Published in final edited form as:

Obstet Gynecol. 2018 June ; 131(6): 1039–1048. doi:10.1097/AOG.0000000000002636.

Variation in the Nulliparous, Term, Singleton, Vertex Cesarean Delivery Rate

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Financial Disclosure

The authors did not report any potential conflicts of interest.

Each author has indicated that he or she has met the journal's requirements for authorship.

Dr. Rouse, Associate Editor of Obstetrics & Gynecology, was not involved in the review or decision to publish this article.

Presented in part at the Society for Maternal-Fetal Medicine's 37th Annual Pregnancy Meeting, Las Vegas, NV, January 23-28, 2017.

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Abstract

Objective—To estimate the contributions of patient and health care provider–hospital characteristics to the variation in the frequency of nulliparous, term, singleton, vertex cesarean delivery in a multi-institutional U.S. cohort.

Methods—We performed a secondary analysis of the multicenter Assessment of Perinatal Excellence cohort of 115,502 mother and infant pairs who were delivered at 25 hospitals between March 2008 and February 2011. Women met inclusion criteria if they were nulliparous and delivered a singleton in vertex presentation at term. Hospital ranks for nulliparous, term, singleton, vertex cesarean frequency were determined after risk-adjustment. The fraction of variation in nulliparous, term, singleton, vertex cesarean frequency attributable to patient and health care provider–hospital characteristics was assessed using hierarchical logistic regression.

Results—Of the 115,502 deliveries in the initial cohort, 38,275 nulliparous, term, singleton, vertex births met inclusion criteria. The median hospital nulliparous, term, singleton, vertex cesarean frequency was 25.3% with a range from 15.0% to 35.2%. The majority of hospitals (16 of 25) changed rank quintiles after risk-adjustment; overall the changes in rank were not statistically significant ($p=0.53$). Patient characteristics accounted for 24% of the nulliparous, term, singleton, vertex cesarean variation. The analyzed health care provider–hospital characteristics were not significantly associated with cesarean frequency.

Conclusion—Although patient characteristics accounted for some of the variation in nulliparous, term, singleton, vertex cesarean frequency and accounting for case-mix had implications for hospital cesarean rankings, the majority of the variation was not explained by the characteristics evaluated. These findings emphasize the importance of continued efforts to understand aspects of obstetric care, including case-mix, that contribute to cesarean variation.

Introduction

The nulliparous, term, singleton, vertex cesarean delivery rate is one of the five Perinatal Care measures (PC-02) endorsed by the National Quality Forum and required by The Joint

Commission.¹ The Society for Maternal-Fetal Medicine also proposed an alternative low-risk cesarean delivery measure.² Despite concerted efforts aimed at reduction,³ the national cesarean rate was most recently 31.9%,⁴ and there is marked variation in the frequency of low-risk cesareans.⁵

Identification of sources of variation in outcome frequencies can guide future quality improvement efforts. This approach has been utilized in neonatology⁶ and was recently applied to obstetric outcomes in the Assessment of Perinatal Excellence (APEX) study.^{7, 8} The primary analysis for APEX developed risk-adjustment models and compared hospital performance for four obstetric outcomes (postpartum hemorrhage, peripartum infection, severe perineal laceration, and a composite neonatal adverse outcome).⁷ Subsequently, Grobman et al. quantified the amount of variation in outcome frequency attributable to patient, health care provider–hospital, and obstetric care characteristics.⁸ Importantly, these prior studies did not examine cesarean delivery.

Although risk-adjustment is not performed for the PC-02 metric,¹ it is recognized that differences in case-mix, provider attributes and hospital characteristics contribute to cesarean variation.^{9–12} An improved understanding of the factors underlying variation in nulliparous, term, singleton, vertex cesarean frequency may facilitate efforts aimed at cesarean prevention and provide insight into its use as a quality metric. Our objective was to estimate the contributions of patient and health care provider–hospital characteristics to the variation in the frequency of nulliparous, term, singleton, vertex cesarean delivery in a multi-institutional U.S. cohort.

