Incidence of Severe Maternal Morbidity and Other Obstetric Complications in Illinois 2016-2018 Using International Classification of Diseases-10

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Short title: ICD-10 Coding of Severe Maternal Morbidity

PRÉCIS (limit 25 words):

Severe maternal morbidity underestimates the incidence of other, route-specific International Classification of Diseases Version 10 coded delivery complications.

ABSTRACT

OBJECTIVE: Although maternal morbidity has been increasing in recent years, quality measures for maternal outcomes of childbirth hospitalizations remain controversial. Previous studies have relied upon International Classification of Diseases (ICD-9) coding with virtually no literature on how the 2015 transition to ICD-10 has affected delivery complication rates. This study describes the incidence of maternal obstetric complications in Illinois using ICD10 coding algorithms.

METHODS: In a retrospective cohort study of all deliveries at 127 Illinois hospitals from January 2016 to December 2018, ICD-10 codes were used to characterize severe maternal morbidity (SMM) and other delivery route-specific complications of vaginal and cesarean delivery. Poisson regression models were used to estimate the association of maternal sociodemographic and clinical characteristics as well as hospital characteristics with the likelihood of complications.

RESULTS: Among 421,426 deliveries, the SMM rate was 0.76% overall, 0.44% for vaginal and 1.50% for cesarean delivery. Other maternal complications occurred in 8.62% of vaginal and 9.96% of cesarean deliveries. Patient age, race and ethnicity, and pre-existing and pregnancy-related clinical conditions were significantly associated with each outcome. Hospital-annual delivery volume, weekend admission and medical record coding intensity, measured by the mean number of ICD-10 codes for uncomplicated deliveries, were also significantly associated with complication incidence.

CONCLUSION: SMM significantly underestimates the incidence of other potentially preventable complications. Complication incidence is higher for women from racial and ethnic minority groups and high poverty neighborhoods. However, the association of the likelihood of complications with hospital coding intensity and post-hoc analyses of length of stay differences between complicated and uncomplicated deliveries raise questions about the reliability of ICD-10 coding, which is incommensurate with previous ICD-9 research. New risk adjusted outcome measures based on detailed clinical data and linked antepartum and postpartum care will be necessary to improve obstetric quality of care.

BACKGROUND

Childbirth accounts for 1,195 hospital admissions per 100,000 population, and the medical and surgical care provided during childbirth has an immense impact on overall population health.[1,2] Accurately characterizing the quality of this care is imperative for improving patient outcomes and reducing healthcare costs, but quality metrics for delivery-related hospitalizations are not well-defined.[3,4] Rates of poor maternal obstetric outcomes, defined by The Centers for Disease Control and Prevention (CDC) as severe maternal morbidity (SMM) have been rising nationally in recent years.[5] This increase in SMM is attributed in large part to increasing average maternal age, and an increase in prevalence of maternal obesity and comorbid medical and obstetric conditions.[6,7] The well-established trends of racial and ethnic disparity in rates of SMM are only becoming more pronounced with rising prevalence; Recent estimates place SMM for non-Hispanic Black women at 1.2–2.1 times that of their non-Hispanic white counterparts.[8-10] However, SMM is a rare event, comprising a wide range of medical and surgical conditions with limited opportunities to improve care for the vast majority of deliveries. There is little consensus about broader measures of delivery complications that would be more amenable to quality improvement initiatives.

Measurement of the quality of obstetric admissions has been further complicated by the 2015 transition the International Classification of Diseases, Tenth Revision (ICD-10), the first revision to the medical coding structure since 1978. ICD-10 presents new challenges for quality metrics, as it utilizes fundamentally a different structural and conceptual organization from its predecessor.[11] Observational studies have relied upon ICD-9 coding with virtually no literature on how the 2015 transition to ICD-10 has affected delivery complication rates. It has also been

previously demonstrated that the number of ICD codes used for an encounter of similar complexity varies significantly between hospitals, and that the number of codes used for uncomplicated deliveries was associated with the likelihood of coded delivery complication. This inter-hospital variation, termed "medical record coding intensity," may have worsened with the inflated number of codes available in ICD-10.

