Severe Obstetric Complications Electronic Clinical Quality Measure (eCQM) Methodology Report

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Yale New Haven Health Services Corporation – Center for Outcomes Research and Evaluation

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Executive Summary

The United States experiences higher rates of maternal morbidity and mortality than most other developed countries, rates that have continued to trend upward in recent decades.[1] There is national interest across maternal health advocacy organizations, payors, and the public to evaluate hospital performance and improve maternal morbidity and mortality rates, and a need to provide timely and accurate data to inform hospital improvement efforts and patient decision making. The broad availability of electronic health record (EHR) data presents an opportunity to measure maternal complication rates that cannot be fully measured using claims data alone.

The Centers for Medicare & Medicaid Services (CMS) contracted with Yale New Haven Health Services Corporation - Center for Outcomes Research and Evaluation (CORE) to support The Joint Commission (TJC) in the development of an EHR-based outcome measure of maternal morbidity and mortality. The goal for this measure is to assess the occurrence of specific severe obstetric complications in the hospital setting by using a methodology that reliably allows comparison across hospitals. Reduction in maternal complications will reduce maternal death and disability and improve maternal quality of life. The Severe Obstetric Complication electronic clinical quality measure (eCQM) is expected to inform hospital efforts to improve maternal health outcomes and thus reduce the costs associated with adverse health outcomes. We sought to keep measure specifications harmonized with other perinatal measures (for cohort alignment) and with the Center for Disease Control and Prevention's (CDC's) 21 indicators of severe maternal morbidity (SMM) (for harmonization of the measure outcome) for broad applicability across hospitals.

This report describes our approach to the development of the Severe Obstetrics Complications eCQM. This eCQM includes all delivery inpatient hospitalizations for women aged eight to 65 years and at least 20 weeks, zero days gestation at the time of delivery. The measure is risk adjusted for patient-level clinically relevant factors. We vetted measure decisions through multiple stakeholder groups, including a Technical Expert Panel (TEP), clinical expert consultants, and a Patient Working Group. In this report, we outline the approach to development, and provide detailed measure specifications for this eCQM. We describe the process and results of testing of this eCQM, which was conducted in three phases, across multiple hospitals with a variety of EHR systems.

1. Measure Introduction

1.1 Measure Overview

The Centers for Medicare & Medicaid Services (CMS) contracted with Yale New Haven Health Services Corporation - Center for Outcomes Research and Evaluation (CORE) to support The Joint Commission (TJC) in the development of an electronic health record (EHR)-based outcome measure of maternal morbidity and mortality. This measure, the Severe Obstetric Complications electronic clinical quality measure (eCQM), reflects a collaborative effort, from finalization of measure specifications through measure testing and completion.

The United States experiences higher rates of maternal morbidity and mortality than most other developed countries. These rates have continued to trend upward in recent decades.[1] Research indicates that the overall rate of severe maternal morbidity (SMM) has increased by almost 200% between 1993 and 2014 to 144 per 10,000 delivery hospitalizations[1], with more than 25,000 women per year experiencing obstetric complications.[2] Recent maternal mortality data from 2018 reveal that 658 women died from maternal causes, resulting in a rate of 17.4 deaths per 100,000 live births, with 77% of the deaths attributed to direct obstetric causes like hemorrhage, preeclampsia, obstetric embolism, and other complications.[3] This has prompted national health experts and organizations to prioritize quality improvement strategies to mitigate risk of adverse outcomes among maternal populations. The U.S. Department of Health & Human Services (HHS) has also called for action to improve maternal health and outcomes and outlines seven actions for healthcare professionals, including participating in quality improvement and safety initiatives.[4] There are currently only a small number of quality measures focused on maternal health, and those implemented at the national level are mostly process measures and limited in scope. While these existing measures aim to promote coordination of care and standardize health care processes, maternal health outcome measures are sorely needed. Measures that are focused on maternal health outcomes will address the patient safety priority area under the Meaningful Measures 2.0 framework, and likewise will use EHR data to address interoperability, another meaningful measure area for assessing quality of health care.[5]

Our goal was to develop a reliable outcome-based eCQM to evaluate hospital-level quality of maternal care for women who were hospitalized for delivery. This measure will use EHR data captured during the delivery hospitalization for an all-payer population. Utilizing EHR data for quality improvement and measurement efforts has several advantages compared to claims data alone, because the data tend to be clinically rich and produced in real time.[6] The Severe Obstetric Complications eCQM is the first hospital quality measure of maternal morbidity developed for national reporting.

This methodology report includes comprehensive information on the importance of measuring maternal outcomes and the measure development approach, specifications, and testing results of the Severe Obstetric Complications eCQM. CORE convened a Technical Expert Panel (TEP) comprising a diverse set of stakeholders, as well as a Patient Working Group, to provide input and expertise throughout the development of this eCQM.

1.2 Key Terminology

Key terms utilized throughout this report include the following:

- Severe Maternal Morbidity (SMM) – (also referred to as severe obstetric complications in this report) defined as "unexpected outcomes of labor and delivery that result in significant short- or long-term consequences to a woman's health" (American College of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine).[7]
- Maternal Mortality – defined as the death of a pregnant woman "irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes" (from the World Health Organization definition).[8] Many definitions also include death soon after pregnancy (e.g., within 42 days, within one year).[8,9] For the purposes of this measure, we focus on death that occurs during the delivery hospitalization.
- Healthcare Disparity – defined as "differences in the quality of care that are not due to access-related factors or clinical needs, preferences, and appropriateness of interventions" (National Quality Forum).[10]
- Electronic Clinical Quality Measure (eCQM) – A measure that "uses data electronically extracted from electronic health records (EHRs) and/or health information technology systems to measure the quality of health care provided" (The Office of the National Coordinator for Health Information Technology [ONC]).[11]
- Electronic Health Record (EHR) – "A digital version of a patient's paper chart. EHRs are real-time, patient-centered records that make information available instantly and securely to authorized users" (ONC).[12]

1.3 Severe Obstetric Complications as a Measure of Quality

1.3.1 Importance

Maternal morbidity and mortality pose serious health threats to pregnant women in the United States, where rates have been on the rise in comparison to other developed nations.[13] Recent data indicate a rate of 17.4 maternal deaths per 100,000 live births[3], and SMM occurring in 144 out of 10,000 delivery hospitalizations.[1] Hemorrhage, hypertensive disorders of pregnancy (HDP), sepsis/infection, cardiovascular conditions, cardiomyopathy, embolism, and mental health conditions have been identified as overall leading causes of peripartum death.[14] Nearly 16% of pregnancy-related deaths can be attributed to cardiovascular conditions.[15] The Centers for Disease Control and Prevention (CDC) report significant increases in SMM events since 1993.[16] The CDC specifically defines SMM by 21 indicators, defined by International Classification of Diseases, Tenth Revision (ICD-10) diagnosis and procedure codes.[17] The top SMM indicators include blood transfusions, which occurred in 122.3 per 10,000 delivery hospitalizations in 2014 and resulted in a substantial 399% rate increase from 1993 to 2014. Acute renal failure, another identified SMM indicator, has steadily increased over the years, with a

300% rate increase from 1993 to 2014. Other events identified among the CDC's SMM indicators with increasing rates over this period include adult respiratory distress syndrome with a rate increase of 205%; cardiac arrest, fibrillation, or conversion of cardiac rhythm with a 175% rate increase; and shock with a 173% increase.[16] Consequences of maternal morbidity are well documented. Not only are these conditions leading causes of pregnancy-related death, but often lead to further pregnancy complications and other SMM conditions.[18,19]

The costs associated with delivery complications are high. Investigators evaluating costs for women with a live inpatient birth in 2013 calculated a 37% increase in delivery hospitalization costs for women experiencing SMM over those without SMM among commercially insured women ($20,380 versus $14,840), and a 47% increase in delivery costs for women experiencing SMM over those without SMM among women insured with Medicaid ($10,134 versus $6,894).[20] The differential in costs was even higher in two studies using the Agency for Healthcare Research and Quality's (AHRQ's) Healthcare Cost and Utilization Project (HCUP) National Inpatient Sample. These studies, one using 2011 to 2012 data[21] and the other using 2012 to 2014 data[22], calculated average risk-adjusted hospital costs (not including physician costs) for SMM during delivery hospitalizations at over two times greater for patients with any SMM compared to patients with no SMM, 5.5 times the cost if the patient had two or more SMM events[22], and over 10 times the cost with five or more SMM events[21]. Costs are incurred due to the treatment required by obstetric complications and the impact on hospital lengths of stay; Premier's Bundle of Joy™ Report (2019) found that women with SMM delivering vaginally have hospital stays that are 70% longer than women with vaginal deliveries experiencing no SMM, and costs that are almost 80 percent higher.[23]

