New Jersey

Hospital Maternity Care Report Card, 2020

New Jersey Department of Health

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HEALTH CARE QUALITY AND INFORMATICS

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Statute

Summary of the Statute

In 2018, New Jersey legislature enacted P.L. 2018, c.82, which requires the New Jersey Department of Health (NJDOH) 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 New Jersey mothers in 2020

- The racial/ethnic profile of New Jersey mothers is changing; racial and ethnic groups that are not non-Hispanic White now represent 54% of all births compared to 46% in 2000.
- Compared to 2019, there was a 2% decline in the number of delivery hospitalizations at the 49 licensed birthing general acute care hospitals, which is the same level of decrease from 2018 to 2019, demonstrating an overall downward trend in delivery volume.
- Cesarean delivery rates dropped to 32.9% of all delivery hospitalizations, a modest decrease of 1% from the 2019 rate.
- Cesarean deliveries continue to have higher rates of complications as compared to vaginal deliveries per 1,000 delivery hospitalizations: obstetric hemorrhage (123.8 cesarean versus 16.1 vaginal); post-admission infections (25.1 cesarean versus 14.5 vaginal); and Severe Maternal Morbidity (SMM) with transfusion (41.6 cesarean versus 11.7 vaginal).
- In 2020, the COVID-19 pandemic emerged, and a markedly lower hospital claim volume statewide was observed (19.9%) as compared to 2019. Of all delivery hospitalizations in 2020, 3.8% of delivering mothers experienced COVID-19 infections sometime during their pregnancy; among mothers with COVID-19 infection, more than half (60.1%) were positive at the time of delivery (within two days of admission for delivery) as opposed to positive any other time during pregnancy.

Variation in Characteristics and Outcomes by Hospital

- Vaginal Birth after Cesarean (VBAC) rates for all delivery hospitalizations varied from hospital to hospital, ranging from 0% to 5.8%, with a statewide rate of 2.3%.
- Episiotomy rates varied widely hospital to hospital, from 1% to 21%, while the statewide rate was 5.6%.
- COVID-19 infection rates at time of delivery at each hospital varied from 0% to 7.5% of delivery hospitalizations.
- The rate of SMM with transfusion was significantly higher than the statewide rate of 21.6 per 1,000 delivery hospitalizations among 17 birthing hospitals (of the 49 total), which is an increase from 2019 during which nine birthing hospitals (of the 49 total) had significantly higher rates; among the 17 hospitals with significantly greater SMM rates in 2020, 10 had higher than average rates of mothers with COVID-19 infection at the time of admission.

Complication Rates by Race/Ethnicity

- Non-Hispanic Black mothers had the highest rate of obstetric hemorrhage with 62.6 per 1,000 delivery hospitalizations; followed by Hispanic mothers with rate of 52.5 per 1,000 delivery hospitalizations; and the rate for other/multi-race mothers was the lowest at 46.1 per 1,000 delivery hospitalizations.

- Non-Hispanic Black mothers had the highest rate of SMM with transfusion at a rate of 36.5 per 1,000 delivery hospitalizations (which is an increase from the 2019 rate of 35.6 per 1,000 delivery hospitalizations); Hispanic mothers had the second highest rate of 25.2 per 1,000 delivery hospitalizations; and the rate for non-Hispanic White mothers was the lowest at 15.7 per 1,000 delivery hospitalizations.
- Asian mothers had the highest rate of third- and fourth-degree perineal lacerations without instrument with 3.4 per 100 delivery hospitalizations; both Hispanic mothers and non-Hispanic Black mothers had the lowest rate at 0.9 per 100 delivery hospitalizations.
- Asian mothers had the highest rate of episiotomy with 11.6 per 100 delivery hospitalizations; Hispanic mothers had a rate of 4.3 per 100 delivery hospitalizations; and the rate for non-Hispanic Black mothers was the lowest at 2.8 per 100 delivery hospitalizations.
- Asian mothers had the highest rate of post-admission infections at rate of 25.4 per 1,000 delivery hospitalizations; followed by Hispanic mothers with rate of 21.8 per 1,000 delivery hospitalizations; and the rate for non-Hispanic White mothers was the lowest at 12.7 per 1,000 delivery hospitalizations.