This study uses ICD-10 coding from hospital discharge data to characterize trends in delivery complications in Illinois hospitals from January 2016 to December 2018. The study is a follow-up to a previously published study of delivery complications, based on 2010-2015 ICD-9 data.[12] We describe the ICD-10 rate of SMM based on the updated definition from the CDC and ICD-10 delivery route-specific models of complications using algorithms originally based on ICD-9 coding. We model the likelihood of a complicated delivery using maternal demographic and clinical and hospital-level characteristics, including hospital delivery volume and coding intensity. Our results highlight the numerous challenges faced when using hospital-level discharge data to investigate quality of care and establish clinically relevant metrics within the field of obstetrics.

METHODS

This is a retrospective cohort study performed using data from the Illinois Health and Hospital Association's (IHA) Comparative Health Care and Hospital Data Reporting Services (COMPdata). We identified all childbirth-related hospital admissions occurring between January 2016 to December 2018 at 127 non-federal Illinois hospitals. Diagnosis-related group (DRG) and

ICD-10 codes were used to identify vaginal and cesarean deliveries. The study involved the use of publicly available, de-identified data and was thus Institutional Review Board exempt.

Complicated deliveries were defined using ICD-10 codes. ICD-10 indicators for SMM were based upon CDC guidelines and were identified in our sample from up to 24 secondary ICD-10 diagnostic codes and up to 24 procedure codes per encounter. We used the Asch et al algorithm to identify more comprehensive delivery route-specific complications. In 2009, to evaluate obstetrics and gynecology residency program quality of care, Asch et al validated their algorithm with a sample of almost five million deliveries from 107 residency programs in Florida and New York, using ICD-9 coding.[13] Complications were defined as hemorrhagic, infectious, and thrombotic diagnoses associated with hospitalization for childbirth, as well as severe lacerations (third- or fourth-degree perineal lacerations, cervical laceration, anal sphincter tear) for women who underwent vaginal delivery and operative complications for women who underwent cesarean delivery. We developed a crosswalk to relevant ICD-10 codes that replicates this delivery route-specific coding algorithm.

Maternal socioeconomic and clinical characteristics were also derived from discharge data. We characterized maternal age as <18, 18-24, 25-29, 30-34, 35-39, and >40 years of age. Race and ethnicity were characterized as non-Hispanic white, non-Hispanic Black, Hispanic, Asian, or other/unknown. Insurance status was described as private, Medicaid, or other (including uninsured, Medicare, and unknown). Pre-existing chronic conditions (diabetes, chronic hypertensive disease, chronic heart disease, chronic respiratory disease, chronic renal disease, chronic liver disease, or HIV/AIDS) and pregnancy-related conditions (gestational diabetes, gestational hypertension, preeclampsia, severe preeclampsia, and multiple gestation)

were identified from up to 24 ICD-10 codes. Body mass index and blood transfusions were not included because the respective ICD-10 codes diagnosis and procedure codes are not reliable. Patients were identified as living in one of four regions: Cook County, the five Chicago-area suburban collar counties (DuPage, Kane, Lake, McHenry, and Will), all other Illinois counties ("downstate"), or out-of-state. Patient zip codes were matched to Zip Code Tabulation Areas (ZCTAs) using the American Community Survey 2017 five-year census data to identify the percentage of households living in each zip code who were at or below the federal poverty level. ZCTAs were then categorized as <5%, 5-9.99%, 10-19.99%, 20% or more poor residents, or non-Illinois residents.

Descriptive statistics were further used to characterize hospital characteristics. We categorized deliveries as occurring on weekends vs weekdays and by the month and year of delivery. We characterized the level of medical record coding intensity as the mean number of ICD-10 codes used for an uncomplicated delivery (negative for any of our three metrics of delivery complications) at each hospital. We empirically defined low-volume hospitals for childbirth hospitalizations as those with fewer than 1,000 deliveries per year, low/medium-volume as 1,000-2,000 deliveries/year, medium/high-volume as 2,000-3,000 deliveries/year, and high-volume hospitals as those with greater than 3,000 deliveries/year. We categorized hospitals as safety net hospitals if greater than 35% of patients had Medicaid insurance.

Chi-square tests were used to determine the significance of associations between complications and patient sociodemographic characteristics, clinical conditions, and hospital-level characteristics. A t-test was used to determine the significance of differences between complicated and uncomplicated deliveries for normally distributed medical record coding

intensity. Poisson regression analyses of the likelihood of each type of complication was used to estimate the incidence rate ratio (IRR) for patient and hospital-level characteristics. Standard errors were adjusted for clustering of observations within hospitals. All analysis used Stata 15 (College Station, Texas).