Lastly, there are considerable racial and ethnic disparities in maternal outcomes. Historically marginalized women of color are at a significantly higher risk for developing severe maternal complications compared to non-Hispanic white women.[24] Non-Hispanic black women are three to four times more likely to die from pregnancy-related causes than non-Hispanic white women.[25] Non-Hispanic American Indian/Alaska Native (AI/AN) women have the second highest pregnancy-related mortality ratio compared to non-Hispanic White, Asian/Pacific Islander, and Hispanic women.[25] Non-Hispanic Black women experience higher mortality from cardiomyopathy and cardiovascular conditions, while AI/AN women have an increased risk of death due to hemorrhage and hypertensive disorders.[26] Based on SMM defined using the 21 indicators identified by the CDC, Black, Hispanic, Asian/Pacific Islander, and AI/AN women had 2.1, 1.3, 1.2, and 1.7 times higher rates of severe morbidity, respectively, compared with white women in data from seven states.[27]

1.3.2 Performance and Preventability

The high maternal mortality and morbidity rates in the United States present unique opportunities for large-scale quality measurement and improvement activities. Statistics on preventability vary but suggest that a considerable proportion of maternal mortality and morbidity events could be prevented. A 2019 report from 14 maternal mortality review committees conducting a thorough review of pregnancy-related deaths determined that 65.8% of them were preventable (Data from 14 U.S. Maternal Mortality Review Committees, 2008-2017).[14] Additionally, a study that examined

preventability of pregnancy-related death, women with near-miss morbidity, and those with severe morbidity found that 40.5% of deaths, 45.5% of near miss morbidity, and 16.7% of other severe morbidities were preventable.[28] Geller et. al. identified areas of focus for preventability of morbidity and mortality that included assessment/point of entry to care, diagnosis and recognition of high risk, referral to experts, treatment, management hierarchy, education, communication, policies and procedures, documentation, and discharge.

Although there are limited measures to assess variability among hospitals, rates in the United States are higher than all other developed countries, presenting opportunity for improvement. Using the CDC definition of SMM, the US median rate was 1.4% and the highest hospital rate was 12.2%.[29] USA Today's database of childbirth complication rates at maternity hospitals, with data from 1,027 hospitals in 13 states from 2014-2017, showed marked variation in median rates of childbirth complications; this variability may reflect similar trends for maternal complications.[29]

Maternal morbidity has garnered much national attention, with a broad range of SMM events and outcomes that can be examined, many of which are closely associated with mortality.[15,30] Several initiatives have shown promise in reducing maternal morbidity events. For example, since the inception of the California Maternal Quality Care Collaborative (CMQCC), focused on metrics and toolkits to improve maternal outcomes, the maternal mortality rate in California declined by 55% between 2006 and 2013.[31] The CMQCC obstetric hemorrhage collaborative resulted in a 20.8% reduction in SMM in California hospitals compared with the 1.2% reduction in SMM among nonparticipating hospitals.[30] The state of California has established a successful framework for assessing and improving quality of maternal care, and outcomes suggest great potential for nationally reducing maternal care complications.

1.3.3 Measurement Gap

National evaluation of hospitals' performance on maternal morbidity and mortality is limited because there are currently no maternal morbidity or obstetric complications outcome measures in national reporting programs. Current quality measures related to pregnancy and maternal health proposed for or in public reporting programs are largely process measures (e.g., Maternity Care: Post-partum Follow Up and Care Coordination) and outcome measures related to delivery type (e.g., PC-01 Elective Delivery).

There are numerous state agencies, private and/or non-profit organizations, and collaboratives that have spearheaded maternal health and quality improvement initiatives. For instance, the Alliance for Innovation in Maternal Health (AIM) developed evidence-based patient safety bundles to address leading causes of SMM, like obstetric hemorrhage and hypertension. The CDC Perinatal Collaboratives also support various state-based efforts to promote high quality maternal care. The CMQCC created the Maternal Data Center (MDC) for hospitals with Labor and Delivery units in California, Oregon, and Washington. The MDC is an online tool that receives patient discharge data on maternity care services, linking these data to birth certificate or clinical data, and feeding back to clinicians' perinatal performance data for supporting quality improvement.[32] The MDC allows hospital performance regional and statewide comparisons. Overall, such quality metrics do not currently cater to a national population because there is extensive variation and timing delays in the widespread adoption and implementation

of safety protocols in obstetric care across states.[30,33] Moreover, data examining the nationwide implementation of these resources are not widely available.[30,34] Therefore, the development of a obstetric complications outcome measure addresses a national measurement gap that can build on learnings from existing maternal health initiatives and measures.

1.3.4 Feasibility and Usability

State and national initiatives to measure, track, and reduce maternal morbidity and mortality have produced encouraging results. The Severe Obstetric Complications eCQM could expand these improvements in care, outcomes, and cost savings at a national level. The eCQM will provide hospitals with benchmarking and actionable data to inform their quality improvement efforts; the use of EHR data will provide them with the potential to repurpose the data and measure logic for internal quality control using real-time feedback to further mitigate harm to mothers. Additionally, the eCQM can provide information that allows patients to compare hospitals' performance to aid in their decision making when choosing care.

Although efforts may require hospitals to initially invest resources to support measure reporting, we anticipate that such investments will help them more fully utilize their EHRs to improve care for pregnant women, which is a shared goal among stakeholders. Using EHR data instead of administrative data allows for more patient-centric, potentially real-time measure results to support hospital quality improvement efforts.[6,35,36]

However, using data from the EHR is only the first step to securing accurate and reliable data for measuring severe obstetric complications. The quality of our measure results depends on the reliability of the data extracted from structured fields in the EHR. In order to reduce hospital burden, we aimed to build a measure based on data captured by hospitals in structured fields in the EHR that are consistently captured during clinical care. We do not use data that might require natural language processing or other data manipulation prior to measure calculation. During measure testing, we tested the feasibility and validity of data elements required to determine the measure cohort, as well as the outcome and risk adjustment. Additionally, we adjudicated outcomes to ensure that the electronically specified definition correlated with the actual occurrence of a severe obstetric complication, according to clinical adjudication of the medical record.

Our goal was to build an eCQM that does not require changes in clinical workflow and for which the electronic specifications are easy to understand and implement.

1.4 Measure Use

This is a *de novo* eCQM intended to measure inpatient acute care hospital quality and performance related to severe obstetric complications and death during the delivery hospitalization. The measure is intended to be used alongside the suite of existing perinatal process of care quality measures and existing quality improvement efforts focused on reducing maternal morbidity and mortality.

1.5 Approach to Measure Development

The goal of the Severe Obstetric Complications eCQM is to assess prevalence of SMM and mortality during hospital delivery encounters for an all-payer population based on EHR data. We began by assessing the critical drivers of maternal morbidity and mortality, health disparities, and risk adjustment variables through an environmental scan and literature review (ES/LR). We then drafted Measure Authoring Tool (MAT) specifications, value sets, and a testing plan. To develop preliminary specifications, we built on prior published specifications when available. It is important to note that a standard and consistent definition for maternal morbidity and mortality is currently lacking; existing definitions vary in scope and in the time frame during which SMM or maternal death is captured.[8,9,15] For this measure, measure specifications are modeled after the nationally available and adopted CDC definition for SMM, which encompasses "unexpected outcomes of labor and delivery that result in significant short- or long-term consequences to a woman's health".[7] We also solicited input from clinicians and a diverse group of stakeholders throughout the development process; specifications were developed with input from the TEP and Patient Working Group. Our goal was to ensure usability by keeping specifications feasible and straightforward.

Development testing included alpha testing and two stages of beta testing. Alpha testing consisted of virtual EHR walkthroughs with recruited hospitals to assess feasibility of the data elements necessary to define the measure specifications. Beta testing consisted of testing of the measure specifications in the MAT to further establish the feasibility and validity of each of the data elements as well as validity of the Severe Obstetric Complications outcome. The accuracy of the data extracted from the EHR and the identification of a severe obstetric complications were assessed through medical record abstraction. Beta testing occurred in two stages: Stage 1 Beta testing revealed select data element feasibility issues and numerator validation informed updates to the measure specifications; Stage 2 Beta testing is being conducted to test the updated measure specifications and further validate measure results. Testing results and updated measure specifications based on results have been presented to the TEP and Patient Working Group for input.

1.5.1 Information Gathering

CORE initially conducted an ES/LR on maternal morbidity and mortality to inform the development of a maternal health eCQM, and subsequently conducted focused literature reviews on three common maternal morbidity events often associated with mortality: obstetric hemorrhage, maternal hypertension and preeclampsia, and maternal infection and sepsis.

In parallel, TJC identified through work on the Unexpected Complications in Term Newborn measure that there was need for a similar measure for maternal care. A broad environmental scan and literature review was conducted on the topic of maternal complications.

These literature reviews served to gather evidence on the prevalence, health consequences, and evidence of preventability of various maternal morbidity events, and how they might be measured based on clinical research, prior measurement efforts, and clinical guidelines. Methods to measure maternal morbidity outcomes through extraction of data from the EHR and through chart review for

clinical adjudication were explored. These reviews informed eCQM specification considerations for measurement of severe obstetric complications.

The environmental scans served to identify existing related or competing quality measures addressing maternal morbidity and mortality overall and measures specific to obstetric complications. An online scan of both pre-specified websites and search engines was conducted to identify existing quality measures related to maternal morbidity outcomes using electronic and other medical record systems, cross-checked against maternal health measure inventories provided by CMS. Websites were searched using keywords for pregnancy and maternity complications in combination with keywords reflecting the 21 SMM indicators used by the CDC to operationally define SMM. We supplemented this search via Google search engine using the following keywords: maternal morbidity and mortality measure, maternal morbidity measure, maternal mortality measure.

