New Jersey
Hospital Maternity Care Report Card, 2019

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Statute

Summary of the Statute

In 2018, New Jersey legislature enacted P.L. 2018, c.82, which requires the Department of Health to issue a report on hospital maternity care. Specifically, the statute states that:

1. The Commissioner of Health shall gather and compile information necessary to develop a New Jersey Report Card of Hospital Maternity Care (Report Card), as provided for in this act. The Report Card, which shall be updated annually and made available on the website of the Department of Health, shall be designed to inform members of the public about maternity care provided in each general hospital licensed pursuant to P.L.1971, c.136 (C.26:2H-1 et 13 seq.), so that a member of the public is able to make an informed comparison.

2. For each hospital, the Report Card shall include:
    a. the number of vaginal deliveries performed;
    b. the number of cesarean deliveries performed; and
    c. the rate of complications experienced by a patient receiving maternity care:
        i. for a vaginal delivery, which shall include the rate of maternal hemorrhage, laceration, infection, or other complication as prescribed by the Commissioner of Health; and
        ii. for a cesarean delivery, which shall include the rate of maternal hemorrhage, infection, operative complication, or other complication as prescribed by the Commissioner of Health.

3. Notwithstanding the provisions of section 2 of this act to the contrary, the commissioner shall revise or add complications or other factors to be included in the Report Card based on maternal quality indicators as may be recommended by the American Congress of Obstetricians and Gynecologists.

A major goal of this report is to provide important information on maternal health care provided in New Jersey by licensed birthing general acute care hospitals.

Summary of Findings

Overview of Delivery Hospitalizations for NJ mothers in 2019:

- The racial/ethnic profile of NJ mothers is changing; minorities now represent 53% of all births compared to 46% in 2000
- Compared to 2018, there was
    - a 2% decline in the number of delivery hospitalizations at 49 licensed birthing general acute care hospitals
    - a 2% increase in mothers covered by private insurance
    - a 3% decrease in mothers covered by Medicaid
- Cesarean delivery rates dropped to 33.3% of all delivery hospitalizations, a decrease of 3% from the 2018 rate and a decrease of 14% from the highest rate in 2010
- Cesarean deliveries had higher rates of complications (obstetric hemorrhage, post-admission infections, Severe Maternal Morbidity [SMM]) than vaginal deliveries

Variation in Delivery Outcomes by Hospital:

- Vaginal Birth after Cesarean (VBAC) rates for all delivery hospitalizations varied from hospital to hospital, ranging from 0% to 7.9%, with a statewide rate of 2.4%
- Episiotomy rates varied widely hospital to hospital, from 1% to 28%, while the statewide rate was 6.3%
- Rates of third- and fourth-degree perineal laceration without an instrument varied from 0% to 3.6%, compared to the statewide rate of 1.4%
- The rate of SMM with transfusion was significantly higher than the statewide rate at 9 birth hospitals (18%), which is an increase from 2018 during which 6 birthing hospitals (12%) had significantly higher rates, but is a drop from 2016 during which 10 birthing hospitals (20%) had significantly higher rates
- Thirteen birth hospitals (27%) had significantly higher post-admission infections rate than the statewide rate, which is an increase from 2018 during which 11 birthing hospitals (22%) had significantly higher post-admission infections rates, but the same as 2016
- Of the 49 birthing hospitals in New Jersey, 18 (37%) had significantly higher Obstetric hemorrhage rates than the statewide rate, while 13 (27%) had significantly lower Obstetric hemorrhage rates than the statewide rate
- Only 20 of the 49 hospitals (41%) did not have any risk-adjusted complication rates that were significantly higher than the statewide rate investigated in the current report, which means that greater than half of all birthing facilities in NJ have significantly higher rates of complications in at least one of the three reported categories (obstetric hemorrhage, post-admission infections, SMM)

Complication Rates by Race/Ethnicity:

- Asian mothers had the highest rate of third- and fourth-degree perineal lacerations without instrument with 3.1 per 100 delivery hospitalizations while the rate for Non-Hispanic Black mothers was the lowest at 0.9 per 100 delivery hospitalizations.
- Asian mothers had the highest rate of episiotomy with 14.7 per 100 delivery hospitalizations, while the rate for Non-Hispanic Black mothers was the lowest at 3.6 per 100 delivery hospitalizations.
- Non-Hispanic Black mothers had the highest rate of SMM with transfusion at a rate of 35.6 per 1,000 delivery hospitalizations, which is a decrease from the 2018 rate of 37.7 per 1,000 delivery hospitalizations; the rate for Non-Hispanic White mothers was the lowest at 13.6 per 1,000 delivery hospitalizations.
- Non-Hispanic Black mothers suffered the highest rate of post-admission infections at a rate of 23.0 per 1,000 delivery hospitalizations while the rate for Non-Hispanic White mothers was the lowest at 11.2 per 1,000 delivery hospitalizations.
- Non-Hispanic Black mothers suffered the highest rate of Obstetric hemorrhage with 60.6 per 1,000 delivery hospitalizations, and the rate for Non-Hispanic White mothers was 46.7 per 1,000 delivery hospitalizations.

Key Recommendations

In collaboration with New Jersey Maternal Care Quality Collaborative (NJMCQ):

- Further research will be needed to understand the mechanisms that contribute to Obstetric hemorrhage, third- and fourth-degree perineal lacerations, post-admission infections and Severe Maternal Morbidity (SMM) at the hospital level.
- Variation in outcomes between hospitals highlight the need to encourage the use of standardized practice guidelines, such as the adoption of a standard measure for Quantitative Blood Loss (QBL) to ensure accuracy of data.
- Based on the statistically significant risk-adjusted complication rates (i.e. SMM, post-admission infections, obstetric hemorrhage) amongst mothers who experienced cesarean deliveries, it is important to identify the modifiable risk factors that contribute to cesarean delivery through carefully designed research studies.

While there is a wealth of research and proven methodologies to improve maternal outcomes, the current report highlights the continuing need for improvement in New Jersey. For example, nulliparous status is found to be associated with an increased risk of complications. This suggests that labor and delivery management guidelines should be developed and adopted to address the differences in labor progression and outcomes between nulliparous and multiparous mothers. Through cooperation between hospitals and the NJMCQC, the development and adoption of appropriate quality improvement methods will have a vast impact on the quality of maternity care in New Jersey.

