give birth at term with a singleton pregnancy in vertex presentation (commonly referred to as NTSV births). Many physical characteristics have been previously reported¹⁴⁻²⁵ to affect the rate of cesarean birth. 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 seeks to discover the impact on outcome that maternal physical characteristics, newborn weight and induction of labor have on the rate of cesarean birth for women who labor with an NTSV pregnancy.

Materials and methods

The publicly available 2014 Natality Public Use File²⁶ 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. United States birth data available in this file represent all births that occurred within the United States in 2014. 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 rate 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 showing the results as the example patient gets older, heavier, has 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 rates published by the National Center for Health Statistics (NCHS) for 2014.²⁷ 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%. Women who underwent induction of labor had more than twice the cesarean birth rate (30.5%) when compared to women with spontaneous labor as shown in table 3 ($p = <0.001$). The association of each risk factor to 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.

The adjusted odds ratios illustrated in table 4 reveal that 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 were associated with a higher rate of 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 rate of cesarean birth increases by almost 50% from 8.76% to 12.87% when the onset of labor was spontaneous. The rate 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 rate of a cesarean birth increases to 20.36% if the

example patient 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 rate 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%

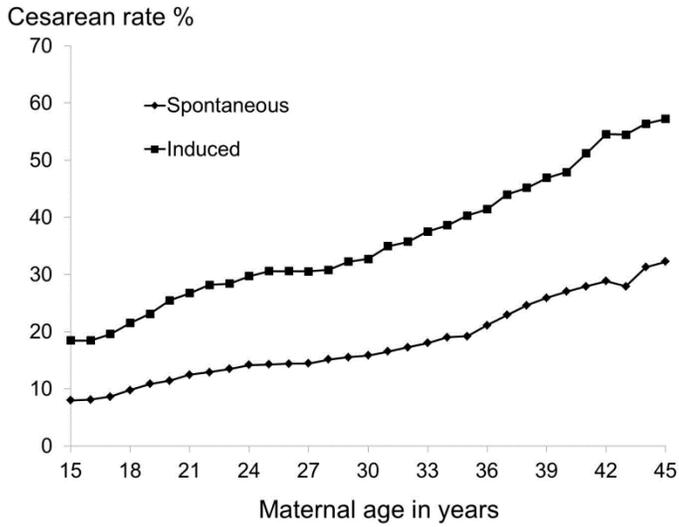


Figure 1 – Maternal age

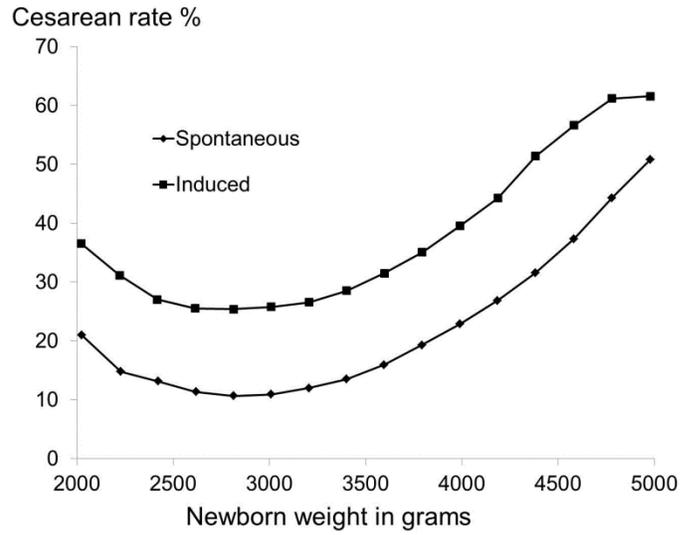


Figure 4 – Newborn weight

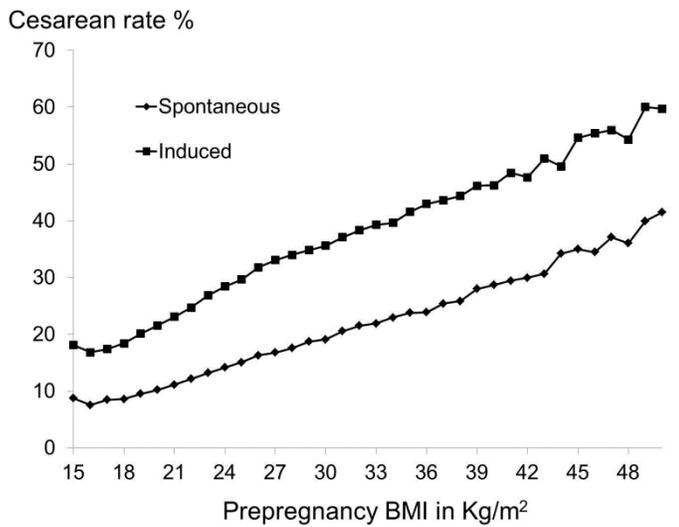


Figure 2 – Prepregnancy body mass index

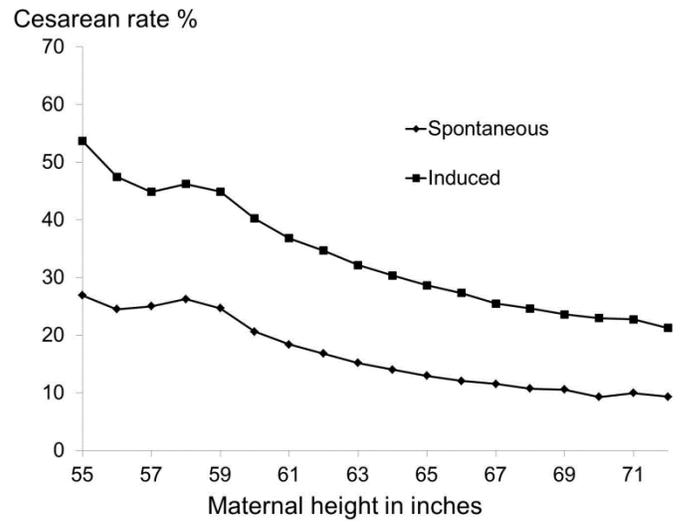