Materials and Methods

This is a secondary analysis of the APEX Study, which was an observational cohort consisting of 115,502 mother and infant pairs who delivered at any of 25 hospitals in the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network between March 2008 and February 2011. Institutional review board approval was obtained from all study sites. A complete description of the study design and methodology has been previously published.⁷ Briefly, women met inclusion criteria for APEX if they delivered on randomly selected days after being admitted with a living fetus at or beyond 23 weeks' gestation. Trained and certified research personnel abstracted data from the medical records of study participants including patient demographics, maternal and neonatal outcomes, characteristics of the providers and hospitals involved in patient care, and obstetric care measures.

The primary outcome of our analysis was the institutional variation in nulliparous, term, singleton, vertex cesarean frequency. Women met inclusion criteria if they were nulliparous and delivered a live-born, singleton in vertex presentation at or beyond 37 weeks' gestation. International Classification of Diseases codes are utilized to define the PC-02 population but were not available for study participants. Therefore, criteria were defined using APEX covariables that are consistent with PC-02 inclusion and exclusion criteria.¹³ For the study analysis, the covariables examined included the baseline characteristics of the mother and infant pairs, maternal and neonatal outcomes, and the characteristics of the obstetric

providers and hospitals. Table 1 provides a complete list of the variables evaluated. These characteristics were determined *a priori*. Women were excluded from the analysis if they were missing data for the covariables that met final model inclusion criteria.

A risk-adjustment model was generated using multivariable logistic regression and k-fold cross-validation as previously described by Bailit et al.⁷ Hospital rank agreement after risk-adjustment was assessed using the Wilcoxon rank sum test. Hospitals were divided into quintiles based on their unadjusted nulliparous, term, singleton, vertex cesarean rank to facilitate visual comparison of the impact of risk-adjustment on hospital ranking and to reflect the approaches used by organizations to categorize hospitals according to quality metric performance.¹⁴

Following development of a risk-adjustment model, hierarchical logistic regression was used to quantify the amount of variation in the hospital frequency of nulliparous, term, singleton, vertex cesareans that was attributable to patient and health care provider–hospital characteristics. The first logistic regression equation incorporated only the hospitals as random-effect terms. The next level of the model incorporated the significant patient characteristics identified during development of the risk-adjustment model. Lastly, health care provider–hospital characteristics were evaluated for inclusion in the final hierarchical logistic regression model using backwards stepwise selection and were retained if $P < 0.05$.

The hospitals' odds ratios for nulliparous, term, singleton, vertex cesarean were determined at each level of the hierarchical model. Per the methods used by Synnes et al.,⁶ each equation contained a random effects term (b_o), and it is the standard deviation (σ) of this term that serves to quantify the overall variation in outcome frequency across the hospitals. The difference in the value of σ as each set of characteristics is added to the model then quantifies the amount of variation between hospitals explained by the additional characteristics (e.g., patient and health care provider–hospital characteristics).

SAS software (SAS Institute, Cary, NC) was used for the statistical analyses. Statistical significance was defined as $P < 0.05$ and 95% confidence intervals were calculated for multivariable models. No imputation for missing data was performed.

Results

Of the 115,502 deliveries in the initial APEX cohort, 38,275 met inclusion criteria for the current analysis. There were 77,227 exclusions: 68,729 for multiparity, 5,597 for delivery less than 37 weeks' estimated gestational age, 401 for multiple gestations, 1,591 for non-vertex presentation, and 2 for fetal demise. An additional 907 (0.8%) women were excluded for missing covariables. The covariables with missing data are enumerated in the footnote of Table 2. Approximately half of the women were of non-Hispanic white ethnicity, age 30 or less years at delivery, and had a body mass index (BMI) greater than 30. The majority of deliveries occurred in teaching hospitals (22/25, 88%), were attended by obstetricians and had 24-hour in-house coverage by obstetricians, anesthesiologists, and neonatologists. The median number of hospital deliveries was 4,252 with a range from 877 to 9,262. The median number of hospital nulliparous, term, singleton, vertex deliveries was 1,380 with a range

from 380 to 4,060. The median nulliparous, term, singleton, vertex cesarean frequency was 25.3% with a range from 15.0% to 35.2%. Cesarean frequencies varied across racial and ethnic groups and increased with increasing maternal age and BMI. Complete baseline characteristics of the cohort and the women who underwent cesarean delivery are enumerated in Table 2.