Background

An increasing body of literature documents childbirth as a significant life event that can be both positive and traumatic depending on the woman's experience during delivery (Berg M et al., 2003; Elmir R et al., 2010). This experience is largely influenced by an array of mild adverse effects to life-threatening events or death that can occur during or shortly after delivery. These morbidities and complications require various levels of intervention from non-invasive (i.e. medication taken by mouth or intravenously) to invasive (i.e. blood transfusion) interventions to save both the woman's life and her offspring's life. To fully understand and reduce maternal morbidities and delivery complications, there is a need for consistent measurement, collection, analysis and dissemination of data related to specifically address labor and delivery. Availability of good quality health care data that allows the construction of performance metrics to support quality improvement efforts is fundamental. Patients and their physicians can use these metrics to inform their discussion in determining the best hospital for the patients' health care and labor and delivery needs.

In this report, the Department of Health uses data collected on all hospital-based births as reported through the Electronic Birth Certificate (EBC) system. The EBC data was complemented by matching records with hospitalization discharge records from each of the hospitals where births occurred. The process also allowed us to capture additional maternal health characteristics that were not included in the EBC.

To account for the patient mix at each birthing facility, risk-adjusted rates of delivery-associated complications, described below, were then calculated. 'Risk-adjusted' rates are rates calculated that reflect the mother's health conditions including her social, demographic, economic statuses. The risk-adjustment process allows for fair comparisons across hospitals, which treat diverse patient populations. Risk-adjusted rates are expressed as ratios of expected complications to observed complications harmonized by the statewide complication rate. Statistical significance is assessed by whether the statewide rate crosses the range between the lower and upper bounds of the confidence limits. A difference is considered 'statistically significant' when the statewide rate falls outside the confidence limits estimated for the hospital rate. As an example, a hospital's rate is statistically significantly higher than the statewide rate if the corresponding hospital's rate confidence bound is completely above the statewide rate. By comparison, we say the hospital's rate is statistically significantly lower than the statewide rate when the statewide rate falls above the corresponding hospital confidence bound.

The measures assessed in this report are: third- and fourth-degree perineal laceration, episiotomy, obstetric hemorrhage, post-admission infections and Severe Maternal Morbidity as a surrogate for "Other Complications". In the following sections, we will discuss each measure in more detail.

Obstetric Hemorrhage

Per the American Congress of Obstetricians and Gynecologists (ACOG), obstetric hemorrhage is a cumulative blood loss greater than 1,000 ml regardless of the method of delivery (i.e. vaginal or cesarean birth) or blood loss accompanied by signs or symptoms of hypovolemia within 24 hours after the birth process (ACOG Practice Bulletin No.183, 2017). However, blood loss greater than 500mL in a vaginal delivery is abnormal and should be investigated and managed (ACOG Practice Bulletin No.183, 2017). Obstetric hemorrhage is common amongst women during delivery or post-delivery secondary to uterine atony, genital tract trauma (i.e. vaginal or cervical lacerations), uterine rupture, retention of placental tissue, or maternal coagulation disorders (ACOG Practice Bulletin No.183, 2017). In addition to being strongly associated with severe maternal morbidities, about a quarter of maternal deaths are due to hemorrhage during delivery or post-delivery (WHO, 2012). Considering the potential negative maternal outcomes linked to obstetric hemorrhage, healthcare providers are encouraged to closely assess for potential risk factors and be ready to implement multidisciplinary and multifaceted guidelines to maintain hemodynamic stability while identifying and treating the cause of blood loss in cases where it occurs (ACOG Practice Bulletin No.183, 2017).

Severe Maternal Morbidity

The Centers for Disease Control and Prevention (CDC) refers to Severe Maternal Morbidity (SMM) as a list of unexpected outcomes of labor and delivery that result in significant short- or long-term consequences to a woman's health (CDC, 2017). This list of unexpected outcomes of labor and delivery (morbidities) encompasses a continuum of health conditions including life-threatening and disabling diseases, organ dysfunction and/or receipt of invasive therapy, during labor and/or after delivery (Frioz et al., 2013). The 2014 SMM report published by the CDC showed a steady national increase in SMM. It is argued that certain sociodemographic factors (i.e. increasing maternal age), chronic disease and increasing rate of cesarean deliveries may have contributed to the rise in SMM rates (Martin et al., 2017). Considering the potential consequences of SMM on a woman's health, the CDC recommends identifying the underlying factors of SMM and designing interventions to target them with the goal of improving the quality of maternal care.

Post-admission Infections

Bacterial infections that occur during labor or the puerperium (period of approximately six weeks following childbirth) usually have a good prognosis when identified and treated promptly, however, occasionally they can become severe and result in morbidity or rarely mortality (Cantwell R et al., 2011). Beyond the immediate effects of the infection, long-term complications can include chronic pelvic pain, fallopian tube blockage or infertility (WHO, 2015). Factors that can lead to infections include pre-existing maternal conditions, such as diabetes or obesity, as well as conditions that may arise during labor, such as premature rupture of the membranes and cesarean birth (Acosta CD et al., 2014). Current recommendations for prevention of infections include judicious use of prophylactic antibiotics (ACOG Practice Bulletin No.199, 2018). While most postpartum infections are diagnosed after the patient is

discharged from the hospital (Yokoe D et al., 2001), the current report only includes those diagnosed during the initial delivery hospitalization.

Third- and Fourth-Degree Perineal Lacerations

Vaginal and perineal trauma often occur during vaginal birth, either spontaneously or secondarily from an episiotomy, which is a surgical incision of the perineum to enlarge the opening for passage of the baby during delivery. Third- and fourth-degree perineal lacerations are severe tears of the vagina and perineum that also may involve tissues of the anus (Royal College, 2007 & 2015). Short-term consequences of these lacerations may include pain and infection (Buppasiri et al., 2014; Fitzpatrick et al., 2005), while potential long-term complications include incontinence and fistula formation (Guise et al., 2007). While lacerations during vaginal birth are not completely avoidable, there are measures that can help avoid or lessen their severity. The American Congress of Obstetricians and Gynecologists (ACOG) has compiled a set of recommendations to mitigate the risk of obstetric lacerations, including the avoidance of routine episiotomy (ACOG Practice Bulletin No.198, 2018).

Episiotomy

An episiotomy is a surgical incision of the perineum to enlarge the posterior aspect of the vagina and is generally performed during the second stage of labor. National rates of episiotomy have been decreasing, with approximately 12% of vaginal deliveries including an episiotomy in 2012 (ACOG Practice Bulletin No.198, 2018). Current recommendations are to restrict the use of this procedure, including in specific clinical situations, such as shoulder dystocia and operative vaginal delivery for which there is insufficient evidence of benefit of the procedure (ACOG Practice Bulletin No.198, 2018).

