Nulliparous term singleton vertex cesarean delivery rates: institutional and individual level predictors

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OBJECTIVE: This study was undertaken to determine individual and institutional level variables predictive of variations in nulliparous term singleton vertex cesarean delivery rates.

STUDY DESIGN: Retrospective cohort study of 28,863 nulliparous term singleton vertex births at 40 Arizona hospitals.

RESULTS: The average nulliparous term singleton vertex cesarean delivery rate was 22.0%, the lowest hospital rate was 10.3%, high, 34.2%. The following individual level variables increased the nulliparous term singleton vertex cesarean delivery rate in a multivariable model: increased mother's age, African American race, increased birthweight, labor induction, and the presence of medical conditions such as diabetes and hypertension. Of the institutional variables, after adjustment, the highest level of nursery or a higher percentage of government-paid births was associated with lower risks, whereas delivery at a hospital with the lowest level of care or with an obstetric and gynecology residency was associated with an increased risk of cesarean delivery.

CONCLUSION: Substantial variations in nulliparous term singleton vertex cesarean delivery rates were seen in this comparative analysis of 40 hospitals.

Key words: cesarean delivery, clinical factors, institutional factors, nullipara, quality measures

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Studies of cesarean deliveries present a rich picture of variations in cesarean delivery rates. These have examined overall cesarean delivery rates and primary cesarean delivery rates.[1,2] These studies have shown variations by both clinical and nonclinical factors, including the presence or absence of conditions such as diabetes, preeclampsia, advanced maternal age, and various institutional factors.[1,2] However, these studies have limitations because, for example, the overall cesarean delivery rate is heavily influenced by the vaginal birth after cesarean rate, and the primary cesarean delivery rate does not necessarily adjust for medical risk factors.[3] As a result, models have been created to adjust for risks through regression models or standardization.[2,4,5] However, these have not been widely adopted as quality measures, because of their complexity, the lack of agreement over which factors should be adjusted, and questionable validity of various risk factors when derived from administrative data. Another method, risk stratification, attempts to create homogenous groups from which to make comparisons. Once such method compares cesarean rates among the "standardized nulliparous patient" introduced in Britain.[6] This rate was broadened and adopted as the nulliparous, term, singleton, vertex (NTSV) cesarean delivery (CD) rate by the US Department of Health and Human Services in their Healthy People 2010 goals[7] and the American College of Obstetrics and Gynecology (ACOG)[8] as a possible quality measure. Despite its adoption, studies examining this measure have been limited. Main et al[9] published a study that revealed substantial variations between hospitals that were predicted by higher rates of induced labor and earlier admissions in labor. Variations, based on maternal age were also found, and the authors suggested using direct standardization by age to compare hospitals. The study by Main et al[9] was based on 20 hospitals belonging to a single network. Other studies that used measures similar to NTSV CD rates have also shown variations in the rate.[10-12]

In our study, we explored the NTSV concept by studying variations among hospitals in the State of Arizona, based on factors collected on birth certificates and easily available institutional data, to further understand this possible quality measure. We designed a retrospective cohort study to examine individual-level risk factors for variations in NTSV rates. We also examined institutional-level risk factors for NTSV CD. Finally, these factors were combined in a multivariable model controlling for clinical and nonclinical risk factors, to study variations among hospitals in NTSV CD rates.

Materials and Methods

Data sources

The Arizona Birth Certificate File for the year 2005 provided the data for the indi-

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vidual deliveries that were analyzed. Data on institutional characteristics came from the Arizona Perinatal Trust, which certifies hospital nurseries in the State of Arizona (Michael S. Clement, MD, Arizona Perinatal Trust, personal communication), and the American Hospital Association Guide based on 2005 data.[13] The Maricopa Integrated Health System Institutional Review Board (IRB) reviewed the study proposal and found the study to be exempt from IRB review, as no files had personal identifiers.

Analytic data file

The 2005 Birth Certificate File contained a total of 97,294 births. To produce the analytic data, the following qualifiers were applied to the data file: nulliparous birth (63.3% of all cases); term birth (gestational age ≥37 weeks; 89.3% of all cases); singleton birth (97.3% of all cases); and vertex presentation (96.8% of all cases). Births meeting all 4 of these criteria represented 31.7% of all cases. Finally, delivery had to occur at a hospital with at least 100 NTSV births during 2005 (97.1% of all cases). The resulting dataset contained 30,045 cases. Another 1182 cases from "other" racial and ethnic groups, with a low representation in the population, were also excluded. The resulting analytic dataset contained 28,863 births from 40 Arizona hospitals.

