OBSTETRICS

A new index for obstetrics safety and quality of care: integrating cesarean delivery rates with maternal and neonatal outcomes

Sangeeta Ramani, MD; Tara A. Halpern, PA-C; Meredith Akerman, MS; Cande V. Ananth, PhD, MPH; Anthony M. Vintzileos, MD

BACKGROUND: Cesarean delivery rates have been used as obstetrical quality indicators. However, these approaches do not consider the accompanying maternal and neonatal morbidities. A challenge in the field of obstetrics has been to establish a valid outcomes quality measure that encompasses preexisting high-risk maternal factors and associated maternal and neonatal morbidities and is universally acceptable to all stakeholders, including patients, healthcare providers, payers, and governmental agencies.

OBJECTIVE: This study aimed to (1) establish a new single metric for obstetrical quality improvement among nulliparous patients with term singleton vertex-presenting fetus, integrating cesarean delivery rates adjusted for preexisting high-risk maternal factors with associated maternal and neonatal morbidities, and (2) determine whether obstetrician quality ranking by this new metric is different compared with the rating based on individual crude and/or risk-adjusted cesarean delivery rates. The single metric has been termed obstetrical safety and quality index.

STUDY DESIGN: This was a cross-sectional study of all nulliparous patients with term singleton vertex-presenting fetuses delivered by 12 randomly chosen obstetricians in a single institution. A review of all records was performed, including a review of maternal high-risk factors and maternal and neonatal outcomes. Maternal and neonatal medical records were reviewed to determine crude and adjusted cesarean delivery rates by obstetricians and quantify maternal and neonatal complications. We estimated the obstetrician-specific crude cesarean delivery rates and rates adjusted for obstetrician-specific maternal and neonatal complications from logistic regression models. From this model, we derived the obstetrical safety and quality index for each obstetrician. The final ranking based on the obstetrical safety and quality index was compared with the initial ranking by crude cesarean delivery rates. Maternal and neonatal morbidities were analyzed as ≥1 and ≥2 maternal and/or neonatal complications.

RESULTS: These 12 obstetricians delivered a total of 535 women; thus, 1070 (535 maternal and 535 neonatal) medical records were reviewed to determine crude and adjusted cesarean delivery rates by obstetricians and quantify maternal and neonatal complications. The ranking of crude cesarean delivery rates was not correlated (rho=0.05; 95% confidence interval, −0.54 to 0.60) to the final ranking based on the obstetrical safety and quality index. Of note, 8 of 12 obstetricians shifted their rank quartiles after adjustments for high-risk maternal conditions and maternal and neonatal outcomes. There was a strong correlation between the ranking based on ≥1 maternal and/or neonatal complication and ranking based on ≥2 maternal and/or neonatal complications (rho=0.63; 95% confidence interval, 0.08−0.88).

CONCLUSION: Ranking based on crude cesarean delivery rates varied significantly after considering high-risk maternal conditions and associated maternal and neonatal outcomes. Therefore, the obstetrical safety and quality index, a single metric, was developed to identify ways to improve clinician practice standards within an institution. Use of this novel quality measure may help to change initiatives geared toward patient safety, balancing cesarean delivery rates with optimal maternal and neonatal outcomes. This metric could be used to compare obstetrical quality not only among individual obstetricians but also among hospitals that practice obstetrics.

Key words: cesarean ranking, composite maternal morbidity, composite neonatal morbidity, crude or adjusted cesarean delivery rates, intrapartum, maternal outcomes, neonatal outcomes, nulliparous, obstetrical medical high-risk conditions, obstetrical quality, quality metric, singleton, term, vertex

Introduction

One of the most important challenges in obstetrics is to establish a single valid outcomes quality measure that can be acceptable to all stakeholders, including patients, healthcare providers, payers, and governmental agencies. As the rising cesarean delivery rates in the United States have been associated with varied concomitant effects on maternal or neonatal morbidity and mortality,[1−6] cesarean delivery rates have been used as a quality measure in comparing obstetricians or hospitals.[7−9] As primary cesarean deliveries contribute approximately 50% to the cesarean delivery rate in the United States, Healthy People 2020 has put forward the objective to reduce cesarean delivery rates to <24.7% among nulliparous with term singleton vertex (NTSV) presenting fetuses, using this as a quality metric of obstetrical care.[10−13] However, the so-defined crude cesarean delivery rates do not consider precesarean delivery high-risk maternal factors or associated maternal and neonatal morbidities.