The patient characteristics meeting statistical criteria for inclusion in the risk-adjustment model were maternal age, race-ethnicity, insurance status, BMI, diabetes mellitus, hypertensive disorders, smoking, chorioamnionitis, hydramnios, presence of a fetal anomaly, large for gestational age at birth, and disorders of placentation including abruption, placenta previa, or placenta accreta (Table 3 provides the odds ratios and 95% confidence intervals for variables meeting inclusion criteria). The majority of hospitals (16 of 25) changed rank quintiles after risk-adjustment. There was no significant difference in rankings after risk-adjustment ($p=0.53$); however, three hospitals experienced a two-quartile rank difference, two hospitals experienced a three-quartile rank difference, and one hospital experienced a four-quartile rank difference (Figure 1).

After the patient covariables were entered into the hierarchical model, health care provider–hospital characteristics were evaluated for inclusion in the next level of the model; however, none of the characteristics analyzed met statistical inclusion criteria. Therefore, subsequent analyses evaluating the variation attributable to health care provider–hospital characteristics were not performed.

The variation attributable to the patient characteristics is reflected as changes in hospital odds ratios for nulliparous, term, singleton, vertex cesarean. As demonstrated in Figure 2, adjusting for patient characteristics resulted in an overall trend in the hospitals' odds ratios toward 1.0. This movement indicates that some of the variation in nulliparous, term, singleton, vertex cesarean frequency was accounted for by the patient characteristics included in the model. The σ and standard error for the crude and patient adjusted hierarchical models are provided in Table 4. We quantified the amount of variation attributable to the patient characteristics using the percentage difference in σ , which was equal to 24%.

Discussion

We examined the contribution of patient and health care provider–hospital characteristics to the variation in frequency of nulliparous, term, singleton, vertex cesareans in a multi-institutional U.S. cohort. Hospital nulliparous, term, singleton, vertex cesarean rates varied by an absolute difference of 20%. Patient characteristics accounted for 24% of the variation, whereas the analyzed health care provider–hospital characteristics were not significantly associated with cesarean frequency. Although the majority of the variation (76%) remained unexplained, adjusting for patient characteristics had meaningful implications for hospital rankings.

While the optimal cesarean rate remains debatable, there are persistent concerns regarding overutilization of the procedure in the United States and globally.^{3, 15} A multitude of factors

including differences in case-mix,^{9–11} provider attributes,¹² institutional factors,^{10, 16} and obstetric care practices^{10, 12, 17, 18} have been implicated in disparate cesarean rates. Yet, considerable unexplained variation persists,⁵ and prevention of the primary cesarean remains a focal point for obstetric quality improvement efforts.¹

Our study quantified the amount of variation in the cesarean rate attributable to patient and health care provider–hospital characteristics derived from standardized medical record abstraction. We demonstrated important contributions of case-mix to the variation in nulliparous, term, singleton, vertex cesarean delivery rates. Of note, we were unable to examine whether specific practice differences (e.g., delivery coverage models¹⁹) might account for variation in cesarean delivery rates. Also, we evaluated the type of provider (e.g., midwife, physician) by considering the proportion of vaginal births that are attended by each provider type at each institution. This approach was necessary because the type of provider managing labor may not be constant. The proportion of vaginal births attended by different providers, however, was felt to provide a reasonable approximation of the proportion of care provided in labor.

If unexplained in future studies, the remaining cesarean variation must primarily be attributed to random variation. However, we were unable to examine all potential contributors to cesarean variation. Different approaches to care, also known as process measures, represent a likely source of unexplained variation (e.g., the frequency of operative vaginal delivery or induction of labor among women with an unfavorable cervix). While our omission of process measures may be considered a limitation, we elected not to evaluate their contribution given that all process measures were not applicable to all patients. Yee et al. demonstrated that labor management guideline adherence was not the etiology for disparate cesarean rates in the APEX cohort;²⁰ however, it is important that future studies continue to evaluate the association between process measure performance and nulliparous, term, singleton, vertex cesarean rates. The unexplained variation in our study may also reflect the influences of cultural factors on labor management.²¹ Although these characteristics pose challenges for measurement, regional differences in healthcare utilization were previously associated with cesarean variation.²² We were unable to evaluate the effect of region on cesarean variation due to hospital unmasking. Lastly, unexplained variation at the health care provider–hospital level may be due to an overrepresentation of academic centers and should not discount the importance of providers and hospitals aiming to safely reduce their cesarean rates.