Analytic approach

The outcome of interest was cesarean vs vaginal delivery. The NTSV CD rate was calculated for each of the hospitals. These rates were then adjusted for a number of characteristics of both the individual mothers/infants and the institutions at which the delivery occurred. Two experienced obstetricians (D.V.C. and M.M.) rated each of these predictor variables in terms of whether they should be considered as (1) clinical markers of cesarean delivery, (2) potential clinical markers, or (3) nonclinical markers. For variables initially deemed as clinical or potential clinical markers, the direction of risk was predicted; for example, it was predicted that those with no prenatal

TABLE 1
Variables used to adjust NTSV CD rates

Variables classified as clinical
Mother's age less than 18 y
Mother's age between 19 and 25 y (reference variable)
Mother's age between 26 and 34 y
Mother's age ≥35 y
Diabetes
Chronic hypertension
Preeclampsia or eclampsia
Congenital anomaly
Other medical complications[a]
Birthweight <2500 g
Birthweight between 2500 and 3999 g (reference variable)
Birthweight ≥4000 g
Estimated gestational age of ≥41 wks
Variables classified as potentially clinical
White, non-Hispanic (reference variable)
Hispanic
Black, non-Hispanic
Native American, non-Hispanic
Induction of labor
Variables classified as nonclinical
No prenatal care
Prenatal care commenced during first trimester (reference variable)
Prenatal care commenced during second trimester
Prenatal care commenced during third trimester
Mother's education level <12th grade
Mother's education level 12th grade (reference variable)
Mother's education level >12th grade
Self-paid insurance status
Private paid insurance status (reference variable)
Government-paid insurance status
Percentage of hospital's NTSV births that were government-paid, hospital quartile[b]
Percentage of hospital's NTSV births in which labor was induced, first quartile (reference variable)[b]
Percentage of hospital's NTSV births in which labor was induced, second quartile[b]
Percentage of hospital's NTSV births in which labor was induced, third quartile[b]
Percentage of hospital's NTSV births in which labor was induced, fourth quartile[b]
Total number of hospital's NTSV births, hospital quartile[b]
Level 1 or not-certified nursery[b]
Level 2 nursery (reference variable)[b]
Level 2 EQ nursery[b]
Level 3 nursery[b]

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TABLE 1
Variables used to adjust NTSV CD rates

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Obstetrician in house[b]
Anesthesiologist in house[b]
Obstetric-gynecologic residency program[b]
Government-owned hospital[b]
For-profit hospital[b]
Not-for-profit hospital (reference)[b]

CD, cesarean delivery; *NTSV*, nulliparous term singleton vertex.

[a] Any of the following: anemia, cardiac disease, lung disease, genital herpes, hydramnios, hemoglobinopathy, incompetent cervix, renal disease, Rh sensitization.

[b] Hospital-level variable.

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care or later prenatal care would be at increased risk of CD. If the direction of risk went contrary to what was predicted, the variable was termed a nonclinical risk factor. The resulting judgments of the 2 obstetricians were highly consistent (kappa = 0.85, $P < .001$). In all cases, except the quartiles for hospital percentage of government-paid births and the hospital volume of NTSV births, which were coded from 1 (lowest quartile) to 4 (highest quartile), the adjustor variables were coded as 1 for present and 0 for absent. Table 1 lists each of the adjustor variables used in the statistical models.

Because both individual-level and institutional-level factors were to be analyzed suggested that a generalized hierarchical linear model[14] might be most appropriate for the statistical adjustment process. Unlike a 1-level regression model, the hierarchical model explicitly recognizes that the data are multilevel (in this case, that individual patients are grouped by hospital). If analysis reveals that patients within specific hospitals are more similar to one another than they are to patients from other hospitals, then "clustering" is present in the data, and a hierarchical approach is indicated. The amount of clustering present within hospitals was measured by using the intraclass correlation coefficient (ICC). Examination of the ICC revealed that the degree of clustering in our data was negligible (ICC = 0.013). Therefore, a simpler 1-level binary logistic regression model was judged adequate to predict the NTSV CD rate, based on the adjustor variables. Three binary logistic regression models were developed. In the first model, the probability that an NTSV delivery would result in a CD was predicted from the clinical variables. In the second model, the NTSV CD rate was predicted from the clinical and potentially clinical variables. In the third model, the NTSV CD rate was predicted from all 3 groups of variables: clinical, potentially clinical, and nonclinical. To assess the predictive power of the models, the areas under the receiver operating characteristic (ROC) curves were calculated to allow for the models to be compared. To study the impact of the hospital, each hospital was dummy coded, and the area under the curve (AUC) was calculated in a model with hospital only, and in a model that combined hospital with all of the third model's predictors.