Ultimately, these literature reviews and environmental scans, in addition to discussions with key stakeholders led by TJC, focused measure development on building off the CDC indicators[17] and The American College of Obstetricians and Gynecologists' (ACOG) detailed list of ICD-10 codes to identify SMM.[37]

In addition, literature revealed the importance of risk adjustment for this patient population. Literature was used to identify common risk factors for SMM[38-41] and risk prediction for SMM to help identify potential risk variables for this eCQM[30,42] through the EHR.

1.5.2 Expert and Stakeholder Input

Expert and stakeholder input for the development of this measure was sought from a TEP, a Patient Working Group, and ongoing consultation with Dr. Elliott Main. The TEP was composed of 17 members (16 members initially, with an additional member replacing a departing member in 2021), including several individuals who had served on TJC's Technical Advisory Panel supporting the development of their perinatal care measures. Members brought expertise in quality improvement, electronic capture of medical information, healthcare disparities, obstetrics and gynecology, and patient perspective. TEP members nominated themselves (or were nominated) to participate in this stakeholder group. The members were engaged during key development milestones.

The first TEP meeting was held in person in February 2020 in Baltimore, MD, during which TEP members provided input on draft measure specifications for the measure cohort, outcome, and risk adjustment. The second TEP meeting was held via a web-based webinar in July 2021, during which TEP members provided input on alpha testing and feasibility results, initial beta testing results, and proposed updated measure specifications. At the third TEP meeting, a web-based webinar held in November 2021, TEP members provided input on the risk adjustment model, measure scores, and further testing results.

To gain targeted input from the patient and caregiver perspective, a Patient Working Group was recruited through collaboration with Rainmakers Strategic Solutions LLC. The Patient Working Group was composed of seven members, including patients and caregivers with diverse experiences and perspectives. The first Patient Working Group meeting was held in August 2020 via web-based webinar during which Patient Working Group members provided input on initial measure specifications for the

measure cohort, outcome and risk adjustment. The second meeting was held in July 2021 via web-based webinar, at which Patient Working Group members provided input on measure specification updates, as well as alpha testing and feasibility results and initial beta testing results. At the third meeting, a web-based webinar held in November 2021, Patient Working Group members provided input on the risk adjustment model, measure scores, and further testing results. Dr. Elliot K. Main, MD, the Medical Director at CMQCC and a Clinical Professor of Obstetrics and Gynecology at Stanford University, provided ongoing consultation for this work throughout measure development and testing. Dr. Main provided his clinical expertise and evidence from prior research to inform the development and evolution of the measure specifications.

2. Methods

2.1 Overview

The Severe Obstetrics Complications eCQM captures SMM events and in-hospital mortality extracted from the EHR to assess quality of maternal care in the hospital setting for an all-payer population. The measure identifies ICD-10 codes consistent with CDC's 21 SMM indicators, as well as death, to define the outcome. Measure specifications were built upon existing specifications from the PC-01 Elective Delivery and PC-02 Cesarean Birth eCQMs[43] that were developed by TJC to define the initial population, and published research from Dr. Elliot K. Main[30,42] to inform key methodological decisions, including risk adjustment. We solicited insight from members of the TEP and Patient Working Group on the measure specifications and partnered with hospitals and qualified vendors to evaluate feasibility, reliability, and validity of clinical data and measure logic.

Many of the data elements within the measure specifications are defined by ICD-10 diagnosis and procedure codes. Additional work has been done to map Systematized Nomenclature of Medicine (SNOMED) codes consistent with delivery encounters, the CDC's 21 SMM indicators, and risk variables in the measure specifications, and these SNOMED codes have been captured in value sets for future consideration in implementation. SNOMED codes are available for clinical data capture in the EHR; however, we found that hospitals participating in the testing of this measure chose to submit ICD-10 codes rather than SNOMED codes for almost all data elements. We believe that including both ICD-10 and SNOMED codes to define these data elements in the future will allow for inclusivity and flexibility to define the data elements of this measure. When SNOMED codes are more readily used in the field, the SNOMED codes in these value sets can be assessed, timing logic can be implemented to address present on admission delineation, and the Severe Obstetric Complication eCQM specifications can be reevaluated for inclusion of these codes.

Alpha and Beta Testing stages are described below.

- Alpha Testing: Alpha testing was conducted via virtual EHR walkthrough with recruited hospitals to confirm preliminary feasibility of documentation and data elements necessary to define the measure.

- Beta Testing: Testing of the MAT output was conducted with recruited hospitals. The MAT output describes the measure logic and value sets associated with each required data element; testing was conducted to further establish the feasibility and validity of each of the data elements as well as the validity of the Severe Obstetric Complications outcome. In Stage 1 Beta testing, conducted with 8 health systems consisting of 25 hospitals, results informed updates to the measure specifications, including the removal of trauma codes initially identified for denominator exclusion and numerator definitions initially considered in addition to the CDC 21 SMM indicators. In Stage 2 Beta testing, five additional hospitals were recruited, and updated measure specifications and measure logic was tested. In both stages of Beta testing, we determined the accuracy of the data extracted from the EHR using the MAT specifications by comparing the data value to values identified through medical record abstraction. Additionally, we confirmed the accuracy of the outcome through clinical medical record review. Alpha testing was conducted in three different EHR systems, and Beta Testing was conducted in four different EHR systems.

2.2 Data Sources

The Severe Obstetric Complications eCQM primarily uses electronic health record data, and data from other electronic clinical systems depending on hospital site workflows, to define all components of the measure, including the measure denominator, measure numerator, risk adjustment variables, and stratification variables.

For Alpha testing, virtual EHR walkthroughs were conducted with nine healthcare sites consisting of 27 individual hospitals, representing three different EHR systems, including Epic, Cerner, and Meditech. The EHR walkthroughs included EHR experts, report writers, and clinical leads to assess feasibility of the data elements necessary to define the measure specifications. Alpha testing included assessment of clinical and documentation workflows compared to measure intent, assessment of data element availability and accuracy, and assessment of use of data standards. A feasibility scorecard was completed for each healthcare test site.

For Stage 1 Beta testing, the MAT specifications were tested using data from eight healthcare Test sites and 25 hospitals, representing Epic, Cerner, and Meditech EHR systems, to further establish the feasibility and validity of each of the data elements as well as the validity of the outcome. Data were pulled for delivery hospital encounters discharged from January 1, 2020 to December 31, 2020**.** The accuracy of the data extracted from the EHR was assessed using the MAT specifications by comparing the data values identified through medical record abstraction, in which the accuracy of the outcome was confirmed through clinical medical record review.

For Stage 2 Beta testing, data from five additional hospital systems were recruited to test the updated measure specifications and measure logic, to further assess the feasibility of data elements required for the measure calculation, and to adjudicate the presence of conditions indicative of severe obstetric complication in the medical record.

2.2.1 Limitations

While rates of maternal morbidity and mortality have continued to trend upward in the US in recent decades[1], severe maternal morbidity is a relatively rare outcome, and as defined with 22 numerator definitions (21 SMM indicators as identified by the CDC and mortality), requires a substantial sample size for testing. For this reason, eight test sites representing 25 hospitals were included for initial Beta testing, and an additional five hospitals were identified for subsequent Beta testing. As testing results have revealed low frequencies for some of the numerator definitions, future testing in reevaluation will be important for assessing measure specifications.

Another limitation is that hospitals that were recruited for Stage 1 Beta testing submitted only ICD-10 codes, and not specified SNOMED codes, identified in the value sets for numerator and risk variable definitions. While SNOMED codes remain in the value sets for future consideration, they are not included in the measure logic at this time but are recommended for testing in reevaluation. As noted, when SNOMED codes are more readily used in the field, an update to the measure specifications to implement the SNOMED code value sets and timing logic can be tested for future implementation.

2.2.2 Missing Data

We developed this eCQM with the intent to, as much as possible, use variables that we expect to be consistently obtained in the target population, available in a structured field, and captured as part of standard clinical workflow. During Alpha testing, data elements were evaluated for feasibility and availability; two data elements were removed from measure specifications when several test sites were unable to accurately capture them (timestamp for procedure performed, and lab result for PaO2/FiO2). All other data elements were assessed to be feasible and available.

Many of the data elements used in the Severe Obstetric Complications eCQM are defined with ICD-10 diagnosis or procedure codes (for example, severe maternal mortality numerator events and risk adjustment variables). None of these data elements are considered to be missing when absent, since the absence of a given code implies absence of the corresponding condition.

For data elements representing vital signs and lab results, it is clinically acceptable that certain vital signs and labs were not performed for certain patients. That being said, vital sign and lab result fields with more than 20% missing were not considered as potential risk adjustment variables based on statistical considerations.