RESULTS

There were 421,426 delivery admissions, including 292,166 vaginal deliveries (69.3%) and 126,260 cesarean deliveries (30.7%), at the 127 Illinois hospitals during the 36-month study period. The overall rate of severe maternal morbidity was 0.76% (0.44% for vaginal delivery and 1.50% for cesarean). Maternal complication incidence based on the Asch et al algorithm for delivery route-specific complication was much higher, at 8.62% of vaginal deliveries and 9.96% of cesarean deliveries.

Figure 1 presents the mean monthly incidence of SMM and delivery route-specific complication rates during the 36-month study period. Incidence of SMM remained relatively flat across the period of observation, while mean monthly incidence of vaginal delivery complications increased over 40% from 2016 to 2018, from 6.87% to 9.85%, and cesarean delivery complications increased over 34% from 8.87% to 11.92%. There were also 11 in-hospital maternal deaths reported during this study period.

Table 1 provides a detailed breakdown of the incidence of each type of maternal complication. Diagnoses consistent with SMM were separated into four groups following the model of Grobman et al; complication groups were not mutually exclusive.[4] Of all 3,220 deliveries with at least one ICD-10 code consistent with SMM, nearly two thirds (65.09%)

reported presence of hypertensive disorders of pregnancy, which occurred more than three times more often than any other SMM etiology. Delivery route-specific complications were primarily attributed to hemorrhagic and infectious diagnoses, and approximately one in four complicated vaginal deliveries was associated with a severe obstetric laceration.

Table 2 presents bivariate associations between SMM and route-of-delivery-specific maternal complications and maternal and hospital characteristics. While there was no significant change in SMM prevalence across the study period, annual incidence of vaginal complications increased 17.6% and cesarean complications by 13.5% from 2016 to 2018.

Consistent with existing literature, the highest rates of obstetric complications were observed at the extremes of maternal age. As compared to women aged 25 to 29 years, women under 18 years old at the time of delivery were 33.4% more likely to have a complication of vaginal delivery and 52.2% more likely to have a complication of cesarean delivery. Women greater than 40 years of age were more than twice as likely to experience SMM as those aged 25 to 29 years. Non-Hispanic Black women had over twice the rate of SMM as non-Hispanic as non-Hispanic white women and 16.1% more vaginal and 47.5% more cesarean complications. Asian and Hispanic women had by far the highest rates of route specific delivery complications, with Asian women having a 68% higher rate of vaginal delivery complications than non-Hispanic white women. Women with private insurance plans had lower rates of SMM, but higher rates of delivery route-specific complications than those with Medicaid or other insurance options. Women residing in Cook county or those traveling to Illinois from out-of-state had higher complication rates than other Illinois residents. Patients from areas with increasing levels of poverty had increasing rates of complications; for example, women from zip codes where >20%

of residents live in poverty had nearly double the incidence of SMM as compared to those with <5% poverty.

Patient clinical characteristics had striking effects on incidence of SMM and other complications. SMM was almost three times more likely for women with pre-existing chronic medical conditions (9.82% of the total study population) and more than four times more likely to have cesarean complications. Women with a diagnosis consistent with preeclampsia were more than five times more likely to have SMM or cesarean complications, and nearly three times as likely to have vaginal complications. Women with other pregnancy-related conditions, including gestational diabetes, but especially gestational hypertension not rising to the level of preeclampsia and multiple gestation also had markedly elevated complication rates.

Hospital-level characteristics also had significant associations with maternal complication rates. High-volume hospitals were more than twice as likely to have cesarean complications as low-volume hospitals. Deliveries that occurred on weekends were 29.9% more likely to have cesarean complications. Safety net hospitals were not associated with a significant difference in overall complication rates.

Mean hospital medical records coding intensity (the average number of ICD-10 codes hospitals used for uncomplicated deliveries) was very significantly associated with higher rates of coded delivery complications. Comparing the lowest coding hospitals (<6 codes per uncomplicated delivery) to the highest coding hospitals (>7 codes per uncomplicated delivery), there was more than a doubling of SMM and cesarean delivery rates and an 87% higher rate of vaginal delivery complications. All risk factors were statistically significant ($p<0.05$) except for safety net hospital status for SMM, weekend delivery for vaginal delivery complications, and

other/unknown insurance status and gestational diabetes mellitus diagnosis for cesarean delivery complications.