RESULTS

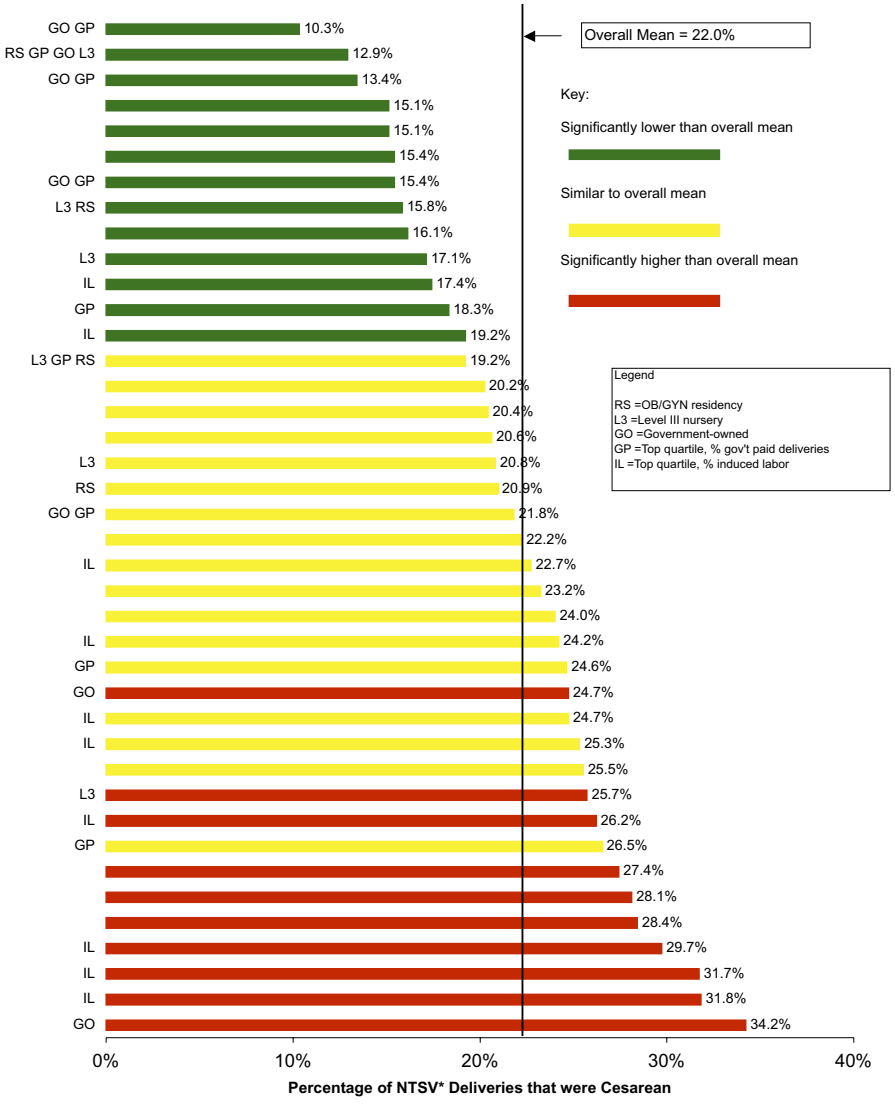
Initial analysis of the 28,863 births revealed an average NTSV cesarean delivery rate of 22.0% (Figure). We also noted substantial variations in NTSV CD rates among the 40 hospitals, ranging from a low of 10.3% to a high rate of 34.2%. By using 2 standard errors above and below the average rate as a cutoff, we found 13 (33%) hospitals with lower than expected rates and 10 (25%) with higher than expected rates.

All individual level variables, with the exception of uterine bleeding, showed significant differences in the univariable analysis (Table 2). The highest risk of NTSV CDs was found among those of older age, African American, more educated, and with risk factors or medical conditions such as diabetes, hypertension, preeclampsia, gestational age beyond 40 weeks, congenital anomalies, and other medical risk factors. Induction of labor also showed an increased risk, as did the extremes of birthweight. Socioeconomic factors associated with more affluence, more education and private insurance were associated with an increased risk. Early prenatal care was associated with an increased risk of cesarean delivery.