2.2.3 Generalizability

Hospital recruitment for participation in testing was aimed at gathering test data from a diversity of settings, and a variety of EHR systems. The 28 hospitals (27 represented in Alpha testing, 25 represented in Stage 1 Beta testing) across 10 sites represent 11 states. Twenty-five hospitals were urban, three were rural, and all 28 were designated to be community hospitals. Three were non-for-profit church operated, 24 were other not-for-profit, and one was government (county) owned. Three of the 28 hospitals were primarily obstetrics and gynecology hospitals. Total births per year ranged from 165 to 8823 with four hospitals with fewer than 500 births, 6 hospitals with 500-999 births, 11 hospitals with

1000-4999 births, four hospitals with greater than 5000 births, and three hospitals not reporting these data. Three EHR systems were utilized across these hospitals: Epic, Meditech, and Cerner.

However, given that this was neither a national nor a randomized sample, we recommend further testing in reevaluation to assess measure specifications.

2.3 Measure Cohort (Denominator)

The measure cohort for this eCQM is drawn from the initial patient population (IPP), defined as all inpatient hospitalizations for women aged eight to 65 years who undergo a delivery procedure with a discharge date during the measurement period. The measure cohort, or denominator, is further defined as women in the IPP who are greater than or equal to 20 weeks, zero days gestation at the time of delivery. The initial patient population is defined using delivery procedure codes (ICD-10 codes) from the EHR, and the measure denominator is further defined by gestation at the time of delivery.

As noted, SNOMED codes mapped to ICD-10 codes for delivery procedure codes remain in the value sets for future consideration but are not included in the measure logic at this time. We recommend future testing of these SNOMED codes in reevaluation.

2.3.1 Inclusion Criteria

The measure includes all delivery hospitalizations for live births and stillbirths with ≥ 20 weeks 0 days gestation completed at delivery for women aged eight to 65 years. The measure does not include delivery hospitalizations for women with gestation fewer than 20 weeks.

Rationale: This measure intends to include still and live births for women of childbearing age. Patients delivering at fewer than 20 weeks' gestation represent a distinct population, and these deliveries are classified as miscarriages.[44]

Gestational age is defined by either measure logic calculating an estimated gestation age (EGA) using the below calculation, or by EGA identified in a discrete field in the EHR.

The EGA is calculated using the American College of Obstetricians and Gynecologists ReVITALize guidelines. Gestational Age = (280-(EDD minus Reference Date))/7 where the Estimated Due Date (EDD) is defined as: the best obstetrical EDD is determined by last menstrual period if confirmed by early ultrasound or no ultrasound performed, or early ultrasound if no known last menstrual period or the ultrasound is not consistent with last menstrual period, or known date of fertilization (e.g., assisted reproductive technology). Reference Date is the date on which you are trying to determine gestational age. For purposes of this eCQM, Reference Date is the Date of Delivery.

2.3.2 Exclusion Criteria

None

2.4 Measure Outcome (Numerator)

The measure outcome (numerator) for this eCQM is based on the CDC definition of SMM (21 indicators) and uses ICD-10 to define diagnoses and procedures that are indicative of an SMM. ICD-10 codes are used for billing in hospitals and therefore are generally widely available and offer stability over time.[15] The numerator also includes patients who expire (die) during the inpatient encounter.

The measure numerator is defined as the number of inpatient delivery hospitalizations in the denominator for patients who experience any of the following numerator events. Note that only diagnoses not present on admission will be considered a numerator event.

- Severe maternal morbidity diagnoses and procedures[1]
    - Acute myocardial infarction
    - Aortic aneurysm
    - Cardiac arrest/ventricular fibrillation
    - Heart failure/arrest during procedure or surgery
    - Disseminated intravascular coagulation
    - Shock
    - Acute renal failure
    - Adult respiratory distress syndrome
    - Pulmonary edema/Acute heart failure[1]
    - Sepsis
    - Air and thrombotic embolism
    - Amniotic fluid embolism
    - Eclampsia
    - Severe anesthesia complications
    - Puerperal cerebrovascular disease
    - Sickle cell disease with crisis
    - Blood transfusion
    - Conversion of cardiac rhythm
    - Hysterectomy
    - Temporary tracheostomy
    - Ventilation
- Patients who expire (die) during the inpatient encounter

[1] CDC utilizes 21 indicators for defining SMM, but for the purposes of this measure's outcome, one of the indicators (Pulmonary edema/Acute heart failure) is defined using two distinct value sets. It is listed here as one indicator, but the value sets identify these as two distinct diagnoses. Likewise, the Measure Authoring Tool (MAT) header that supports this eCQM identifies these two diagnoses separately.

In addition to testing severe obstetric complications as defined above, we tested an additional outcome: severe obstetric complications as defined above but excluding delivery hospitalizations for which blood transfusion was the only numerator event. Blood transfusions, generally in response to excessive bleeding around delivery, account for the greatest proportion of patients identified as having an obstetric complication, but patients for whom this is the only identified numerator event may represent a less severe outcome experience. The secondary outcome will capture severe obstetric complications experienced in delivery hospitalizations that do not include those solely identified in the numerator with a blood transfusion.

Rationale: We chose to align the severe obstetric complications outcome with the 21 diagnoses and procedures widely accepted as SMM, as defined by CDC. Stakeholders supported alignment to ensure comparability of rates with other maternal morbidity reporting.

We included death in this measure outcome because this critical outcome may occur in the absence of one of the defined severe obstetric complication events. We requested feedback from TEP and Patient Working Group members on these specifications, which, along with clinical input and testing, helped inform key decisions for the measure outcome definition.

In development, four additional numerator events were included for consideration in the measure outcome: 1) intensive care unit (ICU) stay > 12 hours during the delivery hospitalization, 2) platelet count < 100 10*3/uL, 3) serum creatinine >= 2 mg/dL, and 4) PaO2 < 60 mmHg. These four candidate numerator definitions were not included in the numerator after clinical adjudication revealed that: patients with ICU stay and patients with creatinine >= 2 mg/dL generally also met other numerator definitions; platelet count <100 10*3/uL alone did not identify severe obstetric complications; and PaO2 is not administered consistently in this population and is burdensome for providers to map in the EHR. In addition, specific concerns about hospitals who may not have ICUs, and differential use of these units for patient care, supported removal of this indicator in the numerator.

As noted, SNOMED codes mapped to ICD-10 codes for the CDC's 21 SMM indicators remain in the value sets for future consideration but are not included in the measure logic at this time. We recommend future testing of these SNOMED codes in reevaluation. In addition, platelet count will continue to be collected for reassessment as a qualifying numerator event during reevaluation.

2.5 Attribution

This Severe Obstetrics Complications eCQM was developed as a hospital-level measure, with outcomes attributable to acute care settings, because deliveries most commonly occur in the acute inpatient setting.

2.6 Risk Adjustment

The goal of risk adjustment is to account for patient-level factors that are clinically relevant, have strong relationships with the outcome, and are outside of the control of the reporting entity, without obscuring important quality differences. Risk factors can increase (or decrease) the likelihood that a patient experiences a certain outcome.

Risk adjustment for case mix differences among hospitals is based on clinical status of the patient and other patient characteristics at the time of admission. Only conditions or comorbidities that convey information about the patient at the time of the admission are included in risk adjustment, determined by present on admission indicators. Complications that arise during the hospitalization are not used in risk adjustment.

We identified candidate risk variables of SMM for consideration in the measure risk adjustment model by utilizing literature and research findings, including An Expanded Obstetric Comorbidity Scoring System for Predicting Severe Maternal Morbidity by Dr. Stephanie Leonard[42], the NQF Maternal Morbidity and Mortality Environmental Scan[15], and our initial ES/LR findings on specific drivers of severe obstetric complications and maternal mortality. We also solicited input from clinicians, patients, and other experts in the TEP who identified for consideration numerous risk-adjustment variables at the patient and hospital levels. These included, but were not limited to, prior pregnancy history, housing instability, and availability of specialists and trauma care in hospitals. The teams acknowledged and carefully considered recommendations from the TEP and Patient Working Group for selection of candidate risk-adjustment variables.

Following the identification of risk-adjustment variables, a risk model was developed for the severe obstetric complications and severe obstetric complications excluding blood transfusion-only encounters. The risk model was developed and tested with data from the test sites included in Stage 1 Beta testing; 60,184 delivery hospitalizations were randomly divided in a 70/30 split for a development dataset (N=42,129)and a validation dataset (N=18,055). Risk variables were removed from inclusion in the model if there were greater than 20% missing values (relevant for vital signs and laboratory results). In addition, due to a lack of variation across encounters, temperature and respiratory rate were not included in the final model. The same risk variables were included in the risk models for severe obstetric complications and severe obstetric complications excluding blood transfusion-only encounters; however, due to very low prevalence of a few risk variables in the risk model of severe obstetric complication excluding transfusion-only cases, Human Immunodeficiency Virus (HIV) was combined with autoimmune disease, and obstetric venous thromboembolism (VTE) was combined with long-term anticoagulant medication use.