Methods

Data Sources

Electronic Birth Certificate (EBC) Data: The Health Department's Office of Vital Statistics has been collecting data on all live births in New Jersey since 1966 in electronic format with its most recent birth records reported through the Vital Information Platform (VIP). In addition to registering information about the child, EBC contains demographic information, including the mother's age, race, ethnicity, education status, health insurance status, the mother's health status as well as information about the pregnancy, such as parity, prenatal care and method of delivery.

Inpatient Hospital Discharge Data: The Office of Health Care Quality Assessment (HCQA) of the Centers for Healthcare Quality and Informatics in the New Jersey Department of Health has been collecting data on hospital encounters via the New Jersey Hospital Discharge Data Collection System (NJDDCS) since 1980. As of 2004, NJDDCS includes emergency, inpatient, outpatient and same day surgery discharges. A hospital discharge record contains demographic, geographic, International Classification of Diseases, tenth Revision, Clinical Modification (ICD-10-CM) diagnosis and procedure codes, hospital charges, discharge statuses, types of services provided and other data elements. The department collects all hospital discharges that occurred in each calendar year. Thus, a 2019 birth-related hospitalization that occurs at the end of the

calendar year may be reported with 2020 discharges. Moreover, NJDDCS is hospital encounter data where a patient (in this case, a mother) could have multiple hospitalizations within the same calendar year. For the purposes of this report, only the first birth-related encounter is included.

The Report Card uses maternal information reported in the EBC and additional data elements from hospital discharge records by matching each birthing mother's information with her corresponding hospital discharge clinical information reported through ICD-10-CM diagnosis and procedure codes.

Summary of Steps to Create Analytic File

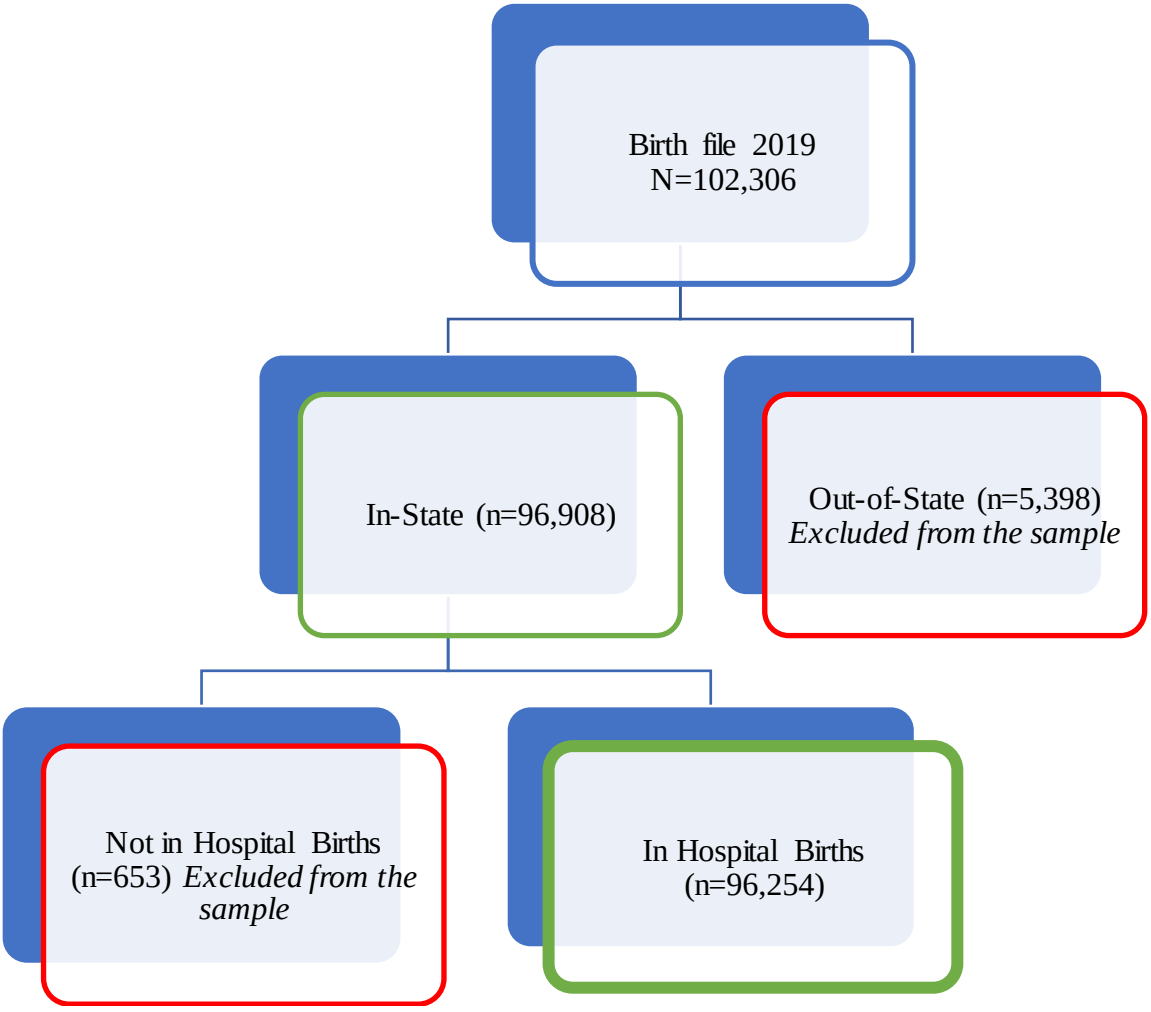
Inpatient Hospitalization Data

- Inclusion criteria
  - All females who gave birth at a Hospital in New Jersey
  - 12 to 65 years of age
  - First record for each patient (mother)
  - 2019 birth-related hospitalizations and *2020 discharges for late 2019 admissions*
- Exclusion criteria
  - Duplicate records for same encounter
  - Males
  - Younger than 12 years old or older than 65 years old
  - Same Day Surgery, ER outpatient or Other Outpatient discharges

Electronic Birth Certificate Data, 2019

- Inclusion criteria
  - All New Jersey hospital births
    In cases of multiple births, select only 1 record
- Exclusion criteria
  - All out-of-state births
  - Births in freestanding birthing centers, home, clinic/doctor's office, other/unspecified location
  - Multiple babies to same mother except the first record