Variation in nulliparous, term, singleton, vertex cesarean rates highlights the potential for quality improvement interventions, which would ideally be directed toward specific sources of variation. However, the implications of using such metrics extend beyond quality improvement in light of the evolving arena of performance-driven reimbursement and the influence of quality metric performance on consumer choice. The implications of risk-adjustment for hospitals in the various rank quintiles of our study are noteworthy as the PC-02 cesarean metric does not require risk-adjustment.¹ The hospitals analyzed were all affiliated with university centers and potentially more similar to one another than hospitals in the general community. While this may limit the generalizability of our findings, it will be important to further evaluate the impact of inclusion of a wider range of hospitals with lower

delivery volumes and lower acuity patients. If such hospitals have similar cesarean variation, it would only magnify the importance of risk-adjustment to facilitate apt comparison of hospital cesarean rates.

Our study has important strengths. We examined the nulliparous, term, singleton, vertex cesarean rate, which is one of the currently utilized obstetric quality metrics. All study data was obtained using standardized medical record abstraction and was not limited by the inaccuracies common to administrative datasets. Additionally, we studied a large cohort of women representing diverse demographic characteristics and U.S. regions.

The nulliparous, term, singleton, vertex cesarean metric has provided useful insight into the marked variation that exists in cesarean delivery rates among hospitals. Yet, our findings also demonstrate that the characteristics of the population that is cared for at different institutions may affect the nulliparous, term, singleton, vertex cesarean rate and have meaningful implications for hospital rankings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The project described was supported by grants from the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) [HD21410, HD27869, HD27915, HD27917, HD34116, HD34208, HD36801, HD40500, HD40512, HD40544, HD40545, HD40560, HD40485, HD53097, HD53118] and the National Center for Research Resources [UL1 RR024989; 5UL1 RR025764]. Comments and views of the authors do not necessarily represent views of the NIH.

The authors thank Dr. Alan T. N. Tita, M.D., Ph.D. for guidance in study design and manuscript preparation; Cynthia Milluzzi, R.N. and Joan Moss, R.N.C., M.S.N. for protocol development and coordination between clinical research centers; and Elizabeth Thom, Ph.D., Madeline M. Rice, Ph.D., Brian M. Mercer, M.D. and Catherine Y. Spong, M.D. for protocol development and oversight.

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Hospital	Cesarean delivery rate	Rank and quintile	Rank and quintile after risk-adjustment*
A	14.96	1	1
B	17.13	2	3
C	20.74	3	22
D	21.21	4	2
E	21.40	5	5
F	21.56	6	7
G	23.30	7	4
H	23.72	8	18
I	24.65	9	21
J	25.14	10	25
K	25.19	11	16
L	25.28	12	12
M	25.30	13	9
N	25.39	14	10
O	25.96	15	8
P	26.92	16	14
Q	27.29	17	13
R	28.25	18	20
S	28.68	19	15
T	29.13	20	6
U	31.39	21	17
V	33.02	22	19
W	33.31	23	23
X	34.34	24	11
Y	35.20	25	24

Figure 1.

Hospital nulliparous, term, singleton vertex cesarean delivery rates, unadjusted ranks and quintiles, and ranks and quintiles after risk-adjustment. *Dark green* indicates first quintile; *light green* indicates second quintile; *yellow* indicates third quintile; *orange* indicates fourth quintile; *red* indicates fifth quintile. There is no significant difference in ranking by Wilcoxon testing ($P=.53$). *Risk-adjustment model included age, race-ethnicity, insurance status, body mass index, diabetes mellitus, hypertensive disorders, smoking, chorioamnionitis, hydramnios, fetal anomaly, large for gestational age, and disorders of placentation.

Figure 2.