The following variables were included in the final risk model:

- Demographics and patient characteristics: maternal age
- Preexisting conditions and pregnancy characteristics defined by ICD-10 codes
    - Anemia
    - Asthma
    - Autoimmune disease
    - Bariatric surgery
    - Bleeding disorder
    - Body Mass Index (BMI)
    - Cardiac disease
    - Gastrointestinal disease

    - Gestational diabetes
    - Human Immunodeficiency Virus (HIV)
    - Hypertension
    - Mental health disorder
    - Multiple pregnancy
    - Neuromuscular disease
    - Obstetric venous thromboembolism (VTE)
    - Other pre-eclampsia
    - Placental accreta spectrum
    - Placental abruption
    - Placenta previa
    - Preexisting diabetes
    - Preterm birth
    - Previous cesarean
    - Pulmonary hypertension
    - Renal disease
    - Severe pre-eclampsia
    - Substance abuse
    - Thyrotoxicosis
- Laboratory tests and vital signs upon hospital arrival (Hematocrit, White blood cell [WBC] count, Heart rate, Systolic blood pressure)
- Long-term anticoagulant medication use
- Social Risk Factors: economic/housing instability

2.6.1 Social Risk Factors

Our goal in selecting risk factors for adjustment was to develop parsimonious models that included clinically relevant variables strongly associated with a severe obstetric complication outcome. We used a two-stage approach, first identifying the comorbidity or clinical status risk factors that were most important in predicting the outcome, then considering the potential addition of social risk factors. Social risk factors considered were also dependent on the availability of information in the EHR. As noted above, economic/housing instability was included in the model, and was chosen due to support in research literature for its inclusion and availability in the EHR.

Because of the stark differences in maternal outcomes by race/ethnicity as demonstrated in the literature, these social risk factors were examined as stratification variables rather than risk variables, as discussed below. It was determined that illumination of outcome disparities by race/ethnicity, rather than adjustment of outcomes by race/ethnicity, would best inform stakeholders and patients and be most impactful in incentivizing improvements in quality of maternal care.

2.7 Statistical Approach to Model Development

With the list of risk variables identified for the risk model, we estimated the hospital-specific risk standardized obstetric complications rate (RSOCR) using a hierarchical logistic regression model (hierarchical model). This strategy accounts for within-hospital correlation of the observed outcome among patients and accommodates the assumption that underlying differences in the quality of care across hospitals lead to systematic differences in patient outcomes. This approach models the log odds of a severe obstetric complication as a function of patient demographics and clinically relevant comorbidities with a random intercept for the hospital-specific effect.

The hospital-specific RSOCRs were calculated as the ratio of a hospital's "predicted" number of delivery hospitalizations with a severe obstetric complication to "expected" number of delivery hospitalizations with a severe obstetric complication multiplied by the overall observed rate of delivery hospitalizations with a severe obstetric complication. The expected number of delivery hospitalizations with a complication for each hospital (denominator) was estimated using its patient mix and the average hospital-specific intercept (i.e., the average intercept among all hospitals in the sample). The predicted number of delivery hospitalizations with a complication for each hospital (numerator) was estimated given the same patient mix but an estimated hospital-specific intercept. Operationally, the expected number of delivery hospitalizations with a complication for each hospital was obtained by summing the expected complications for all delivering patients in the hospital. The expected complications outcome for each delivering patient was calculated via the hierarchical model, which applies the estimated regression coefficients to the observed patient characteristics and adds the average of the hospital-specific intercept. The predicted number of delivery hospitalizations with a complication for each hospital was calculated by summing the predicted complications for all delivering patients in the hospital. The predicted complications outcome for each delivering patient was calculated through the hierarchical model, which applies the estimated regression coefficients to the patient characteristics observed and adds the hospital-specific intercept.

More specifically, we used a hierarchical model to account for the natural clustering of observations within hospitals. The model employs a logit link function to link the risk factors to the outcome with a hospital-specific random effect:

Let Y_{ij} denote the outcome (equal to one if the delivery encounter has a severe obstetric complication, zero otherwise) for patient *i* at hospital *j*; $\boldsymbol{Z}_{ij}$ denotes a set of risk factors for patient i at hospital j; and n_j is the number of delivery admissions to hospital j. We assume the outcome is related linearly to the covariates via a logit function:

Logistic Regression Model

$$\boldsymbol{logit}\big(\mathbf{Prob}(\boldsymbol{Y_{ij}} = \mathbf{1})\big) = \boldsymbol{\alpha} + \boldsymbol{\beta Z_{ij}} \qquad (1)$$

and $\boldsymbol{Z_{ij}} = (\boldsymbol{Z_{1ij}}, \boldsymbol{Z_{2ij}}, \dots, \boldsymbol{Z_{pij}})$ is a set of $\boldsymbol{p}$ patient-specific covariates.

To account for the natural clustering of observations within hospitals, we estimate a hierarchical logistic regression model that links the risk factors to the same outcomes and a hospital-specific random effect.

Hierarchical Logistic Regression Model

$$\boldsymbol{logit}\big(\mathbf{Prob}(\boldsymbol{Y_{ij}} = \mathbf{1})\big) = \boldsymbol{\alpha_j} + \boldsymbol{\beta Z_{ij}} \quad (2)$$

$$\text{where } \alpha_j = \mu + \omega_j;\ \omega_j \sim N(0, \tau^2) \quad (3)$$

where $\alpha_j$represents the hospital-specific intercept, $\boldsymbol{Z}_{ij}$is defined as above, μ is the adjusted average intercept over all hospitals in the sample, ω_j is the hospital-specific intercept deviation from μ, and τ^2 is the between-hospital variance component. This model separates within-hospital variation from between-hospital variation. Both the hierarchical logistic regression model and the logistic regression model are estimated using the SAS software system (GLIMMIX and LOGISTIC procedures, respectively).

2.8 Calculation of Measure Score

Hospital-level measure scores are calculated as a standardized proportion of the number of delivery hospitalizations for women who experience a severe obstetric complication, as defined by the numerator, by the total number of delivery hospitalizations in the denominator during the measurement period. As noted above, the hospital specific RSOCRs were calculated as the ratio of a hospital's "predicted" number of delivery hospitalizations with a severe obstetric complication to "expected" number of delivery hospitalizations with a severe obstetric complication multiplied by the overall observed rate of delivery hospitalizations with a severe obstetric complication. This ratio, referred to as the standardized risk ratio (SRR), is calculated as follows:

Standardized Risk Ratio: $\widehat{SRR}_j = \frac{Number\ of\ predicted\ events}{Number\ of\ expected\ events} = \frac{\sum_{i=1}^{n_j} logit^{-1}(\hat{\alpha}_j + \hat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij})}{\sum_{i=1}^{n_j} logit^{-1}(\hat{\mu} + \hat{\boldsymbol{\beta}}\boldsymbol{Z}_{ij})}$

The risk-standardized obstetric complication rate is calculated by multiplying the SRR by the national observed severe obstetric complications rate as calculated across all hospitals (for testing, this rate was the observed severe obstetric complications rate across all testing sites):

Risk-Standardized Obstetric Complications Rate: $\widehat{RSOCR} = SRR_j \times \bar{y}$

For measure reporting, we report the measure scores as a rate per 10,000 delivery hospitalizations. In addition, stratification of measure scores by a combined race and ethnicity variable for assessment of potential outcome variation will be evaluated.

2.9 Measure Testing

2.9.1 Data Element Reliability

Data element reliability and feasibility were assessed with virtual EHR walkthrough sessions conducted with each test site. The test site shared their screen while navigating through their EHR system as the measure data elements, specifications, and clinical workflows were discussed. Using the NQF's eCQM Feasibility Scorecard template, a scorecard was completed for each test site during this time. The feasibility scorecard results were analyzed for each site and aggregated across all test sites. Each data

element score was examined within each of the domains. Highly feasible was defined as receiving the maximum score of 1 within the domains and was expressed as a percentage.

2.9.2 Measure Score Reliability

During measure testing, we assessed measure score reliability, which is the degree to which repeated measurements of the same entity agree with each other. We estimated the measure score reliability using a signal-to-noise ratio to assess the values according to conventional standards.[46] We assessed signal-to-noise reliability that describes how well the measure can distinguish the performance of one hospital from another. The signal is the proportion of the variability in measured performance that can be explained by real differences in performance. Scores can range from zero to one. A reliability of zero implies that all the variability in a measure is attributable to measurement error. A reliability of one implies that all the variability is attributable to real difference in performance.[47,48]

2.9.3 Data Element Validity

For this measure, both the determination of outcomes and risk factors involve many data elements from hospital EHR systems. We first ensured that the critical data elements were complete by examining:

- Distribution and availability of the data elements, and
- Variation of distribution and completeness of data elements across different hospitals and EHR systems.

In Stage 1 Beta testing, a statistically representative sample of the electronically submitted inpatient encounters from six test sites was selected for re-abstraction for reliability testing and clinical adjudication. During the virtual visits, site staff shared their screen, navigated through the electronic health records of the sampled patients while Joint Commission staff manually re-abstracted each data element. To determine reliability and validity, re-abstraction findings were compared with the original electronic data submission and any disagreements were adjudicated with reasons for discrepancies noted.

In Stage 2 Beta testing, CORE recruited data from five additional hospital to test the updated measure specifications and measure logic as informed by Stage 1 Beta testing, to further assess the feasibility of data elements required for the measure calculation, and to adjudicate the presence of conditions indicative of severe obstetric complication in the medical record. For severe obstetric complication identification, we will perform the following validity tests to evaluate the accuracy of the electronically extracted EHR data elements compared with manually chart abstracted data elements from the same patients, which is considered the “gold standard.”