Figure 1. Birth File Inclusion & Exclusion Criteria



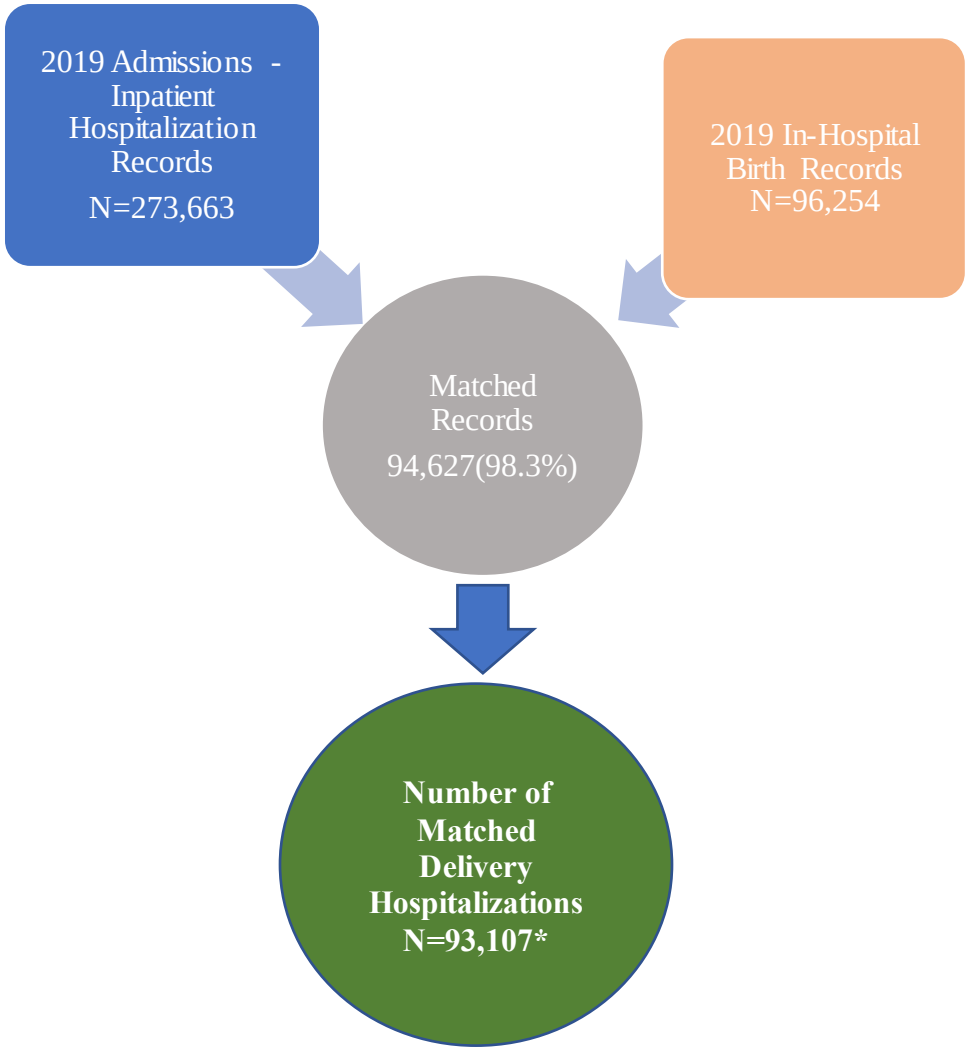
Data Matching

Inpatient delivery hospitalizations and birth certificates records were matched using an algorithm of identifying variables:

(1) Patient level variables (*Mother*): First and Last Name, Date of Birth, Social Security Number, Medical Record Number, Date of Admission and Discharge
(2) Patient level variable (*Newborn*): Date of Birth
(3) Hospital level variable: Hospital code

In cases of multiple births, each infant's birth certificate was matched to the same mother's hospital discharge record to ensure that only the delivery hospitalization was selected for the purposes of analysis. Each matched record represents a delivery where at least one live birth occurred. The team accounted for mothers who were admitted in late December 2019 and discharged in 2020 by linking 2020 birth discharges with late 2019 admissions.

Figure 2. Summary of Data Matching Process: EBC to Inpatient Hospitalization Records, New Jersey, 2019



**8 records from Mullica Hill and unknown birthing facilities removed for analysis*

The Study Population

As part of the process to obtain data to analyze, the team identified 96,254 in-hospital deliveries out of the 102,306 New Jersey births in 2019. These deliveries were comprised of all records including singleton births and multiple births. Of the 96,254 in-hospital deliveries identified, 94,627 deliveries were successfully matched to hospital discharge records for a match rate was 98.3%. Inability to match all records is due to multiple factors, including large discrepancies in the reported identifying variables and incidences of non-reported discharge records for some 2019 deliveries. However, as no pattern in key characteristics of the unlinked

records as compared to linked records was seen, it was concluded that there was no systematic bias introduced by proceeding with the current analysis. Hospitals with greater than 10% unlinked records have been flagged to alert viewers to consider the reported numbers carefully. To identify the number delivering mothers, the first record for each singleton birth or first record of multiple births (e.g. twins, triplets) was used in creating the preliminary analysis file to obtain 93,107 records.

Once the analytic file was created, the next steps included identifying, defining and reviewing the required reportable measures as suggested in the Statute, namely: hemorrhage (Obstetric hemorrhage), laceration (third- and fourth-degree perineal laceration), episiotomy, infections (post-admission infections) and other complications (where Severe Maternal Morbidity is used as surrogate).

Identification of delivery-associated complications

Obstetric Hemorrhage

The ACOG standard defines hemorrhage as blood loss of greater than 1,000cc ml regardless of the method of delivery (i.e. vaginal or cesarean birth) or blood loss accompanied by signs or symptoms of hypovolemia within 24 hours. The Maternal Blood Loss amount reported in cc in the birth certificate data is used to determine the amount of maternal blood loss (hemorrhage) during the delivery hospitalization. There are several caveats when using the above information to identify obstetric hemorrhage. First, there is no specified time-period for the blood loss; it is assumed that all hospitals are measuring blood loss during the same time-period during the hospitalization. Second, the method of blood loss measurement may not be performed similarly across all facilities; some may use a quantified blood loss measurement method while others may report estimated blood loss. Lastly, there is no specification whether signs of hypovolemia were present, which could aid in the final determination of a true diagnosis of hemorrhage.

Severe Maternal Morbidity as proxy for "Other Complications"

Severe Maternal Morbidity (SMM) events were identified during delivery hospitalizations using an algorithm developed by researchers at the Centers for Disease Control and Prevention (CDC) (CDC,2017). The algorithm identifies 18 indicators of SMM that represent either life threatening conditions—such as eclampsia or acute renal failure—or procedure codes for life-saving procedures—such as blood transfusion, ventilation or hysterectomy. The 18 indicators were identified using ICD-10-CM diagnosis codes and procedure codes as prescribed by the CDC (CDC,2017).