All institutional level variables similarly showed significant variations in NTSV cesarean rates, with the exception of the presence of in-house pediatrics (Table 3). The lowest rates of CD were found in hospitals representing higher levels of care, that is, those with tertiary (level 3) nurseries, the presence of in-house obstetricians or maternal fetal medicine specialists, the presence of obstetrics and gynecology residents, and in-house anesthetic. The percentage of government births showed a higher rate of CDs in hospitals with the lowest quartile of government deliveries and government-owned institutions had the lowest rates. Hospitals in the highest quartile of labor induction rates had the highest NTSV cesarean rates.

The multivariable analysis results are shown in Table 4. The first model controlled for clinical variables. All were significant in the multivariable analysis and compared with the unadjusted odds ratios, all showed similar odds after adjustment. Some attenuation of the odds ratio of NTSV CD was noted with conditions associated with older age, notably diabetes and chronic hypertension. When the potential clinical variables of race/ethnicity and induction of labor were added to the model (model 2), there was little change in the odds ratios. Both African American race and induction of labor were significant risk factors. In model 3,

FIGURE 1
Hospital comparisons



Unadjusted NTSV CD rates with selected institutional characteristics.
CD, cesarean delivery; *NTSV*, nulliparous term singleton vertex.
Coonrod. Nulliparous term singleton vertex cesarean delivery rates. Am J Obstet Gynecol 2008.

with the addition of nonclinical variables, the odds ratios of the previously entered variables were largely unchanged, indicating little confounding by the nonclinical variables. There was, however, considerable confounding among the nonclinical variables, and few remained significant. The following remained significant predictors of decreased risk of NTSV CD: no prenatal care, delivery at a hospital with more government-paid births (lower odds of CD among hospitals with more government births), and delivery at a hospital with a level 3 nursery. Elevated risk was seen with delivery at a hospital in the second quartile of induction rate, a for-profit facility, a level 1 or noncertified nursery, or an obstetrics/gynecology residency.

Examination of the AUC of the models revealed that the predictive ability of the variables used in the models was limited. When hospitals were modeled independently, the AUC was 0.582. This may be interpreted to indicate that using the hospital alone as a predictor of NTSV CD produces predictions that are 8.2% better than chance for an individual's risk of CD. In the model with the clinical variables only, the AUC was 0.640, a 10% increase over the hospital only model (Table 4). When all variables were added (model 3), this increased to only 0.659, a 13% increase, indicating that much of the variation in an individual's risk of cesarean was largely not accounted for in the model. Indeed, when hospital was then added to model 3, the ROC curve only increased to 0.669. This indicates that a number of individual-, physician-, and hospital-culture factors may be unaccounted for in this analysis. Finally, many of the clinical factors incorporated into the model, such as diabetes, are relatively rare and may be prone to underreporting in birth certificate databases. Two clinical factors that are considered dependable for all mothers and also strongly related to CD are maternal age and birthweight. It is therefore of interest to test a model including only these 2 factors, to see how it performs against the model including all clinical factors. The resulting model, based on maternal age and birthweight only, produced an AUC of 0.622, a 7% increase over the hospital-only model. To assess overfitting, Mallow's Cp statistic[15] was calculated. The Cp statistic corrects the average Residual Squared Error (RSE) for the fact that the same data are being used to estimate the model as are being used to assess the model's fit. The Cp statistic can be viewed as the average RSE after adjustment for overfitting. For the model that incorporated all of the clinical, potentially clinical, and nonclinical factors, the average RSE was 0.1612. Mallow's Cp was 0.1616, indicating that very little overfitting occurred.

Finally, after adjustment for clinical factors, the changes in hospital rankings were calculated (Table 5). Most hospitals, 31 of 40 (78%), retained their original classifications before and after adjustment. However, 4 of the 13 (31%) hospitals that were noted to have below average rates of NTSV CD before risk adjustment were of average risk after ad-

justment. Of the hospitals of average risk, 18% were at increased risk after adjustment; whereas 80% of the hospitals at increased risk before adjustment retained their above average ranking. Agreement between the adjusted and unadjusted rankings was fair to good, kappa = 0.65, $P < .001$. After adjustment for maternal age and birthweight only, the changes in hospital rankings were once again calculated (Table 6). Once again, agreement between the adjusted and unadjusted rankings was fair to good (kappa = 0.65, $P < .001$).