Nulliparous, Term, Singleton, Vertex (NTSV) Surgical/Cesarean Births

- NTSV surgical birth rate assesses the proportion of nulliparous (first time mother), with a term (37 or more completed weeks of gestation), singleton (one fetus), in a vertex position (head-first presentation of the fetus) delivered by cesarean section.
- The rate of NTSV surgical births in New Jersey decreased from 30.3 per 100 live births in 2016 to 25.9 per 100 live births in 2020. Correspondingly, the percentage of birthing acute care hospitals in New Jersey that achieved the U.S. Department of Health and Human Services Healthy People 2030 target of 23.6 or fewer NTSV surgical births per 100 live births increased from 16% in 2016 to 35% in 2020. Please see the table below for additional details.
- Nurture NJ is a multi-pronged, multi-agency initiative that aims to reduce maternal and infant mortality and morbidity and ensure equity in care and in outcomes for mothers and infants of all ethnic groups thereby making New Jersey the safest and most equitable place in the nation to deliver and raise a baby.

Year	Percentage of Birthing Acute Care Hospitals in NJ achieving the Healthy People 2030 target (23.6 or fewer NTSV surgical births per 100 live births)	NJ Statewide rate of NTSV surgical births (per 100 live births)
2016	16%	30.3
2018	20%	27.8
2019	33%	26.7
2020	35%	25.9

Key Recommendations

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

- 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; and
- Based on the statistically significant risk-adjusted complication rates (i.e., SMM, post-admission infections, obstetric hemorrhage) among 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 likely 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 et al., 2003; Elmir 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 child'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 were complemented by matching records with hospitalization discharge records from each of the hospitals where births occurred. This process also allowed capture of 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, and economic statuses. The risk-adjustment process allows for fair comparison 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 (SMM) as a surrogate for "Other Complications." In the following sections of this report, each measure is discussed 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 (Committee on Practice Bulletins-Obstetrics, 2017). However, blood loss greater than 500 mL in a vaginal delivery is abnormal and should be investigated and managed (Committee on Practice Bulletins-Obstetrics, 2017). Obstetric hemorrhage is common among 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 (Committee on Practice Bulletins-Obstetrics, 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 (World Health Organization [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 (Committee on Practice Bulletins-Obstetrics, 2017).

Severe Maternal Morbidity

The Centers for Disease Control and Prevention (CDC) refers to 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 (Centers for Disease Control and Prevention, 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 (Firoz 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 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 et al., 2014). Current recommendations for prevention of infections include judicious use of prophylactic antibiotics (Committee on Practice Bulletins-Obstetrics, 2018b). While most postpartum infections are diagnosed after the patient is

discharged from the hospital (Yokoe 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 of Obstetricians and Gyneacologists, 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 (Committee on Practice Bulletins-Obstetrics, 2018a).

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 (Committee on Practice Bulletins-Obstetrics, 2018a). 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 (Committee on Practice Bulletins-Obstetrics, 2018a).

Methods

Data Sources

Electronic Birth Certificate (EBC) Data: The Health Department's Office of Vital Statistics and Registry (OVSR) 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 2020 birth-related hospitalization that

occurs at the end of the calendar year may be reported with 2021 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