Therefore, this study aimed to (1) establish a new metric for obstetrical quality improvement among NTSV patients, integrating cesarean delivery rates

Cite this article as: Ramani S, Halpern TA, Akerman M, et al. A new index for obstetrics safety and quality of care: integrating cesarean delivery rates with maternal and neonatal outcomes. Am J Obstet Gynecol 2022;226:556.e1-9.

0002-9378/$36.00

https://doi.org/10.1016/j.ajog.2021.10.005

Click Video under article title in Contents at **ajog.org**

AJOG at a Glance

Why was this study conducted?

Currently, crude or adjusted cesarean delivery rates and neonatal outcomes have been used separately as quality metrics in obstetrics. This study aimed to establish a new single obstetrical quality metric that integrates cesarean delivery rates adjusted for preexisting high-risk maternal factors with maternal and neonatal morbidities.

Key findings

Individual physician ranking based on crude cesarean delivery rates varied significantly after considering high-risk maternal conditions and associated maternal and neonatal outcomes.

What does this add to what is known?

Our single obstetrical quality and safety measure can be used to safely balance cesarean delivery rates with maternal and neonatal mortalities. In addition, this metric could be used to compare obstetrical quality not only among individual obstetricians but also among hospitals or health systems.

adjusted for preexisting maternal high-risk factors and associated maternal and neonatal morbidities (termed obstetrical safety and quality index [OSQI]), and (2) determine whether obstetrician quality ranking by this new metric is different compared with the rating based on individual crude and/or risk-adjusted cesarean delivery rates.

Material and Methods

We conducted a cross-sectional study that used the electronic obstetrical database of the NYU Langone Hospital—Long Island (NYU Winthrop Hospital). We identified all NTSV patients by delivering obstetrician in 2016. The NTSV definition included nulliparous, term (≥37 completed weeks of gestation), singleton gestations with vertex (cephalic) presentation. The hospital is a regional perinatal center with approximately 5000 annual deliveries. Patients of obstetricians who delivered <12 NTSV subjects in 2016 were excluded from the analysis. The focus of this analysis was 12 of 40 individual obstetricians chosen randomly who had performed at least 12 deliveries. All obstetricians had been practicing for at least 10 years; of these obstetricians, 5 were faculty and 7 were private practitioners. The obstetrical and neonatal records of all NTSV patients of these 12 obstetricians were reviewed to verify and record maternal demographic characteristics, precesarean delivery high-risk maternal factors, and maternal and neonatal complications.

Crude and risk-adjusted cesarean delivery rates were determined for each delivering obstetrician. We derived a risk-adjusted cesarean delivery rate for each of the 12 obstetricians after considering maternal demographic factors, including maternal age, body mass index (BMI) at delivery, smoking, racial and ethnic group (non-Hispanic White, non-Hispanic Black, Hispanic, Asian, other), and antepartum maternal complications. Other precesarean delivery risk factors considered for adjustment of obstetrician-specific cesarean delivery rates included chronic hypertension, gestational hypertension, preeclampsia or eclampsia, pregestational or gestational diabetes mellitus, prelabor vaginal bleeding, placenta previa, polyhydramnios, oligohydramnios, history of preterm labor, tocolysis, short midtrimester cervix, cerclage, and major maternal medical disease (Table 1 provides detailed listing).

Composite maternal morbidity (CMM) was defined as any of the following complications experienced by women: perineal lacerations (third or fourth degree), chorioamnionitis or endometritis, postpartum hemorrhage requiring blood transfusion, postpartum hysterectomy, wound infection or separation, venous thromboembolism, or admission to the intensive care unit. Composite neonatal morbidity (CNM) was defined as any of the following complications experienced by neonates: umbilical cord artery pH of <7.00, 5-minute Apgar score of <7, any respiratory distress requiring mechanical ventilation, meconium aspiration, intraventricular hemorrhage, necrotizing enterocolitis, sepsis, pneumonia, seizures, hypoxic-ischemic encephalopathy, shoulder dystocia, trauma, brain or body cooling, or admission to the neonatal intensive care unit (NICU) for other reasons. Combined CMM and/or CNM rate was defined as the proportion of cases that suffered any (≥1) CMM or CNM. The OSQI for each obstetrician was determined by adjusting the cesarean delivery rates for precesarean delivery high-risk factors and observed CMM and CNM. The same analysis was repeated by defining combined CMM and/or CNM as the proportion of cases that suffered ≥2 CMM and/or CNM.

Here, the second objective was to determine whether the ranking of individual obstetricians based on OSQI results is significantly different compared with the ranking based on crude or risk-adjusted cesarean delivery rates. For this purpose, we used Spearman rank correlation tests to compare the ranking based on crude and adjusted cesarean delivery rates with the final OSQI rankings.