Comment

We found substantial variations in NTSV CD rates in Arizona, with a 3-fold difference when comparing the highest to lowest institutions. A number of clinical and nonclinical variables predicted the difference. This substantial variation among the hospitals remained even after adjustment for clinical factors.

Our study had a large sample size when examining individual level variables but a more limited sample size when examining hospitals (n = 40). Nevertheless, this represents the largest number of hospitals in a study of the variations in the NTSV cesarean rate as adopted by Healthy People 2010. Our analytic approach also was prepared to account for clustering through a hierarchical approach, although we found this not necessary, a technique rarely used in studies of CD. Our study has varying levels of accuracy from the primary data source, birth certificates, for many variables.[16-18] Interestingly, the variables used to create the NTSV analytic set have been created from variables considered dependable in the previous work.[19] Indeed, most of the other variables left for consideration are considered less dependable. The fact that, after adjustment for clinical factors, a number of hospitals moved from being high outliers to having average risk and others moved from average to above average risk is an argument for accurate collection of risk factors, especially if the NTSV is widely adopted as a benchmark. The lack of sen-

TABLE 2
Univariable comparisons of NTSV CD: individual variables

	N	Rate	*P* value
Mother's age (y)			
<18	3268	13%	<.001
18-25	15,899	19%	
26-34	8151	28%	
35+	1545	41%	
Race/ethnicity			
White non-Hispanic	13,762	24%	<.001
Hispanic	12,597	20%	
African American	1004	26%	
Native American	1500	19%	
Education (y)			
< 12	7486	17%	<.001
12	8674	22%	
>12	12,484	25%	
Insurance			
Private	12,668	26%	<.001
Government	15,173	19%	
Self/other	912	20%	
Trimester prenatal care began			
None	474	14%	<.001
First	22,761	23%	
Second	4533	19%	
Third	1088	18%	
Diabetes			
No	28,343	22%	<.001
Yes	520	38%	
Chronic hypertension			
No	28,765	22%	<.001
Yes	98	48%	
Uterine bleeding			
No	28,779	22%	NS
Yes	84	27%	
Preeclampsia/eclampsia			
No	27,790	21%	<.001
Yes	1073	39%	
Other medical problems			
No	27,535	22%	<.001
Yes	1328	30%	
Gestational age > 40 wks			
No	25,831	21%	<.001
Yes	3,032	28%	

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TABLE 2
Univariable comparisons of NTSV CD: individual variables

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	N	Rate	*P* value
Congenital anomaly			
No	28,905	22%	.002
Yes	258	29%	
Induced labor			
No	21,909	21%	<.001
Yes	6954	27%	
Birthweight (g)			
<2500	65	27%	<.001
2500-3999	26,114	20%	
4000+	2096	42%	

CD, cesarean delivery; *NS*, not significant; *NTSV*, nulliparous term singleton vertex.
$P > .05$.

Coonrod. Nulliparous term singleton vertex cesarean delivery rates. Am J Obstet Gynecol 2008.

sitivity of the birth certificate for medical conditions is becoming well recognized and if random, should bias risk estimates to the null, but if nonrandom, would bias estimates in an unpredictable manner.[17] However, the effect of this would be minimal because most confounder conditions are not common. For example, recent data from Kaiser Permanente suggest a prevalence of diabetes of 4% vs our 1.8%.[20] Assuming the 38% NTSV CD rate held for all diabetics, and a true rate of diabetes of 4%, removing the misclassified diabetics from the population classified as having no diabetes (28,343) would decrease this population by 635 and their deliveries by 241, leaving a cesarean rate of 21.6%. This is little different than the rate calculated before removing them (22.0%). Furthermore, this changes the relative risk estimate by only 2%. In addition, lack of information about other confounders that are not measured on the birth certificate, such as obesity, early admission in labor[9] or Bishop score on admission,[12] might account for the relatively low predictive ability of our regression models.