Hospital odds ratios for nulliparous, term, singleton vertex cesarean deliveries before and after adjustment for patient characteristics. The *solid line* represents the hospital unadjusted odds ratio and *circles* represent adjusted odds ratios. The *shaded circles* highlight hospitals whose 95% CIs include 1.0. The patient model included age, race–ethnicity, insurance status, body mass index, diabetes mellitus, hypertensive disorders, smoking, chorioamnionitis, hydramnios, fetal anomaly, large for gestational age, and disorders of placentation.

Table 1

Definition of Patient and Health Care Provider–Hospital Covariables

Variables	Categories/details	Definition
Maternal		
Age, years	<20	Age in years on admission.
	20-24.9	
	25-29.9	
	30-34.9	
	40	
Race–ethnicity	Non-Hispanic white	As reported in chart.
	Non-Hispanic black	
	Non-Hispanic Asian	
	Hispanic	
	Other or/not documented	
BMI, kg/m ²	<20	Most recent antepartum weight in medical record. Last height measured in clinic or reported by patient.
	20-24.9	
	25-29.9	
	30-34.9	
	35	
Tobacco use	Yes or/no	Self-identified use.
Cocaine/or methamphetamine use	Yes or/no	Self-identified use or laboratory test positive.
Insurance status	Private	Primary source of medical payment on admission.
Prenatal care	Yes/or no	More than 2 documented prenatal care visits.
Any hypertension	Yes or/no	As documented in medical record including: <ul style="list-style-type: none"> • Chronic hypertension • Gestational hypertension • Preeclampsia • Eclampsia • HELLP syndrome
Diabetes mellitus	None	As documented in medical record.
	Gestational	
	Pregestational	
Amniotic fluid abnormality	Oligohydramnios	Women with intact membranes and most recent US ultrasound (within 2 weeks of hospital admission) with diagnosis of oligohydramnios, amniotic fluid index <5cm, and/or or greatest vertical pocket <2cm.
	Polyhydramnios	Women with most recent US ultrasound (within 2 weeks of hospital admission) with diagnosis of polyhydramnios, amniotic fluid index >24cm, and/or greatest vertical pocket >8cm.
Chorioamnionitis	Yes or no	Suspected antepartum clinical diagnosis of chorioamnionitis.
Prelabor rupture of membranes	Yes or no	Rupture of membranes 12 hours before labor admission.
Disorder of placentation	None	

Variables	Categories/details	Definition
	Abruption	Documentation of vaginal bleeding and/or abruption as indication for admission, induction, cesarean or blood loss.
	Accreta	Documentation of placenta adherent to uterine wall at or after delivery.
	Previa	Documentation of hemorrhage and/or cesarean delivery due to previa.
Neonatal		
EGA at delivery, weeks	37 ⁰ –37 ⁶	Based on best obstetric estimate documented on admission note.
	38 ⁰ –38 ⁶	
	39 ⁰ –39 ⁶	
	40 ⁰ –40 ⁶	
	41 ⁰ –41 ⁶	
	42 ⁰	
Size for gestational age	Small/Appropriate	Estimated as described by Alexander et al (personal communication, G. Alexander, 2000): ²³ <ul style="list-style-type: none"> Small defined as <10th percentile for sex and race–ethnicity Appropriate defined as 10th – 90th percentile for sex and race–ethnicity Large defined as >90th percentile for sex and race–ethnicity
	Large	
Fetal anomaly	Yes or no	Documentation of fetal anomaly after birth or as indication for induction of labor or cesarean delivery.
Health care provider/hospital		
Hospital vaginal deliveries by an OB/GYN or MFM*	%	Total number of vaginal births at each center performed by an OB/GYN or MFM versus midwives and family practitioners, then divided by total vaginal births, then multiplied by 100.
Years since delivery provider graduated training	0-9.9	Number of years since the provider graduated from medical or midwifery school.
	10-14.9	
	15-19.9	
	20-24.9	
	25	
Nurse-to-patient ratio	<1	Total number of nursing hours worked during an 8-hour shift divided by 8, then divided by the number of admissions during the shift.
	1-1.9	
	2-2.9	
	3	
	Unknown	
Prenatal electronic medical record	No	Existence of an electronic medical record during the study period.
	Sometimes	
	Yes	
24-hour in-house service providers	Obstetric anesthesia	In-house presence and availability of providers.
	Attending obstetrician	

Variables	Categories/details	Definition
	Attending pediatrician	Participation in a structured patient review process for laboring patients (e.g., board sign-out during shift change).
	Attending neonatologist	
Attending obstetrician and/or nurses participate in structured patient review	Only nurses present	
	Only obstetricians present	
	Obstetricians and nurses present	

* Included all vaginal births in the Assessment of Perinatal Excellence cohort, n=79,226.