In addition to the above algorithm, to ensure the most conservative estimate of SMM, we excluded hospitalizations with a length of stay less than the 90th percentile as calculated separately for vaginal, primary and repeat cesarean deliveries (Callaghan WM et al., 2012). All SMM hospitalizations associated with in-hospital mortality or transfer-in or -out of the delivery facility, as well as those associated with procedure codes were included, regardless of length of stay. In hospital death was identified via the discharge status specifying the patient as 'expired'. Additionally, transfers were identified using both discharge status and admission source information.

Post-admission Infections

A comprehensive list of ICD-10-CM diagnosis codes, presented in Appendix A of this report, along with information from Electronic Birth Certificate (presence of Intrapartum infections and Clinical Chorioamnionitis) data are used to identify all cases of delivery-associated infections that occur during the delivery hospitalization. Additionally, only cases of infection that are not present on admission are included to eliminate instances of pre-admission infections from the final analysis.

Third- and Fourth-degree Perineal Laceration (*vaginal birth only*)

Perineal laceration associated with delivery is divided into two categories: third- and fourth-degree perineal lacerations differentiated by those with and without instrument. To identify perineal lacerations, we used the Agency for Healthcare Research and Quality (AHRQ) Patient Safety Indicator PSI 18 and PSI 19 definitions and associated ICD-10-CM diagnosis codes, as well as the occurrence of a third- or fourth-degree perineal laceration as reported in the Electronic Birth Certificate data (see Appendix A). Perineal laceration is associated with having a large baby (Groutz A. et al., 2011; Vale de Castro, M. et al., 2016), therefore in addition to the AHRQ PSI guidelines, vaginal delivery hospitalizations excluding those with overweight babies (those weighing greater than 4,000 grams) are included in the rate calculation of this complication to account for the variable distribution of overweight babies in our NJ delivery hospitalizations.

Episiotomy (*vaginal birth only*)

To identify episiotomy, we used the associated ICD-10-CM procedure code: 0W8NXZZ (see Appendix A). To account for providers that may follow the guideline to use episiotomy for management of shoulder dystocia (Royal College, 2015), only vaginal delivery hospitalizations excluding those with shoulder dystocia are included in the rate calculation of this complication.

Risk Factors for Delivery-Associated Complications

The observed complication rate for a measure in each facility is estimated as the number of patients that experienced the complication during the delivery hospitalization divided by the total number of delivery hospitalizations at risk for that complication in that facility during the period of investigation. However, this observed complication rate does not provide a fair assessment of the quality of care provided by the facility or providers, because it does not account for potential risk factors present prior to hospitalization. When assessing outcomes, it is important to account for differences in patient characteristics; for example, hospitals (facilities) that serve patients with pre-existing health conditions, such as cardiac or respiratory diseases, would be expected to have higher rates of complications.

To perform a fairer assessment of the quality of maternal healthcare provided by NJ hospitals that perform deliveries, the Department uses risk-adjustment to estimate complication rates. Risk adjustment is a method to account for the pre-delivery risk factors of each patient that may affect health care outcomes and improve comparability of results. In doing so, hospitals that serve high risk patients will not be at a disadvantage when their estimated rates are presented side-by-side with facilities that serve healthier patients. Risk adjustment is performed using statistical regression modeling, an indirect method of standardization. A mixed effects stepwise

logistic regression model was fitted for the outcome of interest, and risk factors that were controlled for included social, demographic and pre-hospitalization risk factors. For each reported outcome, the selected risk factors were identified based on a literature review and expert consultations using the principles of appropriateness, viability (i.e., sufficient number of events) and data availability. The fitted model was used to obtain the predicted number of complications for each hospital, which is then used to compare against the observed number of complications for each hospital. Further details on the statistical risk adjustment methodology are provided in the following section.

The pre-delivery risk factors used in the statistical models include mothers' socio-demographic characteristics (e.g., race/ethnicity, age, health insurance coverage, educational attainment, marital status), clinical and obstetric factors (e.g., parity, method of delivery, body mass index, prenatal care) (Table 1). We also adjusted for clinical comorbidities (e.g., diabetes; hypertension; chronic liver, respiratory, cardiac and renal diseases; placental disorders) as well as behaviors associated with increased risk of complications (e.g., tobacco use, alcohol and illicit drug abuse) (Table 1). These factors were obtained from ICD-10-CM diagnosis codes as reported through the hospitalization database and the information in the Electronic Birth Certificate. A report, which assessed the validity of information obtained from birth files compared with that in hospital discharge data, shows that a combination of the two data sources is most accurate (Lydon-Rochelle M. et al., 2005). In this report:

- A complication is considered if documented by a corresponding diagnosis code, or if it was identified on the birth file.
- Method of delivery is defined as specified by the Agency for Healthcare Research and Quality Inpatient Quality Indicator 33 to identify primary and repeat cesarean deliveries.

Table 1. List of Covariables Considered for Analysis

	Values/Categories
Sociodemographic Characteristics	
Race/ Ethnicity	Non-Hispanic White Non-Hispanic Black Hispanic Non-Hispanic Asian Other/ Multi-race
Maternal Age	<35 35+
Educational Status	< High School High School Some College College and College+
Health Insurance Coverage	Private Insurance Medicaid Self-Pay/Charity Care Other
Marital Status	Married Not Married

Clinical & Obstetric factors/ Comorbidities	
Method of Delivery	Vaginal *(with and without instrument)* Cesarean *(Primary, Repeat)*
Parity	Nulliparous Multiparous
Gestational Age	Premature- *before 37 weeks of gestation* Mature- *after 37 weeks of gestation*
Diabetes Mellitus (Gestational & Preexisting)	Yes/No
Hypertension (Gestational & Preexisting)	Yes/No
Chronic Disease: Cardiac, Renal, Respiratory, Liver	Yes/No
Placental Disorders (Placenta Abruptio, Previa and /or Accreta)	Yes/No
Uterine ruptured and/or Uterine atony	Yes/No
HIV status	Positive/ Negative
Prenatal Care Utilization	Early (1st Trimester) Late/None (None, 2nd & 3rd Trimester)
Pre-pregnancy Body Mass Index (BMI)	Underweight (Below 18.5) Normal (18.5 – 24.9) Overweight (25.0 – 29.9) Obese (30.0 and Above)
Length of Labor	Precipitous Labor (Less than 3 hours) Prolonged Labor (Greater than or equal to 20 hours)
Infant Birthweight	Low birthweight less-*than 2,500 grams* Normal-birthweight- *between 2,500 grams and 4,000 grams* Overweight (macrosomia)- *over 4,000 grams*
Induction of Labor (Labor induction is the process or treatment that stimulates childbirth and delivery)	Yes/No
Epidural or Spinal Anesthesia	Yes/No
Shoulder Dystocia	Yes/No
Premature Rupture of Membranes	No PROM Full term PROM Preterm PROM PROM Gestation unspecified
Cervical dilation at time of admission (cm.)	≤3 cm 4+ cm
Preexisting Anemia	Yes/No
Preeclampsia	Yes/No
Behavioral Risk Factors	
Substance Use	Yes/No
Alcohol Use	Yes/No
Tobacco Use	Yes/No

Statistical Analysis

Risk Adjustment

Patient case mix varies across hospitals, which may result in variation of delivery outcomes. Therefore, to ensure each NJ birthing facility gets a fair assessment, it is paramount to account for each hospital's patient characteristics (race/ethnicity, age, etc.) and clinical and obstetric risk factors (i.e. hypertension, diabetes, uterine disorders) using risk adjustment. Using a random intercept multivariable logistic regression analysis method, an indirect method of standardization, researchers can control for patient characteristics and other risk factors that may affect birth outcomes.