Figure 5 – Maternal height

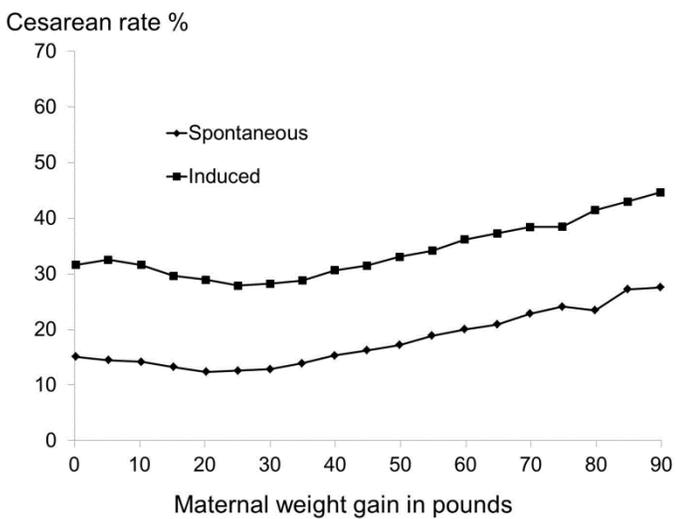


Figure 3 – Maternal weight gain

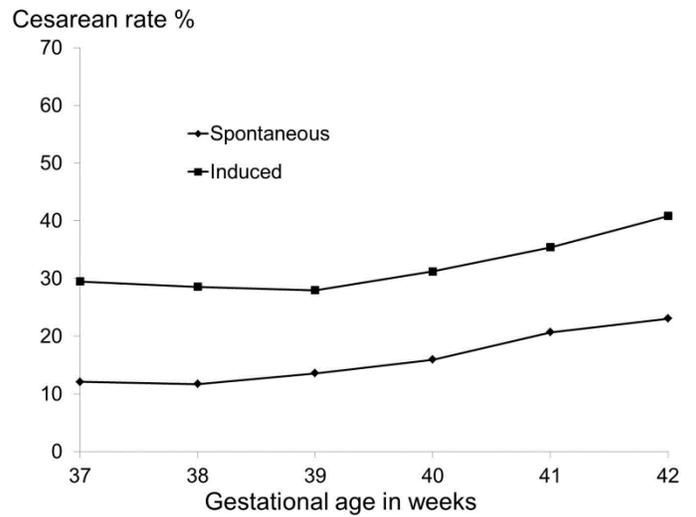


Figure 6 – Gestational age

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%

Discussion

This study confirms that maternal physical characteristics, newborn weight and induction of labor are significantly associated with the NTSV cesarean birth rate for women who labor. Of the seven risk factors analyzed in this study only maternal height and gestational age cannot be changed. The information gained from this study can be used to help obstetrical care providers and nulliparous women to make informed decisions regarding birthing plans as well as to help to interpret publically reported cesarean birth rates and targets.

The example patient in table 5 illustrates that even when the onset of labor is spontaneous women who are older, heavier and gain more weight than recommended will have more than two times the rate of cesarean birth than women who are younger, thinner and gain the recommended amount of weight (20.36% vs 8.76%). The increase in rate reaches 26.17% if the baby is one pound larger and 43.82% if labor is induced. Therefore, it follows that nulliparous women can decrease their risk of a cesarean birth by having their first birth at the youngest age feasible, maintaining a normal prepregnancy BMI, limiting their pregnancy weight gain, avoiding induction of labor and by getting early prenatal care so that medical conditions like hypertension and diabetes can be diagnosed and treated early so as to avoid a newborn weight below 2800 grams (like can occur with hypertension) or an increased newborn weight (like can occur with diabetes).

The seven risk factors analyzed in this study may help to explain the observation that conditions like gestational diabetes and hypertension are thought to increase the risk of cesarean birth. These conditions were specifically omitted from this study because there is no known pathophysiology as to how these conditions themselves affect the physical process of labor. However, women with these conditions are more likely to be induced with an unfavorable cervix and women with these conditions are also more likely to have physical characteristics (BMI, maternal age, maternal weight gain, fetal weight) that are more likely to result in cesarean birth than women without these conditions.

Other studies^{17, 24, 25, 28-30} have demonstrated that the hospital and the obstetrical care provider can also have an effect on the rate of cesarean birth. The results obtained for the example patient in table 5 of this study represent an averaging of the effect attributed to the labor management strategies employed since the results were obtained from births across the nation. If one's goal is to accurately assess the effect of labor management strategies on the rate of cesarean birth then one 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 who 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 both have the same average effect applied by their labor management strategies. Therefore, it is not possible 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.³¹ 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.³²⁻³⁴ 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 their labor management strategies are providing the 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 mathematically incorrect to compare a 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. Hospitals and obstetrical care providers who care for nulliparous women who are older or more obese will be negatively impacted by an unadjusted measure since an unadjusted measure may be more of a measure of the women who are giving birth and not a measure of the effect applied by the hospital or the obstetrical care provider. In order to accurately assess the effect of a hospital's or obstetrical care provider's labor management strategies it is mandatory that the NTSV cesarean birth rate take into account the physical characteristics of the women who are giving birth.

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 2013.³⁵ 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 (Gestational diabetes and hypertension) 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.³⁶ Future studies will benefit from these efforts.