- Sensitivity analysis: describes the probability that a patient with a positive result in the abstracted medical record data was also a positive result in the EHR data (numerator case).
- Specificity analysis: describes the probability that a patient with a negative result in the abstracted medical record data was also a negative result in the EHR data (not a numerator case).

2.9.4 Measure Score Validity

We assessed measure score validity by calculating the positive predictive value (PPV) for events qualifying for the measure numerator. Each component of the measure was validated and considered to have 'agreement' if the EHR and chart abstracted data both identified the encounter as appropriately belonging in the measure numerator. We also calculated the measure sensitivity, specificity, agreement, and negative predictive value (NPV).

- PPV: describes the probability that a patient with a positive result (numerator case) in the EHR data also was a positive result in the abstracted medical record data, as confirmed by a clinical adjudicator.
- NPV: describes the probability that a patient with a negative result (not in the numerator) in the EHR data also was a negative result in the abstracted medical record, confirmed by the clinical adjudicator.
- Sensitivity: describes the probability that a patient with a positive result in the abstracted medical record data was also a positive result in the EHR data.
- Specificity: describes the probability that a patient with a negative result in the abstracted medical record data was also a negative result in the EHR data.
- Agreement: defined as the amount of remaining agreement between the maternal morbidity outcomes based on EHR and the maternal morbidity outcomes based on the abstracted medical record after the agreement by chance is factored in, measured by a Kappa statistic with values closer to one reflecting higher agreement.

2.9.5 Face Validity

To systematically assess face validity, we will survey the TEP, which is composed of national experts and stakeholder organizations. We will ask each member to rate the following statement using a six-point scale (1=Strongly Disagree, 2=Moderately Disagree, 3=Somewhat Disagree, 4=Somewhat Agree, 5= Moderately Agree, and 6=Strongly Agree): "The proportion of severe obstetric complication and mortality events obtained from the Severe Obstetric Complications eCQM as specified can be used to distinguish between better and worse quality care at hospitals."

3. Results

3.1 Measure Cohort

Table 1 provides information on test site, including the number of delivery encounters and number of unique patients, and on select patient demographic characteristics across all eight Stage 1 Beta testing sites.

Table 1. Patient Characteristics (8 Sites, Stage 1 Beta Testing)

Characteristics		Measure Cohort				
		Test Site #1	Test Site #2	Test Site #3	Test Site #5	Test Site #6
		N (%)	N (%)	N (%)	N (%)	N (%)
Number of encounters		18,070	7,196	7,955	6,139	3,359
Number of unique patients		18,070	7,196	7,949	6,139	3,359
Average Maternal Age in Years [Mean (STD)]		30 (6.0)	31 (6.0)	29 (6.0)	29 (6.0)	33 (5.0)
Maternal Age in Years	**<18**	111 (0.6)	39 (0.5)	78 (1.0)	51 (0.8)	1 (0.0)
	18-<25	3158 (17.5)	1130 (15.7)	1822 (22.9)	1530 (24.9)	145 (4.3)
	25-<30	4917 (27.2)	1791 (24.9)	2416 (30.4)	1885 (30.7)	490 (14.6)
	30-<35	5908 (32.7)	2413 (33.5)	2223 (27.9)	1708 (27.8)	1417 (42.2)
	35-<40	3161 (17.5)	1458 (20.3)	1177 (14.8)	800 (13.0)	1007 (30.0)
	40-<45	749 (4.1)	341 (4.7)	223 (2.8)	153 (2.5)	277 (8.2)
	45-<50	60 (0.3)	21 (0.3)	15 (0.2)	12 (0.2)	19 (0.6)
	>=50	6 (0)	3 (0.0)	0 (0.0)	0 (0.0)	3 (0.1)
Race/ Ethnicity	**Hispanic**	2468 (13.7)	2110 (29.3)	734 (9.2)	485 (7.9)	497 (14.8)
	Non-Hispanic, African American	4084 (22.6)	606 (8.4)	2971 (37.3)	952 (15.5)	89 (2.6)
	Non-Hispanic, Asian/Pacific Islander	743 (4.1)	117 (1.6)	157 (2.0)	66 (1.1)	364 (10.8)
	Non-Hispanic, White	9322 (51.6)	3658 (50.8)	3940 (49.5)	4507 (73.4)	2307 (68.7)
	Non-Hispanic, Other	651 (3.6)	633 (8.8)	135 (1.7)	58 (0.9)	35 (1.0)
	Declined/Unknown	802 (4.4)	72 (1.0)	18 (0.2)	71 (1.2)	67 (2.0)
Primary Payer	**Medicare**	50 (0.3)	12 (0.2)	27 (0.3)	36 (0.6)	7 (0.2)
	Medicaid	5857 (32.4)	305 (4.2)	3790 (47.6)	2600 (42.4)	97 (2.9)
	Private Insurance	11170 (61.8)	6863 (95.4)	4119 (51.8)	3482 (56.7)	3230 (96.2)
	Self-pay or Uninsured	0 (0.0)	15 (0.2)	19 (0.2)	21 (0.3)	15 (0.4)
	Other	993 (5.5)	0 (0.0)	0 (0.0)	0 (0.0)	10 (0.3)
	Unknown	0 (0.0)	1 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

Table 2. Test Site and Patient Characteristics (cont.)

Characteristics		Measure Cohort			
		Test Site #7	Test Site #9	Test Site #10	Across Sites
		N (%)	N (%)	N (%)	N (%)
Number of encounters		4,369	3,918	9,178	60,184
Number of unique patients		4,367	3,918	9,173	60,170
Average Maternal Age in Years [Mean (STD)]		32 (5.0)	32 (5.0)	31 (5.0)	30 (6.0)
Maternal Age in Years	**<18**	2 (0.0)	10 (0.3)	52 (0.6)	344 (0.6)
	18-<25	391 (8.9)	356 (9.1)	1255 (13.7)	9787 (16.3)
	25-<30	959 (22.0)	860 (21.9)	2194 (23.9)	15512 (25.8)
	30-<35	1622 (37.1)	1542 (39.4)	3404 (37.1)	20237 (33.6)
	35-<40	1118 (25.6)	914 (23.3)	1864 (20.3)	11499 (19.1)
	40-<45	263 (6.0)	215 (5.5)	387 (4.2)	2608 (4.3)
	45-<50	13 (0.3)	19 (0.5)	18 (0.2)	177 (0.3)
	>=50	1 (0.0)	2 (0.1)	4 (0.0)	19 (0.0)
Race/ Ethnicity	**Hispanic**	1739 (39.8)	163 (4.2)	235 (2.6)	8431 (14.0)
	Non-Hispanic - African American	254 (5.8)	1307 (33.4)	1590 (17.3)	11853 (19.7)
	Non-Hispanic - Asian/Pacific Islander	703 (16.1)	250 (6.4)	532 (5.8)	2932 (4.9)
	Non-Hispanic - White	1648 (37.7)	2077 (53.0)	5912 (64.4)	33371 (55.4)
	Non-Hispanic - Other	17 (0.4)	112 (2.9)	40 (0.4)	1681 (2.8)
	Declined/Unknown	8 (0.2)	9 (0.2)	869 (9.5)	1916 (3.2)
Primary Payer	**Medicare**	1 (0.0)	6 (0.2)	84 (0.9)	223 (0.4)
	Medicaid	408 (9.3)	10 (0.3)	3154 (34.4)	16221 (27.0)
	Private Insurance	3869 (88.6)	3894 (99.4)	4439 (48.4)	41066 (68.2)
	Self-pay or Uninsured	0 (0.0)	8 (0.2)	71 (0.8)	149 (0.2)
	Other	86 (2.0)	0 (0.0)	1429 (15.6)	2518 (4.2)
	Unknown	5 (0.1)	0 (0.0)	1 (0.0)	7 (0.0)

3.2 Attribution

Table 2a and Table 2b provide health care system specific characteristics for each of the test sites. In Table 2b, identification of whether a test site was included in Alpha testing, Stage 1 Beta testing, and

Stage 1 Beta reliability and validity testing is provided. Nine test sites were included in Alpha testing (Test sites 1 – 9), eight test sites were included in Stage 1 Beta testing (Test Sites 1 – 3, 5 – 7, 9 – 10), and six test sites were included in clinical adjudication (Test Sites 1 – 3, 6, 7, 9).