That we could not explain much of the variation among hospitals is not a reason to ignore that such variation exists. Indeed, the fact that nonclinical factors account for some of the variation is an argument that this procedure is possibly overused, which has been well documented with other measures of CD rates.[21,22] That NTSV CD rates vary with various clinical risk factors, is an argument that this measure does not necessarily create a homogeneous group. Indeed, the NTSV population was an adaptation of the "standardized nulliparous patient" that excludes those with medical conditions,[6] many of which are well known to increase risk of CD, and thus is a more homogeneous risk group than the NTSV group. Alternatively, it argues for risk adjusting even the NTSV rate, avoidance of which was a rationale for its use, especially given only fair-to-good agreement between adjusted and unadjusted rankings.

Our study most directly compares with others the limited number of studies of NTSV. We have validated the data of Main et al,[9] which demonstrated that maternal age is an important potential confounding variable. We also showed great variation among hospitals. Our variation was even greater, considering that their analysis was restricted to 20 hospitals in a large health system under single ownership, whereas our study included 40 hospitals with broader ownership types. Main el al[9] found that hospitals with higher induction rates had higher CD rates, which we replicated in our unadjusted analysis. However, after adjustment for confounders and induction at the individual level, there was no clear trend of increased hospital induction rates being associated with higher CD rates. This might indicate that induction rate may not represent a culture of more intervention, including increased CD. Indeed, Fischer et al,[11] when comparing 2 hospitals with low and high CD rates in nulliparous women with vertex presentations, found higher maximal doses of oxytocin and more use of fetal scalp electrodes and intrauterine catheters in the low CD hospital. Le Ray el al[10] found increased rates of CD in their low-risk nulliparous subjects among hospitals with higher levels of perinatal care in France. In our univariable analysis, higher levels of care were associated with lower CD rates (level 3 nursery, in-house obstetrics, in-house anesthetic, obstetrics and gynecology residency), which might be modifiable institutional risk factors. In our multivariate analysis, this persisted for level of nursery, and, unlike Le Ray et al,[10] the lowest level of nursery was associated with increased CD rates. This may represent differences in the study population, as they excluded patients whose labor was induced for medical complications, or a larger presence of midwives in their lower levels of care than in comparable units in the United States.

Our study adds to the literature that yet another measure of cesarean rates shows large variations by nonclinical factors. This variation has been demonstrated for overall cesarean rates,[1,23] primary cesarean rates,[21] elective primary cesarean rates,[24] repeat cesarean rates,[22] and now NTSV rates. When compared with a study of primary cesareans, our study of NTSV was able to account for less variation.[25] It is possible that factors such as parity, multiple gestation, and nonvertex presentation accounted for some of the difference in their AUC (0.84) vs ours (0.659). That much of the variation remains unaccounted for adds to the validity that NTSV is a good measure of variation by nonclinical factors. Such factors from the literature most certainly includes the physician factor,[26,27] including malpractice experience,[28] their day-to-day experiences, and

competing pressures of practice and lifestyle.[29]

The persistent debate in CD revolves around the question of what is the appropriate rate.[30,31] Lack of consensus on this question has led to nihilism with respect to studies that show variations in rates. However, there is good evidence that a higher cesarean rate does not lead to improved neonatal outcomes in studies that have examined the outcomes in hospitals and practices with high rates.[32-34] The NTSV rate has been used in quality improvement programs to decrease the cesarean rate while not losing sight of neonatal outcomes.[35,36] It is a compelling measure, because this group should have a relatively low risk of CD by excluding conditions in which the cesarean rate would be high, and because the route of delivery of a first birth will be highly predictive of the route of delivery of the second birth. Given that there are established methods for reducing the cesarean rate, measurement of the NTSV might be a tool to use in hospital quality improvement programs.[36,37] That we showed variation in rates was not surprising, but we were somewhat disappointed that risk adjustment changed the outlier status of many hospitals, which is a significant concern when comparing hospitals.[25] It is possible that a measure based on the "standardized nulliparous" patient may be more useful in creating a homogeneous group from which to compare hospitals because it simply excludes women with a high-risk condition.[6] Finally, hospital quality improvement teams may want to either "risk adjust" NTSV rates or adopt a "standardized nulliparous" approach when evaluating their CD rates. Given the lack of sensitivity of the birth certificate for these conditions, quality improvement activities should take place around the birth certificate as well or a simple indicator variable with sufficient sensitivity and specificity for low risk should be created. Should the NTSV CD rate be widely adopted as a comparison measure, we should expect this to be a motivating factor for improved data quality.