A mixed effects stepwise logistic regression model, which included the previously discussed pre-delivery clinical factors and demographic characteristics, was fitted to the data for each category of delivery-associated complication for the period covered in this report. The models identified the risk factors important in predicting whether a patient would experience the specific complication under investigation. The general form of the mixed effect logistic regression model for estimating the 'logit' of the probability of experiencing the complication of interest is as follows (SAS/STAT 14.3 User's Guide, 2017):

$$E[Y|\gamma] = g^{-1}(X\beta+Z\gamma)$$

Y = (n x 1) vector of observed values of dependent variable, where n = number of observations
X = (n x p) matrix of fixed effects, where n = number of observations, p = proportion of sample elements that have a particular attribute
β = vector of regression coefficients for fixed-effects parameters
Z = (n x r) design matrix for the random effects, where n= number of observations, r = sample correlation coefficient, based on all the elements from a sample
γ = (r x 1) vector of random effects, where r = sample correlation coefficient, based on all the elements from a sample
g = differentiable monotonic link function (g^{-1} is the inverse)

The statistically significant factors for each complication identified by stepwise logistic regression models are presented in Tables 2a-2c. Each list includes only those factors that were statistically significant in predicting the class of complication under investigation with p-values of 0.05 or smaller.

These models were used to predict the number of a given complication type, which was then compared with the observed rates to create the adjustment factor. This adjustment factor was then applied to the statewide rate for the given complication type to produce the risk-adjusted rate for the hospital.

$$Risk\ Adj\ Rate = \frac{Observed}{Expected} \times Statewide\ rate$$

Ninety five percent confidence intervals were calculated for the risk adjusted rate using the following formula (Kahn H., 1989):

$$CI_{ISR} = \pm 1.96 \sqrt{\frac{(Observed/Expected)}{Expected}} \times Statewide\ rate$$

Rates with confidence intervals above the statewide rate were deemed significantly higher than statewide rate, and conversely hospitals with confidence intervals below the statewide rate were considered to have significantly lower rates than the statewide rate.

The odds ratios are derived from the coefficients and are used to compare the relative importance of the risk factors in predicting complications during delivery. For each of the risk factors identified in Tables 2a-2e, the odds ratio represents how likely a patient is to develop complications compared to a patient in the reference group. For example, Table 2a shows that a delivering woman is almost eight times (odds ratio = 7.8) as likely to experience an obstetric hemorrhage after she had surgical/cesarean birth (primary, repeat) with no placental or uterine disorders compared to a delivering woman who did not have the surgical/cesarean birth or have any placental or uterine disorders, assuming that these delivering mothers have the same set of other risk factors presented in the table.

In another example, the odds of developing post-admission infection during the delivery hospitalization for a delivering mother who is Hispanic is almost twice the odds (odds ratio= 1.95) compared with that of a patient who is Non-Hispanic White (Table 2c).

Table 2a. Risk Factors Identified for Obstetric Hemorrhage

Patient Risk Factors Identified	**Logistic Regression Results**		
	Coefficient	P-value	Odds Ratio
Demographic Factors			
Race/ Ethnicity			
Non-Hispanic White	Ref.		
Non-Hispanic Black	0.09072	0.0735	1.095
Hispanic	0.09761	0.0181	1.103
Non-Hispanic Asian	-0.01974	0.7261	0.98
Other/ Multi-race	-0.2905	0.0277	0.748
Maternal Age	0.01604	<.0001	1.016
Clinical & Obstetric factors/ Comorbidities			
Method of Delivery			
Vaginal and No Placental or Uterine Disorders	Ref.		
Cesarean *(Primary, Repeat)* with Placental or Uterine Disorders	3.2321	<.0001	25.333
Cesarean *(Primary, Repeat)* No Placental or Uterine Disorders	2.0542	<.0001	7.801
Vaginal with Placental or Uterine Disorders	1.9125	<.0001	6.77
Preeclampsia			
No	Ref.		
Yes	0.2736	<.0001	1.315
Infection-Chorioamnionitis			
No	Ref.		
Yes	0.81	<.0001	1.314
Preexisting Anemia			
No	Ref.		
Yes	0.2733	<.0001	2.248
Pre-pregnancy Body Mass Index (BMI)	0.01542	<.0001	1.016
Intercept	-5.4722		
C-statistic	0.807		
Number of Postpartum Hemorrhage (N)	4,708		

Table 2b. Risk Factors Identified for Severe Maternal Morbidities with Transfusion

Patient Risk Factors Identified	Logistic Regression Results		
	Coefficient	P-value	Odds Ratio
Demographic Factors			
Race/ Ethnicity			
Non-Hispanic White	Ref.		
Non-Hispanic Black	0.3981	<.0001	1.489
Hispanic	0.3883	<.0001	1.474
Non-Hispanic Asian	0.2298	0.0126	1.258
Other/ Multi-race	0.2691	0.1259	1.309
Clinical & Obstetric factors/ Comorbidities			
Method of Delivery			
Vaginal and No Postpartum Hemorrhage	Ref.		
Cesarean *(Primary, Repeat)* with Postpartum Hemorrhage	2.6921	<.0001	14.763
Cesarean *(Primary, Repeat)* and No Postpartum Hemorrhage	1.0413	<.0001	2.833
Vaginal with Postpartum Hemorrhage	3.4671	<.0001	32.044
Parity			
Multiparous	Ref.		
Nulliparous	0.1612	0.0015	1.175
Preexisting Anemia			
No	Ref.		
Yes	0.9093	<.0001	2.483
Preeclampsia			
No	Ref.		
Yes	0.8502	<.0001	2.34
Cardiac			
No	Ref.		
Yes	0.7198	<.0001	2.054
Renal			
No	Ref.		
Yes	0.8891	<.0001	2.433
Infection-Chorioamnionitis			
No	Ref.		
Yes	0.7802	<.0001	2.182
Intercept	-5.5336		
C-statistic	0.832		
Number of Severe Maternal Morbidities with Transfusion (N)	1,901		