Table 2a. Test Site Characteristics

Site ID	# of Hospitals	Geography (Urban, Suburban, Rural)	# Total Beds	# of Births	Teaching Program in OB/GYN
Test Site 1	10	Urban	1807 (range 36 - 740)	16334 + (range 473 - 5568)	No
Test Site 2	1	Urban	247	8823	No
Test Site 3	1	Urban	228	8295	No
Test Site 4[a]	2	Urban	446	2921	No
Test Site 5	9	6 Urban 3 Rural	1653 (range 35 - 595)	9283 + (range 165 - 3596)	No
Test Site 6	1	Urban	446	3319	No
Test Site 7	1	Urban	541	4660	Yes
Test Site 8[b]	1	Urban	650	2442	Yes
Test Site 9	1	Urban	401	3854	No
Test Site 10[c]	1	Urban	321	8796	Yes

Table 2b. Test Site Characteristics (con't)

Site ID	Obstetric unit care level	NICU Level	Clinical EHR Software and Version	Included in Alpha Testing	Included in Stage 1 Beta Testing	Included in Stage 1 Beta Clinical Adjudica-tion
Test Site 1	*(Information not provided)*	Level 2 Level 3 Level 4	Epic	Yes	Yes	Yes
Test Site 2	Services all serious illnesses & abnormalities	Level 4	Cerner/ Siemens	Yes	Yes	Yes
Test Site 3	Services all serious illnesses & abnormalities	Level 3	Meditech	Yes	Yes	Yes

Site ID	Obstetric unit care level	NICU Level	Clinical EHR Software and Version	Included in Alpha Testing	Included in Stage 1 Beta Testing	Included in Stage 1 Beta Clinical Adjudica-tion
Test Site 4[a]	Services uncomplicated maternity & newborn cases	Level 2 Level 3	Cerner	Yes	No	No
Test Site 5	*2 hospitals* = Services all serious illnesses & abnormalities *2 hospitals* = Services uncomplicated & most complicated cases *3 hospitals* = Services uncomplicated maternity & newborn cases *2 hospitals* = (Information not provided)	Level 3 (1 central NICU for all hospitals)	Epic	Yes	Yes	No
Test Site 6	Services all serious illnesses & abnormalities	Level 3	Meditech	Yes	Yes	Yes
Test Site 7	Services uncomplicated & most complicated cases	Level 3	Epic	Yes	Yes	Yes
Test Site 8[b]	Services all serious illnesses & abnormalities	Level 3	Epic	Yes	No	No
Test Site 9	Services all serious illnesses & abnormalities	Level 3	Epic	Yes	Yes	Yes
Test Site 10[c]	Services all serious illnesses & abnormalities	Level 3	Cerner	No	Yes	No

a. Test Site 4 declined continued participation after Alpha Testing
b. Data from Test Site 8 was not available in time for Beta Testing
c. Test Site 10 joined after Alpha Testing

3.3 Risk Model and Model Performance Results

Table 3 provides frequencies and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) from the hierarchical model for the final set of demographic and clinical variables used for risk adjustment. The same risk variables were included in the model for severe obstetric complications and severe obstetric complications excluding blood transfusion-only encounters; however, due to the impact of very low prevalence of a few risk variables in the model of severe obstetric complication excluding transfusion-only cases, Human Immunodeficiency Virus (HIV) was combined with autoimmune disease, and obstetric venous thromboembolism (VTE) was combined with long-term anticoagulant medication use.

Table 3. Risk Variables w/Adjusted odds Ratio for Risk Model for Delivery Hospitalizations with Any Severe Obstetric Complication(s) and Risk Model of Delivery Hospitalizations with Severe Obstetric Complication(s) Excluding Blood Transfusion-Only Cases

Variable	Full Sample = 60,184	Adjusted OR (95% CI)	
	N (%)	Any Severe Obstetric Complication	Severe Obstetric Complication Excluding Blood Transfusion-Only Cases
Maternal Age in Years			
<20	1,574 (2.6%)	REF	REF
20-<25	8,558 (14.2)	1.05 (0.76, 1.45)	1.01 (0.42, 2.44)
25-<30	15,512 (25.8)	0.85 (0.62, 1.16)	1.24 (0.53, 2.90)
30-<35	20,237 (33.6)	0.83 (0.60, 1.13)	1.26 (0.54, 2.93)
35-<40	11,499 (19.1)	0.86 (0.62, 1.19)	1.07 (0.45, 2.54)
>=40	2,804 (4.7)	1.41 (0.97, 2.03)	1.92 (0.76, 4.87)
Anemia	11,466 (19.1)	1.76 (1.56, 1.98)	1.45 (1.10, 1.92)
Asthma	5,099 (8.5)	1.21 (1.02, 1.43)	2.00 (1.46, 2.73)
BMI	12,047 (20.0)	1.04 (0.91, 1.20)	1.21 (0.90, 1.61)
Bariatric Surgery	445 (0.7)	0.93 (0.54, 1.60)	0.80 (0.24, 2.68)
Bleeding Disorder	1,768 (2.9)	2.09 (1.66, 2.62)	2.50 (1.62, 3.87)
Cardiac Disease	939 (1.6)	1.61 (1.18, 2.18)	2.86 (1.74, 4.70)
Economic Housing Instability	62 (0.1)	1.79 (0.66, 4.85)	5.10 (1.44, 18.10)
Gastrointestinal Disease	967 (1.6)	1.28 (0.90, 1.81)	1.01 (0.47, 2.19)
Gestational Diabetes	5,793 (9.6)	1.04 (0.87, 1.24)	1.43 (1.02, 2.02)
Hypertension	2,613 (4.3)	0.99 (0.79, 1.24)	0.77 (0.48, 1.23)
Mental Health Disorder	8,753 (14.5)	1.23 (1.07, 1.41)	1.27 (0.95, 1.71)
Multiple Pregnancy	1,178 (2.0)	2.11 (1.64, 2.70)	1.48 (0.84, 2.60)
Neuromuscular	303 (0.5)	0.94 (0.47, 1.87)	0.98 (0.23, 4.13)
Other Preeclampsia	6,025 (10.0)	1.32 (1.11, 1.56)	1.44 (0.99, 2.11)
Placenta Previa	271 (0.5)	3.94 (2.60, 5.95)	1.36 (0.58, 3.18)
Placental Abruption	548 (0.9)	3.69 (2.76, 4.93)	2.52 (1.32, 4.79)
Placental Accreta Spectrum	66 (0.1)	50.11 (27.20, 92.32)	174.25 (91.18, 333.00)
Preexisting Diabetes	903 (1.5)	1.61 (1.19, 2.19)	1.91 (1.11, 3.28)
Preterm Birth	4,097 (6.8)	1.37 (1.15, 1.63)	2.22 (1.59, 3.09)
Previous Cesarean	10,256 (17.0)	1.29 (1.13, 1.48)	1.15 (0.85, 1.55)
Pulmonary Hypertension	23 (0.0)	0.99 (0.23, 4.24)	3.23 (0.76, 13.65)
Renal Disease	146 (0.2)	2.80 (1.68, 4.69)	3.13 (1.41, 6.94)
Severe Preeclampsia	2,337 (3.9)	2.56 (2.07, 3.16)	3.92 (2.62, 5.87)

Variable	Full Sample = 60,184	Adjusted OR (95% CI)	
	N (%)	Any Severe Obstetric Complication	Severe Obstetric Complication Excluding Blood Transfusion-Only Cases
Substance Abuse	4,048 (6.7)	1.06 (0.88, 1.27)	1.21 (0.81, 1.79)
Thyrotoxicosis	212 (0.4)	0.41 (0.13, 1.31)	0.67 (0.09, 4.91)
Autoimmune Disease	157 (0.3)	2.21 (1.16, 4.23)	NA*
HIV	71 (0.1)	1.75 (0.69, 4.49)	NA*
Grouped: Autoimmune Disease or HIV*	227 (0.4)	NA	1.67 (0.51, 5.54)
Long Term Anticoagulant Use	181 (0.3)	1.26 (0.66, 2.42)	NA*
Obstetrical VTE	52 (0.1)	0.58 (0.11, 2.94)	NA*
Grouped: Long Term Anticoagulant Use or Obstetrical VTE*	224 (0.4)	NA	0.95 (0.30, 2.99)
Vitals - Heart Rate			
Result <110	50,945 (84.6)	REF	REF
Result >=110	5,607 (9.3)	1.25 (1.06, 1.48)	1.41 (0.99, 2.00)
Missing	3,632 (6.0)	2.32 (1.23, 4.40)	1.77 (0.37, 8.58)
Vitals - Systolic BP			
Result <140	47,677 (79.2)	REF	REF
Result >=140 & <160	7,275 (12.1)	1.11 (0.94, 1.31)	0.95 (0.67, 1.36)
Result >=160	1,664 (2.8)	1.13 (0.87, 1.48)	0.61 (0.34, 1.09)
Missing	3,568 (5.9)	0.65 (0.33, 1.28)	0.91 (0.18, 4.64)
Labs - Hematocrit			
Result <33	11,344 (18.8)	2.66 (2.36, 3.01)	1.13 (0.84, 1.53)
Result >=33	41,293 (68.6)	REF	REF
Missing	7,547 (12.5)	1.25 (0.95, 1.66)	0.82 (0.45, 1.49)
Labs - WBC			
Result <14	42,099 (70.0)	REF	REF
Result >=14	7,010 (11.6)	1.19 (1.01, 1.40)	1.46 (1.05, 2.04)
Missing	11,075 (18.4)	0.60 (0.47, 0.76)	0.68 (0.41, 1.13)

* Due to low prevalence of select risk variables, for the risk model of severe obstetric complication excluding transfusion-only cases, Human Immunodeficiency Virus (HIV) was combined with autoimmune disease, and obstetric venous thromboembolism (VTE) was combined with long-term anticoagulant medication use.