TABLE 3
Univariable comparisons of NTSV CD: institutional variables

	N	Rate	*P* value
Percentage of government deliveries			
1st quartile (11-46%)	11,705	26%	<.001
2nd quartile (47-59%)	8345	20%	
3rd quartile (60-76%)	5309	20%	
4th quartile (77-100%)	3504	18%	
Percentage of induced labors			
1st quartile (0-10%)	6570	21%	<.001
2nd quartile (11-21%)	7691	21%	
3rd quartile (22-33%)	6767	19%	
4th quartile (34-50%)	7624	25%	
Number of deliveries			
1st quartile (0-272 births)	1994	21%	.024
2nd quartile (273-558 births)	4026	23%	
3rd quartile (559-882 births)	7266	23%	
4th quartile (993-2516 births)	15,577	22%	
Hospital ownership			
Government	2086	18%	<.001
Not for profit	20,834	22%	
For profit	5943	22%	
Level of nursery			
1/not certified	3648	23%	<.001
2	10,444	23%	
2EQ	5714	24%	
3	9057	19%	
OB/GYN residency			
No	24,037	23%	<.001
Yes	4826	17%	
In-house OB/GYN or MFM			
No	17,328	23%	<.001
Yes	11,535	21%	
In-house pediatrics			
No	9474	22%	NS
Yes	19,389	22%	
In-house anesthetic			
No	8063	24%	<.001
Yes	20,800	22%	

$P > .05$.
CD, cesarean delivery; *MFM*, maternal fetal medicine; *NS*, not significant, *NTSV*, nulliparous term singleton vertex; *OB/GYN*, obstetric-gynecology.

Coonrod. Nulliparous term singleton vertex cesarean delivery rates. Am J Obstet Gynecol 2008.

TABLE 4
NTSV CD births logistic regression adjusting for clinical, potential clinical, and nonclinical factors

		Model 1[a] 0.640		Model 2[b] 0.647		Model 3[c] 0.659	
AUC	ORu	ORa	95% CI	ORa	95% CI	ORa	95% CI
Mother's age (y)							
<18	0.64	0.68	(0.61-0.76)	0.68	(0.61-0.76)	0.66	(0.58-0.75)
18-25	1.00	1.00		1.00		1.00	
26-34	1.66	1.65	(1.55-1.76)	1.65	(1.54-1.76)	1.73	(1.61-1.86)
35+	2.96	2.97	(2.66-3.32)	2.98	(2.66-3.33)	3.21	(2.85-3.62)
Diabetes							
No	1.00	1.00		1.00		1.00	
Yes	2.17	1.74	(1.44-2.09)	1.74	(1.44-2.09)	1.77	(1.47-2.14)
Chronic hypertension							
No	1.00	1.00		1.00		1.00	
Yes	3.27	2.79	(1.85-4.23)	2.68	(1.77-4.06)	2.69	(1.77-4.09)
Preeclampsia/eclampsia							
No	1.00	1.00		1.00		1.00	
Yes	2.12	2.12	(1.87-2.41)	2.05	(1.8-2.33)	2.07	(1.82-2.36)
Other medical problems							
No	1.00	1.00		1.00		1.00	
Yes	1.52	1.48	(1.3-1.67)	1.44	(1.27-1.63)	1.41	(1.24-1.6)
Gestational age >40 wk							
No	1.00	1.00		1.00		1.00	
Yes	1.46	1.38	(1.26-1.51)	1.36	(1.24-1.48)	1.41	(1.29-1.54)
Congenital anomaly							
No	1.00	1.00		1.00		1.00	
Yes	1.45	1.48	(1.12-1.96)	1.49	(1.13-1.96)	1.38	(1.04-1.83)
Birthweight (g)							
<2500	1.48	1.40	(1.17-1.68)	1.38	(1.15-1.66)	1.40	(1.17-1.68)
2500-3999	1.00	1.00		1.00		1.00	
4000+	2.90	2.57	(2.34-2.82)	2.58	(2.34-2.83)	2.59	(2.35-2.85)
Race/ethnicity							
White non-Hispanic	1.00			1.00		1.00	
Hispanic	0.79			1.03	(0.96-1.10)	1.11	(1.03-1.19)
African American	1.11			1.45	(1.25-1.69)	1.54	(1.32-1.80)
Native American	0.74			0.89	(0.77-1.03)	0.97	(0.83-1.14)
Induced labor							
No	1.00			1.00		1.00	
Yes	1.39			1.21	(1.13-1.29)	1.20	(1.12-1.29)
Education (y)							
<12	0.73					1.02	(0.93-1.12)
12	1.00					1.00	
>12	1.18					0.88	(0.81-0.95)

Continued on page 694.e9.