Table 3 presents the multivariable Poisson regression estimates for the likelihood of each type of complication. These results confirm the upward trend in route-specific complications between 2016-2018. With women age 25-29 as the reference, only older women had significantly higher SMM rates while only younger mothers had higher rates of route-specific complications. In particular, SMM rates were 75% higher in women over 40 than women aged 25 to 29 years, but there was no significant increase in SMM for women at the lower extremes of maternal age. On the other hand, women under 18 were more likely to have other complications (36% more likely to have vaginal and 47% more likely to have cesarean complications), while there were no significant differences for women above 40 years of age. Incidence rates of SMM were still almost 50% higher among non-Hispanic Black women as compared to non-Hispanic white women, but rates of other complications were similar between the two groups. Hispanic women were more likely than non-Hispanic white women to have non-SMM complications, but their rates of SMM were unchanged. Asian women were significantly more likely than non-Hispanic white women to be diagnosed with any of the three complication groups. Insurance status, when controlling for other factors, did not have a significant effect on SMM or complications, except that women with Medicaid were significantly less likely to have complications of vaginal delivery than those with private insurance. Women with primary residence in Cook county had 16-56% higher complication rates than those from the collar counties or elsewhere in Illinois. The incidence of cesarean delivery complications was about 20% greater in the areas with the highest poverty (>20%) as

compared with the lowest (<5%). Patients with pre-existing chronic conditions had SMM rates nearly 2.5 higher than those without, though the effect on other complications was mitigated when controlling for other variables. Gestational hypertension, preeclampsia, and multiple gestation retained a significant increase in SMM and complication rates, but gestational diabetes had no significant association with the likelihood of complications.

Lower hospital delivery volume was primarily associated with lower cesarean complication rates in multivariable analysis, while weekend deliveries were associated with higher cesarean delivery complications. Safety net hospital status had no significant effect on any complication outcome. Finally, there was a sharp gradient in the likelihood of complications by each level of hospital coding intensity, the more codes used by a hospital for uncomplicated deliveries the higher the complication rate.

DISCUSSION

Our 2016-2018 results revealed an overall SMM rate of 0.76% (0.44% for vaginal delivery and 1.50% for cesarean), as compared with 1.85% (0.99% for vaginal and 3.76 for cesarean delivery) in the 2010-2015 study of the same Illinois hospitals by Roy et al.[12] However, despite the published CDC crosswalk of SMM ICD-9 to ICD-10 codes, it is not possible to equate these data, which indicate a sharp downturn in SMM in October 2015 corresponding to implementation of ICD-10. Most notably ICD-10 procedure codes for blood transfusions were absent from most hospital discharge data, and there were additional coding differences introduced for other SMM conditions. Similar differences in coding were evident in the route-specific maternal complication rates based on translating the Asch eat al algorithm to ICD-10. Our ICD-10 data demonstrate an 8.62% complication rate for vaginal deliveries as compared to

9.44% in Roy et al. and 9.96% complication rate for cesarean deliveries as compared to 14.66% in Roy et al. However, there were very significant differences in the ICD-10 coding of iatrogenic conditions that also produced a sharp rupture in these rates in October 2015.

Although ICD coding systems are incommensurate, hospital discharge data currently remain essential as the only universal, population-based measure of potentially preventable maternal complications. Birth and death certificate data have helped to establish many important trends in maternal and newborn health, .such as the significant racial and ethnic disparity in rates of low birth weight and mortality outcomes not accounted for by socioeconomic status or education.[14-16] However, vital statistics data have major limitations on clinical data related to maternal birth outcomes. Mortality is a catastrophic but rare outcome with an etiology that is multifactorial and often difficult to ascertain.[17] SMM, while still rare, offers the statistical advantages of being 50 to 100 times more common that maternal mortality and is believed to be up to 50% preventable; therefore, it has become the main population-level metric for hospital quality of care for deliveries.[5,18]

The Asch et al maternal complication codes were developed to reflect potentially preventable, route-specific complications that, after risk-adjustment, were found to vary consistently across residency programs, providing evidence for their value for a measure of quality of care.[12] Our findings reflect the much higher prevalence of these other complications which may provide a better target than SMM rates for quality improvement and risk-adjusted maternal outcome metrics.