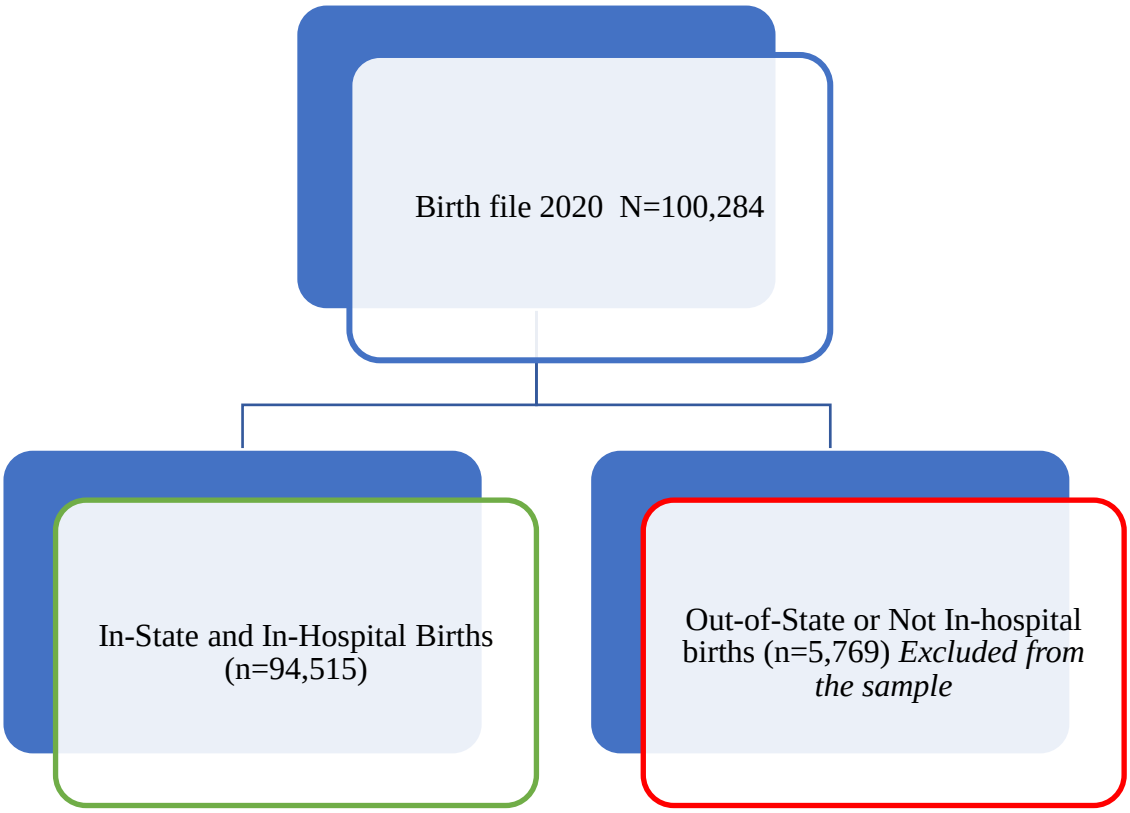
Inpatient Hospitalization Data

- 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)
  - 2020 birth-related hospitalizations
- 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, 2020

- Inclusion criteria
  - All New Jersey hospital births
    - In cases of multiple births, select only one 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