References

1. Safe prevention of the primary cesarean delivery. Obstetric Care Consensus No. 1. American College of Obstetricians and Gynecologists. *Obstet Gynecol* 2014;123:693–711.
2. Stotland NE, Hopkins LM, Caughey AB. Gestational Weight Gain, Macrosomia, and Risk of Cesarean Birth in Nondiabetic Nulliparas. *Obstet Gynecol* 2004;104:671-7
3. Durie DE, Thornburg LL, Glantz JC. Effect of second-trimester and third-trimester rate of gestational weight gain on maternal and neonatal outcomes. *Obstet Gynecol* 2011;118:569–75.
4. Caughey AB, Nicholson JM, Cheng YW, Lyell DJ, Washington AE. Induction of labor and cesarean delivery by gestational age. *Am J Obstet Gynecol* 2006;195:700–5.
5. Stock SJ, Ferguson E, Duffy A, Ford I, Chalmers J, Norman JE. Outcomes of elective induction of labour compared with expectant management: population based study. *BMJ* 2012;344:e2838.
6. Cheng YW, Kaimal AJ, Snowden JM, Nicholson JM, Caughey AB. Induction of labor compared to expectant management in low-risk women and associated perinatal outcomes. *Am J Obstet Gynecol* 2012;207:502.e1–502.e8.
7. Osmundson SS, Ou-Yang RJ, Grobman WA. Elective induction compared with expectant management in nulliparous women with a favorable cervix. *Obstet Gynecol* 2010;116:601–5.
8. Darney BG, Snowden JM, Cheng YW, Jacob L, Nicholson JM, Kaimal A, et al. Elective induction of labor at term compared with expectant management: maternal and neonatal outcomes. *Obstet Gynecol* 2013.
9. Osmundson S, Ou-Yang RJ, Grobman WA. Elective induction compared with expectant management in nulliparous women with an unfavorable cervix. *Obstet Gynecol* 2011;117:583–7.
10. Caughey AB, Sundaram V, Kaimal AJ, Gienger A, Cheng YW, McDonald KM, et al. Systematic review: elective induction of labor versus expectant management of pregnancy. *Ann Intern Med* 2009;151:252–63.
11. Gülmezoglu AM, Crowther CA, Middleton P, Heatley E. Induction of labour for improving birth outcomes for women at or beyond term. *Cochrane Database of Systematic Reviews* 2012, Issue 6. Art. No.: CD004945.
12. Walker KF, Bugg GJ, Macpherson M, McCormick C, Grace N, Wildsmith C, Bradshaw L, Smith GCS, Thornton JG. Randomized Trial of Labor Induction in Women 35 Years of Age or Older. *N. Engl J Med* 2016; 374:813-22
13. Miller NR, Cypher RL, Foglia LM, Pates JA, Nielsen PE. Elective Induction of Labor Compared With Expectant Management of Nulliparous Women at 39 Weeks of Gestation. *Obstet Gynecol* 2015;126:1258-1264
14. Ehrenthal DB, Jiang X, Strobino DM. Labor Induction and the Risk of a Cesarean Delivery Among Nulliparous Women at Term. *Obstet Gynecol* 2010;116:35-42
15. Barber EL, Lundsberg LS, Belanger K, Pettker CM, Funai EF, Illuzzi JL. Indications Contributing to the Increasing Cesarean Delivery Rate. *Obstet Gynecol* 2011;118:29-38
16. Declercq E, MacDorman M, Osterman M, Belanoff C, Iverson R. Prepregnancy Obesity and Primary Cesareans among Otherwise Low-Risk Mothers in 38 U.S. States in 2012. *Birth* 2015;42(4):309-18
17. Bailit JL, Love TE, Mercer B. Rising cesarean rates: are patients sicker? *Am J Obstet Gynecol* 2004;191:800-3.
18. Chen G, Uryasev S, Young T. On prediction of the cesarean delivery risk in a large private practice. *Am J Obstet Gynecol* 2004;191:617-25
19. Wilkes P, Wolf D, Kronbach D, Kunze M, Gibbs R. Risk Factors for Cesarean Delivery at Presentation of Nulliparous Patients in Labor. *Obstet Gynecol* 2003;102:1352-7
20. Bergholt T, Lim L, Jorgensen J, Robson M. Maternal body mass index in the first trimester and risk of cesarean delivery in nulliparous women in spontaneous labor. *Am J Obstet Gynecol* 2007;196(2):163.e1-5
21. Maslow A, Sweeny A. Elective Induction of Labor as a Risk Factor for Cesarean Delivery Among Low-Risk Women at Term. *Obstet & Gynecol* 2000;95:917-22
22. National Collaborating Centre for Women’s and Children’s Health. Induction of Labour – Clinical