In post-hoc analyses, we examined differences in length of stay and total charges between complicated and uncomplicated deliveries. Vaginal deliveries with an SMM-coded

complication had a mean hospital length of stay (LOS) that was 1.66 days longer than admissions without SMM, and charges were greater by an average of over $23,000. Cesarean deliveries with SMM were associated with a LOS that was on average 2.98 days longer and associated with almost $40,000-more in charges. Vaginal deliveries flagged as complicated by the Asch et al algorithm had a mean LOS that was 0.55 days longer and charges that were on average almost $6000 greater than uncomplicated vaginal deliveries, and complicated cesarean deliveries had a mean LOS 1.45 days longer and charges that were almost $13,000 greater than uncomplicated cesarean deliveries (all comparisons $p<0.0001$).

While these data provide some support for the reliability of complication coding, our post-hoc examination of long LOS patients raises concerns. When a long LOS was defined as >5 days for cesarean deliveries and >3 days for vaginal deliveries (accounting for 5% of all admissions) only 14% of complicated cases had long LOS. Over 73% of deliveries associated with long LOS did not meet criteria for SMM or either route-specific complication rate. While causes for prolonged childbirth admission LOS are unclear, these data raise concerns about the sensitivity and specificity of ICD-10 complication coding.

These concerns are compounded by our findings about the association of complication incidence with hospital medical records coding intensity. Because ICD coding is used for billing purposes, hospital medical record departments have an incentive to list all possible codes. This was already problematic with ICD-9 coding but has clearly intensified with the addition of thousands of additional new codes in ICD-10 and a resulting increase in the mean number of codes used for delivery admissions. Indeed, our finding of increasing rates of route-specific complications could potentially be explained by medical records departments gaining facility

299 with ICD-10; the mean number of codes used for uncomplicated admissions rose from 6.61 in
300 2016 to 6.66 in 2018.

301 An additional challenge to reporting childbirth outcomes is risk adjustment. Many
302 models have been proposed to evaluate the quality of women's healthcare using metrics
303 related to SMM, but these have largely been shown to have poor predictive value due to the
304 significant variation attributable to patient and hospital characteristics.[3,19-22] For example,
305 Creanga et al demonstrated that Black- or Hispanic-serving hospitals across seven states
306 performed worse than other hospitals on 12 out of 15 indicators related to SMM. However,
307 these results were significantly confounded by racial and socioeconomic inequity in childbirth
308 outcomes, a higher rate of medical comorbidities among patients delivering at these hospitals,
309 and differences in hospital resource availability.[23] Even using risk adjustment models
310 accounting for differences in patient characteristics, multiple health outcome metrics have
311 been shown to be poorly correlated with each other, and thus not easily generalizable for
312 overall institutional quality of obstetric care.[22] Hospital discharge data lack accurate risk
313 adjustment measures like body mass index, gestational age and nulliparity. While groups like
314 the National Quality Forum continue to evaluate more clinically tailored outcome metrics,
315 future risk adjustment efforts will likely require electronic health records data and the ability to
316 link antepartum inpatient and outpatient care records. Birth outcomes research will also have
317 to incorporate linked, longitudinal data to better reflect postpartum pregnancy-related
318 readmissions, emergency department visits and mortality.[24]

319 Despite these limitations, our results are consistent with prior literature in
320 demonstrating that obstetric complications have a disproportionately high prevalence in

women from racial and ethnic minority groups and high poverty neighborhoods, women who are at the extremes of maternal age, and women who have pre-existing comorbid conditions. Non-Hispanic Black women were nearly 50% more likely than non-Hispanic white women to have SMM, after controlling for pre-existing conditions, hospital of delivery, insurance status, and other factors that have previously been suggested as confounding factors. Hispanic women were more likely to have route-of delivery specific complications and Asian women had significantly higher rates of both SMM and other delivery complications. These outcome differences are related to both women's baseline health and access to timely and high-quality medical care and raise major challenges for improving both antepartum and postpartum care for lower income mothers. Given the enormous stakes for both mothers and babies, greater investment in health and social services for pregnant women is should be among the highest priorities for health system reform in the United States.