TABLE 4
NTSV CD births logistic regression adjusting for clinical, potential clinical, and nonclinical factors

Continued from page 694.e8.

		Model 1[a]		Model 2[b]		Model 3[c]	
AUC		0.640		0.647		0.659	
	ORu	ORa	95% CI	ORa	95% CI	ORa	95% CI
Insurance							
Private	1.00					1.00	
Government	0.67					0.98	(0.91-1.06)
Self/other	0.71					0.88	(0.73-1.05)
Trimester prenatal care began							
None	0.54					0.72	(0.54-0.95)
First	1.00					1.00	
Second	0.79					0.96	(0.88-1.05)
Third	0.73					0.92	(0.78-1.09)
Percentage of government deliveries[d]	0.85					0.88	(0.84-0.92)
Percentage of induced labors							
1st quartile (0-10%)	1.00					1.00	
2nd quartile (11-21%)	1.00					1.14	(1.01-1.28)
3rd quartile (22-33%)	0.88					0.91	(0.82-1.00)
4th quartile (34-50%)	1.25					1.00	(0.89-1.12)
Number of deliveries[d]	0.99					1.00	(0.94-1.06)
Hospital ownership							
Government	0.78					0.95	(0.82-1.12)
Not for profit	1.00					1.00	
For profit	1.00					1.13	(1.01-1.26)
Level of nursery							
1/not certified	1.00					1.37	(1.18-1.60)
2	1.00					1.00	
2EQ	1.06					0.91	(0.80-1.04)
3	0.79					0.68	(0.57-0.82)
OB/GYN residency							
No	1.00					1.00	
Yes	0.69					1.16	(1.00-1.34)
In-house OB/GYN or MFM							
No	1.00					1.00	
Yes	0.89					1.12	(1.00-1.27)
In-house anesthesia							
No	1.00					1.00	
Yes	0.84					0.99	(0.89-1.11)

AUC, area under receiver operator curve; *CD* cesarean delivery; *CI*, confidence interval; *MFM*, maternal fetal medicine; *NTSV*, nulliparous term singleton vertex; *OB/GYN*, obstetric-gynecology; *ORu*, odds ratio unadjusted; *ORa*, odds ratio adjusted for the other variables in the column.
Odds ratio represent the change in risk with increasing quartiles.

[a] Model 1 controls for clinical variables (Table 1).

[b] Model 2 controls for clinical and potential clinical variables (Table 1).

[c] Model 3 controls for clinical, potential clinical and nonclinical variables.

[d] Coded as an ordinal variable.

Coonrod. Nulliparous term singleton vertex cesarean delivery rates. Am J Obstet Gynecol 2008.

TABLE 5
Impact of adjusting for clinical variables on hospital outlier status

		After adjustment for clinical variables		
NTSV CD rates at 40 hospitals:		Significantly below average	Similar to average	Significantly above average
Before adjustment	Significantly below average	9	4	0
	Similar to average	0	14	3
Significantly above average	1	1	8	

CD, cesarean delivery; *NTSV*, nulliparous term singleton vertex.

Coonrod. Nulliparous term singleton vertex cesarean delivery rates. Am J Obstet Gynecol 2008.

TABLE 6
Impact of adjusting for age and birthweight on hospital outlier status

		After adjustment for clinical variables		
NTSV CD rates at 40 hospitals:		Significantly below average	Similar to average	Significantly above average
Before adjustment	Significantly below average	8	5	0
	Similar to average	0	15	2
Significantly above average	1	1	2	

CD, cesarean delivery; *NTSV*, nulliparous term singleton vertex.

Coonrod. Nulliparous term singleton vertex cesarean delivery rates. Am J Obstet Gynecol 2008.

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DISCUSSION

Kimberly Gregory, MD. I would like to commend Dr Coonrod et al on a study well done and succinctly written. The authors demonstrated once again that there is wide variation in cesarean delivery rates (ranging from 10-34%), and that the variation persists after adjusting for patient specific and hospital specific variables.[1-4] They conclude that our statistical manipulations are not able to explain much of the variation, but that it is probably prudent to continue to adjust for case mix in some fashion because adjusting may impact ranking—and in the end that's what life is all about... right? Who's on first? What place did you come in? Are you better than average? Better than the best? One star, 3 stars, or 5 stars?

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