Statistical analysis

Overall descriptive statistics (mean±standard deviation for continuous measures and frequency and percentage for categorical variables) were calculated. Crude cesarean delivery rates were calculated for each obstetrician. Univariate analyses were performed to compare cesarean deliveries and vaginal deliveries for patient demographics, clinical characteristics, and comorbidities. The chi-square test or Fisher exact probability test for categorical variables (ie, race and ethnicity, smoking status, chronic hypertension), and the 2-sample *t* test or Mann-Whitney test for continuous measures (ie, maternal age,

TABLE 1
Patient demographic characteristics

Characteristic	Total population (N=535)	Cesarean delivery (n=183)	Vaginal delivery (n=352)	*P* value
Maternal age (y)	28.9±6.0	30.4±6.0	28.0±5.8	<.001
<20	12 (2.2)	3 (1.6)	9 (2.6)	
20–34	434 (81.1)	134 (73.2)	300 (85.2)	
≥35	89 (16.6)	46 (25.1)	43 (12.2)	
Body mass index (kg/m^2)	32.1±6.1	33.5±6.6	31.3±5.7	<.001
Race and ethnicity				.130
White	328 (61.3)	110 (60.1)	218 (61.9)	
Black	66 (12.3)	28 (15.3)	38 (10.8)	
Hispanic	60 (11.2)	14 (7.6)	46 (13.1)	
Asian	31 (5.8)	15 (8.2)	16 (4.6)	
Other	31 (5.8)	11 (6.0)	20 (5.7)	
Unknown	19 (3.6)	5 (2.7)	14 (4.0)	
Gestational diabetes mellitus	41 (7.7)	21 (11.5)	20 (5.7)	.017
Gestational age (wk)	39.4±1.1	39.6±1.1	39.3±1.1	.008
Other medical conditions[a]	21 (3.9)	7 (3.8)	14 (4.0)	.932

Data are presented as mean±standard deviation or number (percentage), unless otherwise indicated.

[a] Chronic hypertension, pregestational diabetes mellitus, cardiac disease, and other conditions, including pyelonephritis, renal colic, alcohol use, substance abuse, viral hepatitis, and syncope.

Ramani et al. A new index for obstetrical safety and quality of care. Am J Obstet Gynecol 2022.

gestational age, BMI, previous number of miscarriages) were used, as deemed appropriate, to compare the distribution of risk factors by cesarean delivery status. Variables that were significant in the univariate analysis and were clinically relevant (maternal age, gestational age, BMI, and gestational diabetes mellitus) were included for adjustment in a multivariable logistic regression model for cesarean delivery. Adjusted cesarean delivery rates by provider were calculated from this model by applying the inverse-link transformation to the least-squares means estimated from the logistic regression model. A similar adjusted model (using the same risk factors) was applied to the combined CMM and/or CNM outcomes to calculate the adjusted OSQI of each obstetrician. The Spearman rank correlation coefficient was used to estimate the association between the final OSQI rankings and crude and adjusted cesarean delivery rates. A result was considered statistically significant at $P<.05$ level of significance. All analyses were performed using SAS (version 9.4; SAS Institute Inc, Cary, NC).

Results

The electronic medical records (EMRs) of 535 NTSV patients and neonates (a total of 1070 medical records) were reviewed. Of the 535 deliveries, 247 (46%) were performed by faculty, and 288 (54%) were performed by private obstetricians. These proportions were representative of the breakdown of deliveries performed by faculty and private practitioners in our hospital. Of these deliveries, 188 (34.2%) were delivered by cesarean delivery by the 12 obstetricians. Table 1 summarizes the demographic characteristics of patients. The cesarean delivery rates ranged from 23.1% to 71.4% across obstetricians. Table 2 ranks providers based on their individual crude cesarean delivery rates from lowest to highest. In addition, corresponding CMM and CNM for each provider were calculated, along with combined CMM and/or CNM rate. The distributions of maternal age, BMI, and gestational age were substantially different by cesarean delivery status (all $P<.01$), as was gestational diabetes mellitus ($P=.02$); therefore, these factors were included in the final models for adjustment. The adjusted cesarean delivery rates ranged from 20.0% to 65.6%.