Table 2c. Risk Factors Identified for Post-admission Infections – All Deliveries

	Logistic Regression Results		
	Coefficient	P-value	Odds Ratio
Demographic Factors			
Non-Hispanic White			
Non-Hispanic White	Ref.		
Non-Hispanic Black	0.6536	<.0001	1.922
Hispanic	0.6691	<.0001	1.953
Non-Hispanic Asian	0.5303	<.0001	1.699
Other/ Multi-race	0.5178	0.0053	1.678
Private Insurance			
Medicaid	Ref.		
Self-Pay/Charity Care	0.2554	0.0059	1.291
Non-Hispanic White	0.3175	<.0001	1.374
Clinical & Obstetric factors/ Comorbidities			
Parity & Prolonged Length of Labor (> or = 20 hours)			
Multiparous, No Prolonged labor	Ref.		
Multiparous, Prolonged labor	1.8722	<.0001	6.503
Nulliparous, No Prolonged labor	1.4949	<.0001	4.459
Nulliparous, Prolonged labor	2.6807	<.0001	14.595
Gestational Age			
Mature (after 37 weeks of gestation)	Ref.		
Premature (before 37 weeks of gestation)	0.2903	0.0004	1.337
Induction	0.4848	<.0001	1.624
Premature Rupture of Membranes	0.5216	<.0001	1.685
Hypertension (Gestational & Preexisting)	-0.3007	0.0012	0.74
Tobacco Use	0.3233	0.0102	1.382
Epidural or Spinal Anesthesia	0.3956	<.0001	1.485
Intercept	-6.3072		
C-statistic	0.798		
Number of Post-admission Infection (N)	1,623		

Table 2d. Risk Factors Identified for Post-admission Infections – Cesarean Deliveries

	Logistic Regression Results		
	Coefficient	P-value	Odds Ratio
Demographic Factors			
Non-Hispanic White			
Non-Hispanic White	Ref.		
Non-Hispanic Black	0.5223	<.0001	1.686
Hispanic	0.5145	<.0001	1.673
Non-Hispanic Asian	0.5066	<.0001	1.66
Other/ Multi-race	0.09992	0.7392	1.105
Private Insurance			
Medicaid	Ref.		
Self-Pay/Charity Care	0.2387	0.0141	1.27
Non-Hispanic White	0.3808	0.0321	1.463
Clinical & Obstetric factors/ Comorbidities			
Parity & Prolonged Length of Labor (> or = 20 hours)			
Multiparous, No Prolonged labor	Ref.		
Multiparous, Prolonged labor	1.8378	<.0001	6.283
Nulliparous, No Prolonged labor	1.4826	<.0001	4.404
Nulliparous, Prolonged labor	2.3665	<.0001	10.66
Gestational Age			
Mature (after 37 weeks of gestation)	Ref.		
Premature (before 37 weeks of gestation)	0.2068	0.0696	1.23
Induction	0.9619	<.0001	2.617
Premature Rupture of Membranes	0.8439	<.0001	2.326
Hypertension (Gestational & Preexisting)	-0.4345	0.0005	0.648
Tobacco Use	0.3289	0.0716	1.389
Epidural or Spinal Anesthesia	0.1633	0.1765	1.177
Intercept	-5.8181		
C-statistic	0.832		
Number of Post-admission Infection (N)	767		

Table 2e. Risk Factors Identified for Post-admission Infections – Vaginal Deliveries

	Logistic Regression Results		
	Coefficient	P-value	Odds Ratio
Demographic Factors			
Non-Hispanic White			
Non-Hispanic White	Ref.		
Non-Hispanic Black	0.6692	<.0001	1.953
Hispanic	0.7672	<.0001	2.154
Non-Hispanic Asian	0.4517	0.0004	1.571
Other/ Multi-race	0.773	0.0011	2.166
Private Insurance			
Medicaid	Ref.		
Self-Pay/Charity Care	0.3469	<.0001	1.415
Non-Hispanic White	0.3669	0.0163	1.443
Clinical & Obstetric factors/ Comorbidities			
Parity & Prolonged Length of Labor (> or = 20 hours)			
Multiparous, No Prolonged labor	Ref.		
Multiparous, Prolonged labor	1.7126	<.0001	5.543
Nulliparous, No Prolonged labor	1.3765	<.0001	3.961
Nulliparous, Prolonged labor	2.6144	<.0001	13.659
Gestational Age			
Mature (after 37 weeks of gestation)	Ref.		
Premature (before 37 weeks of gestation)	0.3197	0.0085	1.377
Induction	0.1844	0.0111	1.202
Premature Rupture of Membranes	0.3732	<.0001	1.452
Hypertension (Gestational & Preexisting)	-0.2817	0.0441	0.754
Tobacco Use	0.2899	0.0979	1.336
Epidural or Spinal Anesthesia	0.5244	<.0001	1.69
Intercept	-6.493		
C-statistic	0.792		
Number of Post-admission Infection (N)	856		

Limitations

Obstetric Hemorrhage

Hemorrhage rates should be considered carefully. While they are defined using a nationally recognized standard definition and identified using the report of quantity of blood loss, there are limitations to consider with the reported quantities. There is no standard method for measuring the quantity of blood loss, because there is no universal system of timing and manner of measurement. Therefore, variation in method of recording blood loss volume may be occurring between hospitals. Additionally, the new ACOG definition does not account for method of delivery. A less stringent rule for vaginal delivery, "1,000cc of blood loss regardless of method of delivery", means that only severe situations are considered 'obstetric hemorrhage' whereas no similar stringency is applied to cesarean delivery. Finally, other clinical factors used to assess the clinical impact of blood loss (such as other signs of hypovolemia) are not reported. Moreover, in cases where there is a large amount of amniotic fluid or irrigation, it is difficult to provide an exact quantity for the loss of blood (Lyndon A et al., 2015). Therefore, comparing rates across hospitals should be done with these limitations in mind.

Severe Maternal Morbidities with Transfusion

In the transition from ICD-9-CM to ICD-10-CM coding schema, the codes specified by the CDC to identify transfusion rely on the hospital to identify the route of administration. This coding scheme does not appear to be universally used by all hospitals, which results in difficulty identifying transfusions. This results in an underestimation of the extent of transfusions in some facilities, though it is noted that since the first report of 2016 data, hospitals do appear to be addressing this concern. Additionally, the inclusion of transfusion, which some consider a useful proxy for identifying instances of hemorrhage, with other complications, such as eclampsia or aneurysm, implies that transfusion is a negative outcome. However, high transfusion rates may reflect an appropriate recognition and response to the underlying cause for needing a transfusion, i.e. hemorrhage. When considering transfusion rates at a hospital, readers are advised to also take into consideration the total picture of the clinical outcomes for a better understanding of a facility's performance.