- Guideline. 2nd ed. Regent's Park, London: RCOG Press; 2008
23. Main E, Moore D, Farrel B, Schimmel L, Altman R, Abrahams C, et al. Is there a useful cesarean birth measure? Assessment of the nulliparous term singleton vertex cesarean birth rate as a tool for obstetric quality improvement. *Am J Obstet Gynecol* 2006;194:1644-52
 24. Luthy DA, Malmgren JA, Zingheim RW, Leninger CJ. Physician contribution to a cesarean delivery risk model. *Am J Obstet Gynecol* 2003;188:1579-87.
 25. Coonrod DV, Drachman D, Hobson P, et al. Nulliparous term singleton vertex cesarean delivery rates: institutional and individual level predictors. *Am J Obstet Gynecol* 2008;198:694.e1-694.e11
 26. National Center for Health Statistics, Birth Data File for 2014, Available at http://www.cdc.gov/nchs/data_access/vitalstatsonline.htm. Retrieved August 26, 2016.
 27. Hamilton BE, Martin JA, Osterman MJ, Curtin SC, Mathews TJ. Births: Final Data for 2014. National vital statistics reports; vol 64 no 12. Hyattsville, MD: National Center for Health Statistics. Released December 23, 2015.
 28. Kozhimannil KB, Law MR, Virnig BA. Cesarean Delivery Rates Vary 10-Fold Among US Hospitals; Reducing Variation May Address Quality, Cost Issues. *Health affairs (Project Hope)*. 2013;32(3):527-535
 29. Goyert GL, Bottoms SF, Treadwell MC, Nehra PC. The Physician Factor in Cesarean Birth Rates. *N. Engl J Med* 1989; 320:706-9
 30. Clark SL, Belfort MA, Hankins GDV, Meyers JA, Houser FM (2007) Variation in the rates of operative delivery in the United States. *Am J Obstet Gynecol* 196:526.e1–5
 31. Healthy People 2020, MICH-7.1 Reduce cesarean births among low-risk women with no prior cesarean births. Available at <https://www.healthypeople.gov/2020/topics-objectives/topic/maternal-infant-and-child-health/objectives>. Retrieved September 12, 2016.
 32. The Leapfrog Group, Rate of C-Sections. Available at <http://www.leapfroggroup.org/ratings-reports/rate-c-sections>. Retrieved September 12, 2016.
 33. The Joint Commission, Explanation for PC-02: Cesarean Birth. Available at https://www.jointcommission.org/assets/1/6/PC-02_Cesarean_Birth_Explanation.pdf. Retrieved September 12, 2016.
 34. Covered California, Attachment 7 to Covered California 2017 Individual Market QHP Issuer Contract: Quality, Network Management, Delivery System Standards and Improvement Strategy. Section 5.03. Available at http://board.coveredca.com/meetings/2016/4-07/2017%20QHP%20Issuer%20Contract_Attachment%207__Individual_4-5-2016_CLEAN_V3.pdf. Retrieved September 12, 2016.
 35. Martin JA, Wilson EC, Osterman MJK, Saadi EW, Sutton SR and Hamilton BE. Assessing the quality of medical and health data from the 2003 birth certificate revision: results from two states. National vital statistics reports; vol 62 no 2. Hyattsville, MD: National Center for Health Statistics. Released July 22, 2013.
 36. American College of Obstetricians and Gynecologists. reVITALize obstetric Data Definitions ver5sion 1.0 2014. Available from: <https://www.acog.org/-/media/Departments/Patient-Safety-and-Quality-Improvement/2014reVITALizeObstetricDataDefinitionsv10.pdf>. Retrieved September 12, 2016