Based on the individual adjusted cesarean delivery rates, the ranking of 6 of 12 providers was altered (Table 3). Similarly, the unadjusted composite outcome rate (ie, combined CNM or CMM) altered the provider ranking when adjusting for the same covariates (Table 3). The final column of adjusted composite outcome rate corresponded to the OSQI, considering maternal pre-cesarean delivery high-risk factors and associated maternal and neonatal morbidity outcomes. The lower the OSQI, the higher the quality as it is built fundamentally on cesarean delivery rates adjusted for maternal high-risk factors and the accompanying neonatal and maternal morbidities. Furthermore, 8 of 12 (66%) obstetricians shifted their rank

TABLE 2
Ranking based on crude cesarean delivery rates and rates of composite maternal morbidity and composite neonatal morbidity

Obstetrician[a]	Unadjusted cesarean delivery rate	CMM[b]	CNM[b]	CMM[b] and/or CNM[b]
1	6/26 (23.1)	3/26 (11.5)	7/26 (26.9)	8/26 (30.8)
2	8/33 (24.2)	5/33 (15.2)	5/33 (15.2)	8/33 (24.2)
3	19/72 (26.4)	11/72 (15.3)	24/72 (33.3)	27/72 (37.5)
4	28/102 (27.5)	7/102 (6.8)	28/102 (27.5)	29/102 (28.4)
5	27/89 (30.3)	12/89 (13.5)	19/89 (21.3)	22/89 (24.7)
6	4/12 (33.3)	1/12 (8.3)	3/12 (25.0)	4/12 (33.3)
7	8/23 (34.8)	0/23 (0)	1/23 (4.3)	1/23 (4.3)
8	15/41 (36.6)	6/41 (14.6)	11/41 (26.8)	13/41 (31.7)
9	14/37 (37.8)	7/37 (18.9)	12/37 (32.4)	13/37 (35.1)
10	17/41 (41.5)	6/41 (14.6)	13/41 (31.7)	15/41 (36.6)
11	12/24 (50.0)	6/24 (25.0)	8/24 (33.3)	10/24 (41.7)
12	25/35 (71.4)	2/35 (5.7)	7/35 (20.0)	7/35 (20.0)

Data are presented as number/total number (percentage).

CMM, composite maternal morbidity; *CNM*, composite neonatal morbidity.

[a] The obstetricians were rank ordered based on their crude cesarean delivery rates; [b] Defined as ≥1 maternal and/or neonatal complications.

Ramani et al. A new index for obstetrical safety and quality of care. Am J Obstet Gynecol 2022.

quartiles after adjustments for high-risk maternal conditions and maternal and neonatal outcomes (Table 3). Those who were ranked 4, 9, 10, and 11 stayed in the same quartiles. There was no correlation between the initial crude cesarean delivery ranking of obstetricians and the final OSQI ranking, based on the Spearman correlation analysis (rho=0.05; 95% confidence interval [CI], −0.54 to 0.60). There was also no correlation between the adjusted cesarean delivery ranking of obstetricians and the final OSQI ranking (rho=−0.10; 95% CI, −0.63 to 0.51).

In addition, the OSQI was evaluated using ≥2 maternal and/or neonatal complications (Supplemental Tables 1 and 2). Based on this definition, there was no correlation between the initial crude cesarean delivery ranking of obstetricians and the final OSQI ranking (Spearman rho=−0.15; 95% CI, −0.66 to 0.47). There was also no correlation between the adjusted cesarean ranking of obstetricians and the final OSQI ranking (Spearman rho=−0.27; 95% CI, −0.73 to 0.36). Only 3 obstetricians (4, 8, and 10) remained in the same quartiles. However, there was a strong correlation between the ranking based on ≥1 CMM and/or CNM vs ranking based on ≥2 CMM and/or CNM (Spearman rho=0.63; 95% CI, 0.08−0.88).

Comment

Principal findings

The main findings of this study were that a single metric, our OSQI, which combines cesarean delivery rates adjusted not only for high-risk maternal factors but also for associated maternal and neonatal morbidities, provided a complete quality profile, leading to a significantly different ranking in terms of obstetrical care quality. This new metric that allows for a more robust evaluation compared with crude or adjusted cesarean delivery rates could be used to compare obstetrical quality not only among individual obstetricians or units but also among hospitals or health systems. Therefore, this study illustrated the importance of reevaluating current quality metrics and the need to incorporate additional health indicators combining both maternal and neonatal health.