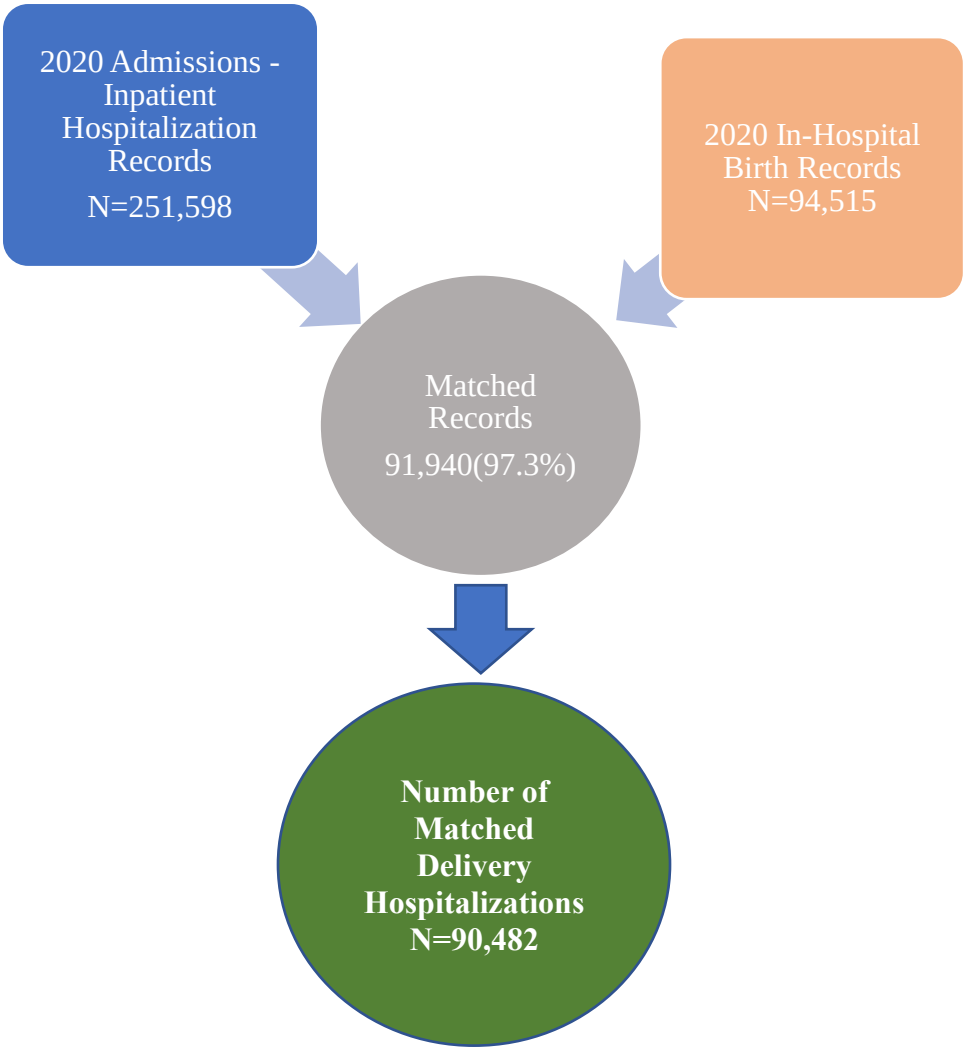
Data Matching

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 2020 and discharged in 2021 by linking 2021 birth discharges with late 2020 birth certificates.

Figure 2. Summary of Data Matching Process: EBC to Inpatient Hospitalization Records, New Jersey, 2020



The Study Population

As part of the process to obtain data to analyze, the team identified 94,515 in-hospital deliveries out of the 100,284 New Jersey births in 2020. These deliveries were comprised of all records including singleton births and multiple births. Of the 94,515 in-hospital deliveries identified, 91,940 deliveries were successfully matched to hospital discharge records for a match rate of 97.3%. 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 2020 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 of 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 90,482 linked 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 SMM is used as surrogate).

Identification of Delivery-associated Complications

Obstetric Hemorrhage

The ACOG standard defines hemorrhage as blood loss of 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. 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"

SMM events were identified during delivery hospitalizations using an algorithm developed by researchers at the 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 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 et al., 2011; Vale de Castro 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 of Obstetricians and Gyneacologists, 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 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 (Bachelors) and College + (Masters, PhD, etc.)
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
Admission to ICU	Maternal admission to ICU anytime during delivery hospitalization
Arrested Progress of labor	Arrested active phase of labor; hypotonic uterine dysfunction or uterine inertia during latent phase of labor
Preexisting Anemia	Yes/No
Preeclampsia	Yes/No
Transfer status (mother transferred from another facility, e.g., hospital, SNF, ICF, Healthcare facility, prior to delivery	Yes/No
COVID-19 Infection*	COVID-19 Positive at time of admission (PCR positive 2 days prior* or after date of admission OR ICD-10 code U071 COVID-19 on delivery discharge bill) COVID-19 Positive during pregnancy (PCR positive for COVID-19* anytime during pregnancy except within 2 days of admission for delivery)
Substance Use	Yes/No
Alcohol Use	Yes/No
Tobacco Use	Yes/No

*Data source: Communicable Disease Reporting and Surveillance System (CDRSS), New Jersey Department of Health

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 Institute Inc., 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, 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 the 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-2c, 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 about two times (odds ratio = 2.094) 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 experiencing a SMM during the delivery hospitalization for a delivering mother who is COVID-19 positive at the time of delivery is about two times (odds ratio = 2.065) compared with that of a patient who is not infected (Table 2b).

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	0.1149	0.0244	1.122
Hispanic	0.06331	0.1286	1.065
Non-Hispanic Asian	-0.1652	0.0045	0.848
Other/Multi-race	-0.1607	0.1191	0.852
Maternal Age	0.02975	<.0001	1.03
Clinical & Obstetric factors/Comorbidities			
Method of Delivery			
Vaginal and No Placental or Uterine Disorders	Ref.		
Cesarean *(Primary, Repeat)* with Placental or Uterine Disorders	3.3567	<.0001	28.696
Cesarean *(Primary, Repeat)* No Placental or Uterine Disorders	2.094	<.0001	8.117
Vaginal with Placental or Uterine Disorders	2.6417	<.0001	14.037
Nulliparous			
No	Ref.		
Yes	0.4314	<.0001	1.539
Gestational Age			
Mature	Ref.		
Premature	0.1998	<.0001	1.221
Infection-Chorioamnionitis			
No	Ref.		
Yes	0.726	<.0001	2.067
Preexisting Anemia			
No	Ref.		
Yes	0.2338	<.0001	1.263
ICU Admission			
No	Ref.		
Yes	1.0632	<.0001	2.896
Pre-pregnancy Body Mass Index (BMI)			
Normal	Ref.		
Overweight	0.1917	<.0001	1.211
Obese	0.2657	<.0001	1.304
Intercept	-5.8427		
C-statistic	0.821		
Number of Postpartum Hemorrhage (N)	4,785		