Abbreviations: C/S, cesarean; BMI, body mass index; HELLP, hemolysis, elevated liver enzyme levels, and low platelet levels count; US, ultrasound; PROM, premature rupture of membranes; EGA, estimated gestational age; OB/GYN, obstetrician/gynecologist; MFM, maternal-fetal medicine.

Table 2

Baseline patient and health care provider–hospital characteristics

Variables	Cohort (n=38,275)	Cesarean delivery (n=10,269)
Age, years *		
<20	6,846 (17.9)	1,225 (11.9)
20-24.9	9,959 (26.0)	2,336 (22.8)
25-29.9	9,855 (25.8)	2,654 (25.8)
30-34.9	8,043 (21.0)	2,476 (24.1)
35	3,572 (9.3)	1,578 (15.4)
Race-Ethnicity *		
Non-Hispanic white	18,714(48.9)	4,866 (47.4)
Non-Hispanic black	7,765 (20.3)	2,287 (22.3)
Non-Hispanic Asian	2,581 (6.7)	769 (7.5)
Hispanic	6,890 (18.0)	1,715 (16.7)
Other or not documented	2,325 (6.1)	632 (6.2)
BMI at delivery, kg/m ² *		
<25	5,209 (13.6)	715 (7.0)
25-29.9	14,964 (39.1)	3,168 (30.9)
30-34.9	10,455 (27.3)	3,168 (30.9)
35-39.9	4,596 (12.0)	1,688 (16.4)
40	3,051 (8.0)	1,530 (14.9)
Tobacco use *	3,202 (8.4)	921(9.0)
Cocaine or methamphetamine use	121 (0.3)	33 (0.3)
Insurance status *		
Private	21,737 (56.8)	6,249 (60.9)
Prenatal care (2 or more visits) †	36,300 (94.8)	9,705 (94.5)
Any hypertension *	4,672 (12.2)	1,754 (17.1)
Diabetes mellitus *		
None	36,198 (94.6)	9,357 (91.1)
Gestational	1,745 (4.6)	715 (7.0)
Pregestational	332 (0.9)	197 (1.9)
Amniotic fluid abnormality *		
Oligohydramnios	1,756 (4.6)	616 (6.0)
Polyhydramnios	242 (0.6)	150 (1.5)
Chorioamnionitis *	3,424 (9.0)	1,439 (14.0)
Prelabor rupture of membranes	4,547 (11.9)	1,225 (11.9)
Disorder of placentation *		

Variables	Cohort (n=38,275)	Cesarean delivery (n=10,269)
Abruption	164 (0.4)	88 (0.9)
Placenta accreta	15 (0.04)	7 (0.07)
Placenta previa	60 (0.2)	60 (0.6)
EGA at delivery, weeks		
37 ⁰ –37 ⁶	3,250 (8.5)	817 (8.0)
38 ⁰ –38 ⁶	6,512 (17.0)	1,503 (14.6)
39 ⁰ –39 ⁶	11,600 (30.3)	2,943 (28.7)
40 ⁰ –40 ⁶	11,374 (29.7)	3,057 (29.8)
41 ⁰ –41 ⁶	5,213 (13.6)	1,792 (17.5)
42 ⁰	326 (0.9)	157 (1.5)
Large for gestational age ^{*,23}	2,393 (6.3)	1,212 (11.8)
Fetal anomaly [*]	953 (2.5)	351 (3.4)
Percentage of hospital vaginal deliveries by an OB/GYN or MFM [‡]	90.4 (76.0 -100)	
Years since birth attendant completed training [§]		
0-9.9	9,116 (24.1)	2,339 (23.1)
10-14.9	7,285 (19.3)	1,927 (19.0)
15-19.9	6,519 (17.3)	1,836 (18.1)
20-24.9	5,358 (14.2)	1,509 (14.9)
25	9,492 (25.1)	2,520 (24.9)
Nurse-to-patient ratio		
<1	9,601 (25.1)	2,573 (25.1)
1-1.9	19,195 (50.2)	5,136 (50.0)
2-2.9	5,752 (15.0)	1,516 (14.8)
3	3,531 (9.2)	990 (9.6)
Unknown	196 (0.5)	54 (0.5)
Prenatal electronic medical record		
No	15,372 (40.2)	4,010 (39.1)
Sometimes	12,643 (33.0)	3,248 (31.6)
Yes	10,260 (26.8)	3,011 (29.3)
24-hour in-house service providers		
Obstetric anesthesia	33,777 (88.3)	9,046 (88.1)
Attending obstetrician	33,768 (88.2)	9,209 (89.7)
Attending pediatrician	1,471 (27.6)	408 (4.0)
Attending neonatologist	32,850 (85.8)	8,858 (86.3)
Attending obstetrician or nurses participate in structured patient review		
Only nurses present	4,775 (12.5)	1,091 (10.6)
Only obstetricians present	13,655 (35.7)	3,878 (37.8)
Obstetricians and nurses present	17,495 (45.7)	4,559 (44.4)