One key outcome discovered was that the ranking of crude cesarean delivery rates was not correlated to the final adjusted composite outcome rate (OSQI) regardless of the definition of outcomes used (≥1 or ≥2 maternal and/or neonatal complications). The sample size of 12 obstetricians was not large, but the rho values and wide CIs made the possibility of type II errors very unlikely. Our findings underscored that the cesarean delivery ranking of 12 obstetricians differed after accounting for maternal and neonatal outcomes. In fact, 8 of 12 obstetricians shifted quartiles after adjustments for maternal and neonatal outcomes when using ≥1 maternal and/or neonatal complication, and 9 of 12 obstetricians shifted quartiles after adjustments for maternal and neonatal outcomes when ≥2 maternal and/or neonatal complications were used as outcomes of interest This suggested that the OSQI could be useful to rank the quality of obstetricians within an institution and function as a comprehensive quality measure for obstetrics. Furthermore, it should be emphasized that there was a strong

TABLE 3
Ranking based on unadjusted and adjusted (obstetrical safety and quality index) composite outcome rates

	Cesarean delivery (%)			Composite outcome (CMM and/or CNM) (%)[a]		
Obstetrician	Unadjusted (ranking)	Adjusted (ranking)[b]	Difference (%)	Unadjusted (ranking)	Adjusted (ranking) (OSQI)	Difference (%)
1	23.1 (1)	20.0 (1)	−3.1	30.8 (6)	34.3 (9)	+3.5
2	24.2 (2)	28.8 (4)	+4.6	24.2 (3)	25.2 (4)	+0.9
3	26.4 (3)	27.8 (3)	+1.4	37.5 (11)	36.9 (10)	−0.6
4	27.5 (4)	23.6 (2)	−3.9	28.4 (5)	27.9 (5)	−0.5
5	30.3 (5)	34.3 (8)	+4.0	24.7 (4)	24.7 (3)	−0.1
6	33.3 (6)	29.3 (5)	−4.0	33.3 (8)	33.0 (8)	−0.4
7	34.8 (7)	31.7 (7)	−3.1	4.3 (1)	3.6 (1)	−0.7
8	36.6 (8)	39.3 (10)	+2.7	31.7 (7)	30.8 (6)	−0.9
9	37.8 (9)	30.4 (6)	−7.4	35.1 (9)	31.6 (7)	−3.6
10	41.5 (10)	37.6 (9)	−3.9	36.6 (10)	38.7 (11)	+2.1
11	50.0 (11)	44.0 (11)	−6.0	41.7 (12)	41.6 (12)	−0.1
12	71.4 (12)	65.6 (12)	−5.8	20.0 (2)	15.9 (2)	−4.1

CMM, composite maternal morbidity; *CNM*, composite neonatal morbidity; *OSQI*, obstetrical safety and quality index.

[a] Defined as ≥1 maternal and/or neonatal complication; [b] Adjusted for the following maternal factors: maternal age, body mass index, gestational age, and gestational diabetes mellitus.

Ramani et al. A new index for obstetrical safety and quality of care. Am J Obstet Gynecol 2022.

correlation between the 2 final rankings (≥1 vs ≥2 CMM and/or CNM), indicating that the associated final rankings are significantly related to one another, no matter how the composite CMM and/or CNM is defined.

Results in the context of what is known

Previous studies have identified cesarean delivery rates by individual provider, institution, or region of the United States. However, quality assurance practices and safety programs vary from hospital to hospital.[14,15] A retrospective study examined approximately 17,000 primiparous women with singletons in Georgia and determined a crude cesarean delivery rate of 37.1%, with variations by region and certain predisposing factors, such as maternal age, obesity, and baby weight of ≥4000 g.[16] Arguably, the risk-adjusted, rather than crude, cesarean delivery rate may be a more appropriate quality measure. Although adjusting for these predisposing factors may help to establish less cofounded rates, proponents of crude cesarean delivery rate argue that adjusting for high-risk factors does not necessarily alter the individual risk for cesarean delivery.[17]

Another aspect of the controversy surrounding crude vs risk-adjusted cesarean delivery rate is the rate of adverse maternal and neonatal outcomes. Studies have shown that lower than expected cesarean delivery rates (crude or risk-adjusted) are associated with increased risk of adverse maternal and neonatal outcomes not only for primiparous pregnancies but also for multiparous pregnancies.[17] Therefore, it may not be reasonable to solely use crude or risk-adjusted cesarean rates as a safety or quality measure without considering the rate of associated adverse maternal and neonatal outcomes. In addition, overall maternal and neonatal morbidity rates have been shown to portend substantial variability across hospitals and, importantly, by the type of hospital. Therefore, assessing maternal and neonatal outcomes would allow for a more comprehensive assessment of the quality of a hospital.[18]