References

1. Bailit JL. Measuring the quality of inpatient obstetrical care. Obstet Gynecol Surv 2007;62:207-13.
2. HCUP Fast Stats– Healthcare Cost and Utilization Project. (Accessed April 3, 2020, at www.hcup-us.ahrq.gov/faststats/national/inpatientcommondiagnoses.jsp.)
3. Grobman WA, Feinglass J, Murthy S. Are the Agency for Healthcare Research and Quality obstetric trauma indicators valid measures of hospital safety? Am J Obstet Gynecol 2006;195:868-74.
4. Grobman WA, Bailit JL, Rice MM, et al. Frequency of and factors associated with severe maternal morbidity. Obstet Gynecol 2014;123:804-10.
5. Reproductive Health: Severe Maternal Morbidity in the United States. (Accessed January 4, 2020, at https://www.cdc.gov/reproductivehealth/maternalinfanthealth/severematernalmorbidity.html .)
6. Timofeev J, Reddy UM, Huang CC, Driggers RW, Landy HJ, Laughon SK. Obstetric complications, neonatal morbidity, and indications for cesarean delivery by maternal age. Obstet Gynecol 2013;122:1184-95.
7. Somerville NJ, Nielsen TC, Harvey E, et al. Obstetric Comorbidity and Severe Maternal Morbidity Among Massachusetts Delivery Hospitalizations, 1998-2013. Matern Child Health J 2019;23:1152-8.
8. Grobman WA, Bailit JL, Rice MM, et al. Racial and ethnic disparities in maternal morbidity and obstetric care. Obstet Gynecol 2015;125:1460-7.
9. Creanga AA, Bateman BT, Kuklina EV, Callaghan WM. Racial and ethnic disparities in severe maternal morbidity: a multistate analysis, 2008-2010. Am J Obstet Gynecol 2014;210:435 e1-8.
10. Admon LK, Winkelman TNA, Zivin K, Terplan M, Mhyre JM, Dalton VK. Racial and Ethnic Disparities in the Incidence of Severe Maternal Morbidity in the United States, 2012-2015. Obstet Gynecol 2018;132:1158-66.
11. Boyd AD, Li JJ, Burton MD, et al. The discriminatory cost of ICD-10-CM transition between clinical specialties: metrics, case study, and mitigating tools. J Am Med Inform Assoc 2013;20:708-17.
12. Roy A, Peaceman A, Son M, Feinglass J. Maternal Obstetric Complication Rates Remain High in Illinois: A Retrospective Study, 2010-2015. Jt Comm J Qual Patient Saf 2019;45:24-30.
13. Asch DA, Nicholson S, Srinivas S, Herrin J, Epstein AJ. Evaluating obstetrical residency programs using patient outcomes. JAMA 2009;302:1277-83.
14. 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.
15. Rosenberg D, Geller SE, Studee L, Cox SM. Disparities in mortality among high risk pregnant women in Illinois: a population based study. Ann Epidemiol 2006;16:26-32.
16. Howland RE, Angley M, Won SH, et al. Determinants of Severe Maternal Morbidity and Its Racial/Ethnic Disparities in New York City, 2008-2012. Matern Child Health J 2019;23:346-55.

17. Callaghan WM. State-based maternal death reviews: assessing opportunities to alter outcomes. Am J Obstet Gynecol 2014;211:581-2.
18. Lawton B, MacDonald EJ, Brown SA, et al. Preventability of severe acute maternal morbidity. Am J Obstet Gynecol 2014;210:557 e1-6.
19. Callaghan WM, Creanga AA, Kuklina EV. Severe maternal morbidity among delivery and postpartum hospitalizations in the United States. Obstet Gynecol 2012;120:1029-36.
20. Cavazos-Rehg PA, Krauss MJ, Spitznagel EL, et al. Maternal age and risk of labor and delivery complications. Matern Child Health J 2015;19:1202-11.
21. Gibson C, Rohan AM, Gillespie KH. Severe Maternal Morbidity During Delivery Hospitalizations. WMJ 2017;116:215-20.
22. Bailit JL, Grobman WA, Rice MM, et al. Risk-adjusted models for adverse obstetric outcomes and variation in risk-adjusted outcomes across hospitals. Am J Obstet Gynecol 2013;209:446 e1- e30.
23. Creanga AA, Bateman BT, Mhyre JM, Kuklina E, Shilkrut A, Callaghan WM. Performance of racial and ethnic minority-serving hospitals on delivery-related indicators. Am J Obstet Gynecol 2014;211:647 e1-16.
24. National Quality Forum. Perinatal and Reproductive Health 2015-2016, Final Report. Washington, DC: National Quality Forum; 2016.