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

	Logistic Regression Results		
Patient Risk Factors Identified	Coefficient	P-value	Odds Ratio
Demographic Factors			
Race/Ethnicity			
Non-Hispanic White	Ref.		
Non-Hispanic Black	0.1816	.0176	1.199
Hispanic	0.1974	.003	1.218
Non-Hispanic Asian	-0.0124	.8981	0.988
Other/Multi-race	0.1349	.3567	1.144
Maternal Age			
Less than 35 years of age	Ref.		
Greater than 35 years of age	0.1346	.0138	1.144
Clinical & Obstetric factors / Comorbidities			
Method of Delivery			
Vaginal and No Postpartum Hemorrhage	Ref.		
Cesarean *(Primary, Repeat)* w/ Postpartum Hemorrhage	2.7343	<.0001	15.399
Cesarean *(Primary, Repeat)* and No Postpartum Hemorrhage	1.0304	<.0001	2.802
Vaginal with Postpartum Hemorrhage	3.3441	<.0001	28.336
Gestational Age			
Mature (after 37 weeks of gestation)	Ref.		
Premature (before 37 weeks of gestation)	0.7406	<.0001	2.097
Pre-pregnancy Body Mass Index (BMI)			
Normal	Ref.		
Overweight/Obese	-0.192	.0002	0.825
Prenatal Care Initiation			
Prenatal care initiated during first trimester	Ref.		
No care obtained/Prenatal care initiated late	0.1394	.011	1.15
COVID-19 Positive status at time of delivery	0.7249	<.0001	2.065
Uterine or Placental disorders	0.8028	<.0001	2.232
Preexisting Anemia	0.9306	<.0001	2.536
Preeclampsia	0.7444	<.0001	2.105
Induction	0.2535	<.0001	1.289
Drugs and/or Alcohol Abuse	0.52	.0004	1.682
Infection-Chorioamnionitis	0.7267	<.0001	2.068
Intercept	-5.6334		
C-statistic	0.846		
Number of Severe Maternal Morbidities with Transfusion (N)	1,951		

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

	Logistic Regression Results		
	Coefficient	P-value	Odds Ratio
Demographic Factors			
Race/Ethnicity			
Non-Hispanic White	Ref.		
Non-Hispanic Black	0.3618	<.0001	1.436
Hispanic	0.4788	<.0001	1.614
Non-Hispanic Asian	0.599	<.0001	1.82
Other/Multi-race	0.325	.0351	1.384
Maternal Age	-0.0095	.0574	0.991
Private Insurance			
Private Insurance	Ref.		
Medicaid	0.3631	<.0001	1.438
Self-Pay/Charity Care	0.2676	.0254	1.307
Clinical & Obstetric factors/ Comorbidities			
Method of Delivery & Prolonged Length of Labor (> or = 20 hours)			
Vaginal, No Prolonged labor	Ref.		
Vaginal, Prolonged labor	1.2395	<.0001	3.454
Cesarean, No Prolonged labor	0.4255	<.0001	1.53
Cesarean, Prolonged labor	0.8845	<.0001	2.422
Infant Birthweight			
Normal Birthweight (up to 2,500 grams)	Ref.		
Overweight - macrosomia (>4,000 grams)	0.3086	.0008	1.362
Induction (Y vs N)	0.547	<.0001	1.728
Premature Rupture of Membranes (Y vs N)	0.6434	<.0001	1.903
Hypertension (Gestational & Preexisting, Y vs N)	-0.1958	.02	0.822
Parity (Nulliparous Y vs N)	1.3282	<.0001	3.774
Epidural or Spinal Anesthesia (Y vs N)	0.1848	.0161	1.203
Arrested Progress of labor (Y vs N)	0.8119	<.0001	2.252
ICU admission (Y vs N)	1.1118	<.0001	3.04
COVID-19 Positive status at time of delivery (Y vs N)	0.3705	0.025	1.448
Uterine or Placental disorders (Y vs N)	0.386	0.0015	1.471
Transfer Status (Y vs N)	0.5704	0.025	1.769
Intercept	-6.1059		
C-statistic	0.815		
Number of Post-admission Infection (N)	1,668		

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 (Committee on Practice Bulletins-Obstetrics, 2017). 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 may be difficult to provide an exact quantity for the loss of blood (Lagrew et al., 2022). 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, although it is noted that since the first report of 2016 data, hospitals do appear to be addressing this concern as staff have likely become more familiar with the new coding schema. 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 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 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 (Committee on Practice Bulletins-Obstetrics, 2018a). 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 1,000 mL 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 et al., 2012).