Previous studies have correlated cesarean deliveries with worsening maternal and/or neonatal outcomes. One cross-sectional study identified approximately 2000 pregnant women who delivered between August 2014 and December 2016 in Thailand and found that cesarean deliveries significantly increased the risk of severe adverse maternal outcomes (defined by maternal death, organ dysfunction, life-threatening condition within 7 days of delivery) and severe adverse neonatal outcomes (defined by neonatal death, neonatal resuscitation, 5-minute Apgar score of <7, or admission to the NICU occurring within 7 days after delivery).[19] Furthermore, other factors that may worsen maternal mortality have been described in detail in the literature, such as unintended births, unmarried status, non-Hispanic Black women ethnicity, and cesarean deliveries.[20]

Like previous studies, our study supported that the ideal way to assess an obstetrician's or hospital's performance is by combining maternal and neonatal outcomes, as it is widely known that

these individually vary between obstetricians and hospitals.[18] Our proposed single metric OSQI integrates adjusted cesarean delivery rates with maternal and neonatal outcomes into 1 succinct formula and can be used to rank and evaluate the quality of obstetricians or institutions.

Clinical implications

The results of our study have several important clinical implications. Minimizing overall cesarean delivery rates and encouraging vaginal delivery have been important goals worldwide.[3,21,22] However, cesarean delivery rates with their corresponding maternal and neonatal outcomes have not consistently been evaluated. Studies have shown that it is challenging to capture obstetrical hospital quality, as there are 2 groups involved that are being taken care of: mother and baby.[23] On an institution-wide level, by using the new OSQI, resources may be better allocated toward improving maternal and neonatal outcomes in areas where this quality indicator may reveal a deficiency manifested by increasing OSQI: the goal being to decrease OSQI, therefore improving overall obstetrical outcomes.

Research implications

Weiss et al[24] collected various maternal and neonatal adverse events and assigned weighted scores based on the severity of the event, such as uterine rupture, which received more points than perineal lacerations. The scores of these events were summed and subsequently divided by the total number of deliveries. Future research using a similar methodology but considering the entire combined maternal and neonatal outcomes is urgently needed.

Strengths and limitations

Study strengths included moderate sample size, robust evaluation and detailed analysis of all possible preexisting maternal high-risk factors, and detailed collection of all maternal and neonatal outcomes until discharge from the hospital. However, extracting this detailed information from maternal and neonatal records was time-consuming. We hope that EMRs can develop systems to capture all such detailed data shortly. Study limitations included a single institution review, inclusion of only a fraction of practicing obstetricians, and the unknown generalizability of this tool to other hospital systems. Therefore, findings should be confirmed and validated by other centers or institutions. In addition, arguments could be made about using different definitions or scoring for maternal or fetal outcomes, but the concept of using all outcomes (maternal high-risk factors combined with maternal and neonatal outcomes) will remain the same. Our proposed quality index uniquely integrates the mode of delivery with corresponding maternal and neonatal outcomes. Hopefully, future studies using different methodologies can consider the severity of the associated maternal and neonatal complications and may offer new insights into obstetrical quality measures.

Conclusions

We developed a new tool that may function as a comprehensive quality measure of obstetrical care. Use of this novel quality measure may help to change initiatives geared toward patient safety, balancing reduction of cesarean delivery rates and achieving the most optimal maternal and neonatal outcomes. The OSQI helps to identify potential ways to improve clinician practice standards and to highlight areas of improvement within an institution and among institutions. Future research should focus on the usefulness of the OSQI to improve obstetrical care. ■