Post-admission Infections

Currently, there is no standard definition of 'post-admission delivery-associated infection'. The definition used to identify infection in the current report reflects a carefully considered list of diagnoses that reflect clinically rational and significant post-delivery genitourinary tract and other infections that represent quality of maternal care and not just a general infection. Additionally, it is recognized that most delivery-associated infections are diagnosed and treated post-discharge from the hospital (Yokoe D et al., 2001). The current report examines only the *delivery hospitalization*; therefore, the rate of infections is likely underestimated.

Third- and fourth-degree Perineal Lacerations

The use of rates of third- and fourth-degree perineal lacerations as a performance metric for maternal care has been recently questioned. A study determined that operative delivery and

shoulder dystocia were the factors with greatest risk of lacerations. However, the measures to reduce lacerations, such as avoiding operative vaginal delivery, may inadvertently lead to higher rates of cesarean births (Friedman A. et al.,2015). Given the current stated goals of reducing cesarean rates in NJ, lacerations may be unavoidable in certain circumstances. As such, interpretation of rates needs to be done with care and with consideration for the characteristics of the hospital's patient mix. Based on the findings of the logistic regression analysis on the 2018 data, nulliparous mothers have a much greater risk of lacerations. Providing these first-time mothers with counseling and following guidelines in the ACOG Practice Bulletin on Prevention and Management of Obstetric Lacerations at Vaginal Delivery may help lessen the impact of these types of complications.

Episiotomy

An episiotomy is usually done to facilitate the delivery of an infant, however the procedure confers a risk of advanced perineal tears and obstetric anal sphincter injuries (OASIS); additionally, evidence of effectiveness of the procedure in managing shoulder dystocia is also lacking (ACOG Practice Bulletin No.198, 2018). Current recommendations are to limit routine use of episiotomy, instead using clinical judgement to determine its appropriate use. As such, rates of episiotomy vary greatly among hospitals in NJ. This may be a reflection more of hospital culture, provider training and preference rather than a reflection of delivery complication. As such, interpretation of episiotomy rates should be conducted within the context of the other reported metrics.

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Appendix A: Inclusion & Exclusion Criteria to Identify Reported Complications

Obstetric Hemorrhage

Denominator inclusion criteria:

All delivery hospitalizations; Stratified by method of delivery

- Cesarean
- Vaginal – assumption that all delivery hospitalizations not identified as cesarean were vaginal deliveries

Numerator inclusion criteria:

Maternal Blood Loss – reported as cc in Electronic Birth Certificate. Any blood loss greater than or equal to 1,000mL regardless of vital signs or method of delivery as Obstetric Hemorrhage

Post-admission Infection

Denominator inclusion criteria:

All delivery hospitalizations; Stratified by method of delivery

- Cesarean
- Vaginal – assumption that all delivery hospitalizations not identified as cesarean were vaginal deliveries

Numerator Inclusion criteria:

EBC identified cases (coded response and EBC field category and name)	
Yes	Characteristics of Labor and Delivery: Intrapartum Infection
Yes	Characteristics of Labor and Delivery: Clinical Chorioamnionitis
Hospital Discharge identified cases (ICD-10 codes and diagnosis)	
O860	Infection of obstetric surgical wound
O8600	Infection of obstetric surgical wound, unspecified
O8601	Infection of obstetric surgical wound, superficial incisional site
O8602	Infection of obstetric surgical wound, deep incisional site
O8603	Infection of obstetric surgical wound, organ and space site

O8609	Infection of obstetric surgical wound, other surgical site
O8612	Endometritis following delivery
O8621	Infection of kidney following delivery
O8681	Puerperal septic thrombophlebitis
O8689	Other specified puerperal infections
O41121x	Chorioamnionitis, first trimester
O41122x	Chorioamnionitis, second trimester
O41123x	Chorioamnionitis, third trimester
O41129x	Chorioamnionitis, unspecified trimester

Inclusion (specific to ICD-10 identified cases): cases in which Present on Admission 'No' included

Numerator exclusion criteria:

Cases in which Diagnosis Present on Admission coded as 'Yes' (specific to ICD-10 identified cases)

Third- and Fourth-degree Perineal Lacerations

Denominator inclusion criteria:

Vaginal delivery hospitalizations only

Stratified by use of instrument during delivery (with vs. without instrument) as defined in AHRQ PSI 18 and PSI 19

Denominator exclusion criteria:

Cesarean deliveries

Deliveries of overweight babies (>4,000 grams at birth; reported in EBC Birth Weight-grams)

Numerator inclusion criteria:

EBC identified cases (coded response and EBC field category and name)	
Yes	RH Immune, Mother's Morbidity & Discharge Information: Third- or fourth-degree perineal laceration
Hospital Discharge identified cases (ICD-10 codes and diagnosis)	
O702	Third degree perineal laceration during delivery

O7020	Third degree perineal laceration during delivery, unspecified
O7021	Third degree perineal laceration during delivery, IIIa
O7022	Third degree perineal laceration during delivery, IIIb
O7023	Third degree perineal laceration during delivery, IIIc
O703	Fourth degree perineal laceration during delivery

Episiotomy

Denominator inclusion criteria:

Vaginal delivery hospitalizations only (as identified via linkage of EBC to in-hospital discharge data)

Denominator exclusion criteria:

Cesarean deliveries

Deliveries with shoulder dystocia diagnoses (as per CMQCC* definition)

Numerator inclusion criteria:

Hospital Discharge identified cases (ICD-10 codes and procedure)	
0W8NXZZ	Division of Female Perineum, External Approach

*CMQCC – California Maternal Quality Care Collaborative

Severe Maternal Morbidity

Denominator inclusion criteria:

All delivery hospitalizations (as identified via linkage of EBC to in-hospital discharge data)

Stratified by method of delivery

- Cesarean (see definition below)
- Vaginal – assumption that all delivery hospitalizations not identified as cesarean were vaginal deliveries

Numerator inclusion criteria:

All SMM hospitalizations associated with in-hospital mortality or transfer-in or -out of the delivery facility, as well as those associated with procedure codes were included, regardless of length of stay.

The 18 indicators were identified using ICD-10-CM diagnosis codes and procedure codes as prescribed by the CDC, listed here.

Numerator exclusion criteria:

Hospitalizations with a length of stay less than the 90th percentile as calculated separately for vaginal, primary and repeat cesarean deliveries (Callaghan WM et al., 2012).