All values presented as n (%) or median (interquartile range).

* Variables met statistical inclusion criteria for the risk-adjustment and hierarchical model.

[†] Total n=36,610 for this variable due to 1,665 missing values.

[‡] Variable included all vaginal births in the Assessment of Perinatal Excellence cohort (n=79,226); therefore, a value for cesarean delivery is not provided.

[§] Total n=37,770 for this variable due to 505 missing values.

Abbreviations: BMI, body mass index; EGA, estimated gestational age; OB/GYN, obstetrician/gynecologist; MFM, maternal-fetal medicine.

Table 3

Odds ratios and 95% confidence intervals for patient characteristics in final hierarchical model for nulliparous, term, singleton, vertex cesarean deliveries

Variables	Hierarchical model with patient characteristics OR (95% CI)
Maternal	
Age, years	
<20	1.0 (ref)
20-24.9	1.37 (1.26-1.49)
25-29.9	1.74 (1.59-1.90)
30-34.9	2.32 (2.10-2.55)
35	4.06 (3.63-4.53)
Race/ethnicity	
Non-Hispanic white	1.0 (ref)
Non-Hispanic black	1.47 (1.36-1.59)
Non-Hispanic Asian	1.27 (1.14-1.40)
Hispanic	1.15 (1.06-1.26)
Other/not documented	1.16 (1.04-1.30)
BMI at delivery, kg/m ²	
<25	1.0 (ref)
25-29.9	1.60 (1.46-1.75)
30-34.9	2.50 (2.28-2.75)
35-39.9	3.16 (2.85-3.52)
40	5.24 (4.67-5.88)
Insurance status	
Private	1.0 (ref)
Government assisted or none	0.92 (0.85-0.99)
Any hypertension	1.36 (1.26-1.46)
Tobacco use	1.23 (1.12-1.35)
Diabetes mellitus	
None	1.0 (ref)
Gestational	1.32 (1.19-1.48)
Pregestational	2.30 (1.80-2.94)
Amniotic fluid abnormality	
Oligohydramnios	1.58 (1.41-1.76)
Polyhydramnios	3.16 (2.37-4.22)
Chorioamnionitis	2.15 (1.97-2.35)
Placental abnormality (abruption, accreta, or previa)	5.35 (3.96, 7.23)
Neonatal	
Size for gestational age ²³	

Variables	Hierarchical model with patient characteristics OR (95% CI)
Small/appropriate	1.0 (ref)
Large	2.40 (2.19-2.64)
Fetal anomaly	1.66 (1.42-1.93)

Abbreviations: OR, odds ratio; CI, confidence interval; BMI, body mass index.

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Table 4

Hospital variation (σ) in nulliparous, term, singleton, vertex cesarean frequency after adjustment for patient characteristics

Outcome	Crude hierarchical regression	Hierarchical regression with patient characteristics
NTSV Cesarean	0.06937 (0.02146)	0.05260 (0.01685)

All values presented as σ (standard error).