References

1. Gregory KD, Jackson S, Korst L, Fridman M. Cesarean versus vaginal delivery: whose risks? Whose benefits? Am J Perinatol 2012;29:7–18.
2. Ananth CV, Vintzileos AM. Trends in cesarean delivery at preterm gestation and association with perinatal mortality. Am J Obstet Gynecol 2011;204:505.e1–8.
3. Lipschuetz M, Guedalia J, Rottenstreich A, et al. Prediction of vaginal birth after cesarean deliveries using machine learning. Am J Obstet Gynecol 2020;222:613.e1–12.
4. Cohen WR, Friedman EA. Guidelines for labor assessment: failure to progress? Am J Obstet Gynecol 2020;222:342.e1–4.
5. Wagner SM, Bell CS, Gupta M, et al. Interventions to decrease complications after shoulder dystocia: a systematic review and Bayesian meta-analysis. Am J Obstet Gynecol 2021 [Epub ahead of print].
6. Pavličev M, Romero R, Mitteroecker P. Evolution of the human pelvis and obstructed labor: new explanations of an old obstetrical dilemma. Am J Obstet Gynecol 2020;222:3–16.
7. Metz TD, Allshouse AA, Gilbert SAB, Doyle R, Tong A, Carey JC. Variation in primary cesarean delivery rates by individual physician within a single-hospital laborist model. Am J Obstet Gynecol 2016;214:531.e1–6.
8. Lundsberg LS, Illuzzi JL, Gariepy AM, et al. Variation in hospital intrapartum practices and association with cesarean rate. J Obstet Gynecol Neonatal Nurs 2017;46:5–17.
9. Robson MS. The 10-Group Classification System-a new way of thinking. Am J Obstet Gynecol 2018;219:1–4.
10. 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.
11. Hehir MP, Ananth CV, Siddiq Z, Flood K, Friedman AM, D'Alton ME. Cesarean delivery in the United States 2005 through 2014: a population-based analysis using the Robson 10-Group Classification System. Am J Obstet Gynecol 2018;219:105.e1–11.
12. Office of Disease Prevention and Health Promotion. Reduce cesarean births among low-risk women with no prior births. Healthy People 2020. 2021. Available at: https://www.healthypeople.gov/2020/data-search/Search-the-Data?nid=4900. Accessed August 30, 2021.
13. Cross SN, Greenberg JT, Pettker CM, Raab CA, Illuzzi JL. Indications contributing to the decreasing cesarean delivery rate at an academic tertiary center. Am J Obstet Gynecol MFM 2019;1:165–72.
14. Lundsberg LS, Lee HC, Dueñas GV, et al. Quality assurance practices in obstetric care: a survey of hospitals in California. Obstet Gynecol 2018;131:214–23.
15. Mehlhaff KM, Pettker CM. Establishing and maintaining a quality and safety program on labor and delivery. Clin Obstet Gynecol 2019;62:572–9.
16. Nedberg IH, Rylander C, Skjeldestad FE, Blix E, Ugulava T, Anda EE. Factors associated with cesarean section among primiparous women in Georgia: a registry-based study. J Epidemiol Glob Health 2020;10:337–43.
17. Srinivas SK, Fager C, Lorch SA. Evaluating risk-adjusted cesarean delivery rate as a measure of obstetric quality. Obstet Gynecol 2010;115:1007–13.
18. Campbell KH, Illuzzi JL, Lee HC, et al. Optimal maternal and neonatal outcomes and associated hospital characteristics. Birth 2019;46:289–99.
19. Kongwattanakul K, Thamprayoch R, Kietpeerakool C, Lumbiganon P. Risk of severe adverse maternal and neonatal outcomes in

deliveries with repeated and primary cesarean deliveries versus vaginal deliveries: a cross-sectional study. J Pregnancy 2020;2020:9207431.
20. Moaddab A, Dildy GA, Brown HL, et al. Health care disparity and pregnancy-related mortality in the United States, 2005-2014. Obstet Gynecol 2018;131:707–12.
21. Visser GHA, Ayres-de-Campos D, Barnea ER, et al. FIGO position paper: how to stop the caesarean section epidemic. Lancet 2018;392:1286–7.
22. Smith V, Gallagher L, Carroll M, Hannon K, Begley C. Antenatal and intrapartum interventions for reducing caesarean section, promoting vaginal birth, and reducing fear of childbirth: an overview of systematic reviews. PLoS One 2019;14:e0224313.
23. Howell EA, Zeitlin J, Hebert PL, Balbierz A, Egorova N. Association between hospital-level obstetric quality indicators and maternal and neonatal morbidity. JAMA 2014;312:1531–41.
24. Weiss D, Fell DB, Sprague AE, et al. Effect of implementation of the MORE ^{OB} program on adverse maternal and neonatal birth outcomes in Ontario, Canada: a retrospective cohort study. BMC Pregnancy Childbirth 2019;19:151.

Author and article information

From the Department of Obstetrics and Gynecology, NYU Langone Hospital—Long Island, NYU Long Island School of Medicine, Mineola, NY (Dr Ramani, Ms Halpern, and Dr Vintzileos); Biostatistics Core, NYU Langone Hospital—Long Island, NYU Long Island School of Medicine, Mineola, NY (Ms Akerman); Division of Health Services Research, Department of Foundations of Medicine, NYU Long Island School of Medicine, Mineola, NY (Ms Akerman); Division of Epidemiology and Biostatistics, Department of Obstetrics, Gynecology and Reproductive Sciences, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ (Dr Ananth); Cardiovascular Institute of New Jersey and Department of Medicine, Rutgers Robert Wood Johnson Medical School, New Brunswick, NJ (Dr Ananth); Environmental and Occupational Health Sciences Institute, Rutgers Robert Wood Johnson Medical School, Piscataway, NJ (Dr Ananth); and Department of Biostatistics and Epidemiology, Rutgers School of Public Health, Piscataway, NJ (Dr Ananth).

Received Aug. 2, 2021; revised Oct. 4, 2021; accepted Oct. 5, 2021.

The authors report no conflict of interest.

Corresponding author: Sangeeta Ramani, MD. sangeeta091@gmail.com

SUPPLEMENTAL TABLE 1

Ranking based on crude cesarean delivery rates and rates of composite maternal morbidity and composite neonatal morbidity: ≥2 maternal or neonatal complications

Obstetrician[a]	Unadjusted cesarean delivery rate	CMM[b]	CNM[b]	CMM and/or CNM[b]
1	6/26 (23.1)	1/26 (3.9)	3/26 (11.5)	4/26 (15.4)
2	8/33 (24.2)	0/33 (0)	2/33 (6.1)	2/33 (6.1)
3	19/72 (26.4)	0/72 (0)	17/72 (23.6)	17/72 (23.6)
4	28/102 (27.5)	0/102 (0)	10/102 (9.8)	10/102 (9.8)
5	27/89 (30.3)	3/89 (3.4)	11/89 (12.4)	11/89 (12.4)
6	4/12 (33.3)	0/12 (0)	0/12 (0)	0/12 (0)
7	8/23 (34.8)	0/23 (0)	1/23 (4.3)	1/23 (4.3)
8	15/41 (36.6)	0/41 (0)	6/41 (14.6)	6/41 (14.6)
9	14/37 (37.8)	0/37 (0)	2/37 (5.4)	2/37 (5.4)
10	17/41 (41.5)	1/41 (2.4)	7/41 (17.1)	7/41 (17.1)
11	12/24 (50.0)	1/24 (4.2)	4/24 (16.7)	4/24 (16.7)
12	25/35 (71.4)	0/35 (0)	1/35 (2.9)	1/35 (2.9)

Data are presented as number/total number (percentage).

CMM, composite maternal morbidity; *CNM*, composite neonatal morbidity.

[a] The obstetricians were rank ordered based on their crude cesarean delivery rates; [b] Defined as ≥2 maternal and/or neonatal complications.

Ramani et al. A new index for obstetrical safety and quality of care. Am J Obstet Gynecol 2022.

SUPPLEMENTAL TABLE 2

Ranking based on unadjusted and adjusted (obstetrical safety and quality index) composite outcome rates: ≥2 maternal or neonatal complications

	Cesarean delivery (%)			Composite outcome (CMM and/or CNM) (%)[a]		
Obstetrician	Unadjusted (ranking)	Adjusted (ranking)[b]	Difference (%)	Unadjusted (ranking)	Adjusted (ranking) (OSQI)	Difference (%)
1	23.1 (1)	20.0 (1)	−3.1	15.4 (9)	17.5 (11)	+2.1
2	24.2 (2)	28.8 (4)	+4.6	6.1 (5)	6.1 (5)	0
3	26.4 (3)	27.8 (3)	+1.4	23.6 (12)	22.7 (12)	−0.9
4	27.5 (4)	23.6 (2)	−3.9	9.8 (6)	9.4 (6)	−0.4
5	30.3 (5)	34.3 (8)	+4.0	12.4 (7)	12.1 (7)	−0.3
6	33.3 (6)	29.3 (5)	−4.0	0 (1)	0 (1 or 2)	0
7	34.8 (7)	31.7 (7)	−3.1	4.3 (3)	4.3 (3)	0
8	36.6 (8)	39.3 (10)	+2.7	14.6 (8)	14.3 (8)	−0.4
9	37.8 (9)	30.4 (6)	−7.4	5.4 (4)	5.3 (4)	−0.1
10	41.5 (10)	37.6 (9)	−3.9	17.1 (11)	15.8 (10)	−1.3
11	50.0 (11)	44.0 (11)	−6.0	16.7 (10)	15.4 (9)	−1.3
12	71.4 (12)	65.6 (12)	−5.8	2.9 (2)	0 (1 or 2)	−2.9

CMM, composite maternal morbidity; *CNM*, composite neonatal morbidity; *OSQI*, obstetrical safety and quality index.

[a] Defined as ≥2 maternal and/or neonatal complications; [b] Adjusted for the following maternal factors: maternal age, body mass index, gestational age, and gestational diabetes mellitus.

Ramani et al. A new index for obstetrical safety and quality of care. Am J Obstet Gynecol 2022.