Table 4 shows statistics on the logistic regression model performance for the model of any severe obstetric complications and for the model of severe obstetric complications excluding blood transfusion-only cases. The risk model was developed and tested with data from the test sites included in Stage 1 Beta testing; 60,184 delivery hospitalizations were randomly divided in a 70/30 split for a development

dataset and a validation dataset. The calculated C-statistic for the risk model for any severe obstetric complications was 0.74 using the development dataset and 0.75 using the validation dataset; the calculated C-statistic for the severe obstetric complications excluding blood transfusion-only cases measure was 0.77 using the development dataset and 0.77 using the validation dataset. For both versions of the measure, the C-statistics indicate good model discrimination.

The calibration indices (γ0, γ1) used to assess the risk model for the any severe obstetric complications in the validation dataset are (0.15, 1.05) and for the severe obstetric complications excluding blood transfusion-only cases in the validation dataset are (0.22, 1.04). The calibration values which are consistently close to 0 at one end and close to 1 at the other end indicates good calibration of the model. If the γ0 in the model performance using validation data is substantially far from zero and the γ1 is substantially far from 1, there is potential evidence of over-fitting.

With both the Development and Validation Datasets, both models show a reasonable range between the lowest decile and highest decile of predicted ability, given the low prevalence of the outcome. Overall, these diagnostic results demonstrate the risk-adjustment model adequately controls for differences in patient characteristics.

Table 4. Model Performance Statistics for Risk Model for Delivery Hospitalizations with Any Severe Obstetric Complication(s) and Risk Model of Delivery Hospitalizations with Severe Obstetric Complication(s) Excluding Blood Transfusion-Only Cases

Model Performance Statistic	Any Severe Obstetric Complication(s)		Severe Obstetric Complication(s) Excluding Blood Transfusion-Only Cases	
	Development Dataset	Validation Dataset	Development Dataset	Validation Dataset
C-statistic	0.74 (0.72,0.76)	0.75 (0.72,0.77)	0.77 (0.73,0.81)	0.73 (0.67,0.80)
Calibration (γ0, γ1)	(0.00,1.00)	(0.15,1.05)	(0.00,1.00)	(0.22,1.04)
Predictive ability[a]	(0.72,9.63)	(0.45,10.07)	(0.17,2.59)	(0.12,2.49)

a. Predicted ability displays the percent of cases with severe obstetric complications in the (lowest, highest) decile of predicted risk

3.3.1 Social Risk Factor Assessment

Table 5 shows the distribution of delivery encounters and unadjusted severe obstetric complication rates by race/ethnicity across all Stage 1 Beta test sites. Non-Hispanic Black or African-American patients have the highest unadjusted rates of severe obstetric complications; non-Hispanic White patients have the lowest unadjusted rate of any severe obstetric complications and non-Hispanic White and non-Hispanic patients of "Other" race have the lowest unadjusted rates of severe obstetric complications excluding blood transfusion only cases.

Table 5. Unadjusted Outcome Rates among Race/Ethnicity Groups Across Sites (Stage 1 Beta Testing)

Race/Ethnicity	Denominator	Any Severe Obstetric Complication(s)		Severe Obstetric Complication(s) Excluding Blood Transfusion-Only Cases	
		Numerator	Outcome Rate (95% CI) Unadjusted	Numerator	Outcome Rate (95% CI) Unadjusted
Number of Unique Encounters	60,184	1,466	2.4% (2.3, 2.6)	302	0.5% (0.4, 0.6)
Hispanic	8,431	213	2.5% (2.2, 2.9)	43	0.5% (0.4, 0.7)
Non-Hispanic – Black or African American	11,853	412	3.5% (3.1, 3.8)	70	0.6% (0.5, 0.7)
Non-Hispanic - Asian/Pacific Islander	2,932	74	2.5% (2.0, 3.1)	15	0.5% (0.3, 0.8)
Non-Hispanic - White	33,371	683	2.0% (1.9, 2.2)	157	0.3% (0.4, 0.5)
Non-Hispanic - Other	1,681	36	2.1% (1.4, 2.8)	5	0.3% (0.0, 0.6)

3.4 Measure Results

Table 6 provides the unadjusted and the risk-standardized rate per 10,000 deliveries rates for severe obstetric complications and severe obstetric complications excluding blood transfusion only cases for each test site and across all sites.

Table 6. Observed and Risk-Standardized Severe Obstetric Complication Rates Across Test Sites (Stage 1 Beta Testing)

Test Site	Delivery Encounters	Any Severe Obstetric Complication(s)		Severe Obstetric Complication(s) Excluding Blood Transfusion-Only Cases	
		Observed rate per 10,000 Delivery Hospitalizations	Risk-Standardized Rate per 10,000 Delivery Hospitalizations	Observed rate per 10,000 Delivery Hospitalizations	Risk-Standardized Rate per 10,000 Delivery Hospitalizations
Test Site 1	18,070	226	241	41	49
Test Site 2	7,196	235	248	72	55
Test Site 3	7,955	303	268	48	50
Test Site 5	6,139	209	223	44	50
Test Site 6	3,359	104	158	27	48
Test Site 7	4,369	213	255	41	50
Test Site 9	3,918	202	299	26	48
Test Site 10	9,178	341	285	81	51
Across Sites	60,184	244	252	50	50

Table 7 shows observed (unadjusted) frequencies for each defined severe obstetric complication in the Stage 1 Beta testing population. Singular numerator events identified are not mutually exclusive; delivery encounters in which multiple numerator events occurred are included in the frequency for each numerator event experienced.

Table 7. Observed (Unadjusted)) Frequencies for Numerator Events Across Sites (Stage 1 Beta Testing)

Numerator Events (among 60,184 eligible delivery encounters)	Across Sites	
	Total N	%
Numerator	1,466	2.44
Delivery encounter with any of the 21 CDC numerator events **or** mortality	1,466	2.44
Delivery encounter with **blood transfusion only (encounter has no other numerator events)**	1,164	1.93
Delivery encounter with any of the 21 CDC numerator events or mortality but excluding **blood transfusion only encounters**	302	0.50
Delivery encounter with **mortality**	3	< 0.01
Delivery encounter with **acute heart failure**	6	0.01
Delivery encounter with **acute myocardial infarction**	0	0.00
Delivery encounter with **aortic aneurysm**	0	0.00
Delivery encounter with **cardiac arrest/ventricular fibrillation**	2	< 0.01
Delivery encounter with **heart failure/arrest during procedure or surgery**	0	0.00

Numerator Events (among 60,184 eligible delivery encounters)	Across Sites	
	Total N	%
Delivery encounter with **disseminated intravascular coagulation**	71	0.12
Delivery encounter with **shock**	33	0.05
Delivery encounter with **acute renal failure**	94	0.16
Delivery encounter with **adult respiratory distress syndrome**	31	0.05
Delivery encounter with **pulmonary edema**	18	0.03
Delivery encounter with **sepsis**	31	0.05
Delivery encounter with **air and thrombotic embolism**	7	0.01
Delivery encounter with **amniotic fluid embolism**	1	< 0.01
Delivery encounter with **eclampsia**	10	0.02
Delivery encounter with **severe anesthesia complications**	3	< 0.01
Delivery encounter with **puerperal cerebrovascular disease**	1	< 0.01
Delivery encounter with **conversion of cardiac rhythm**	4	0.01
Delivery encounter with **hysterectomy**	57	0.09
Delivery encounter with **temporary tracheostomy**	0	0.00
Delivery encounter with **ventilation**	26	0.04
Delivery encounter with **sickle cell disease with crisis**	0	0.00
Delivery encounter with **blood transfusion**	1,295	2.15

3.5 Reliability

3.5.1 Data Element Reliability

Data element reliability testing was completed for 15 individual hospitals. This included one system of 10 hospitals and five individual hospitals. The minimum number of denominator cases per measured entity was established to achieve sufficient measure score reliability and was determined to be 30 to 36 sampled cases per test site. This includes 30 to 36 charts at each of the individual hospitals and three-to-four charts for each hospital in the system. 100% of the test sites met the minimum denominator requirement.

Data element reliability and feasibility were assessed with virtual EHR walkthrough sessions conducted with each Alpha test site. Each data element score was examined within each of the domains. Subsequent to the fourth EHR Walkthrough, Joint Commission staff determined several of the test sites were unable to accurately capture 2 main data elements: the timestamp for the procedure performed and the laboratory test result of the Pa02/Fi02 ratio. Joint Commission staff proposed to address these feasibility challenges by revising the draft specifications used for alpha testing to better align with clinical intent and decrease burden for a lab result not commonly calculated in the EHR. Consequently, feasibility scores based on the revised specifications increased to 98%.

Table 8 provides the data element feasibility rates prior to and following revision of draft measure specifications during Alpha testing. Feasibility Rate 1 reflects the rate inclusive of the timestamp for the procedure performed and the laboratory test result of the Pa02/Fi02 ratio. Feasibility Rate 2 reflects the

rate with the revised specifications, using date only for procedures performed (no timestamp) and laboratory test results of PaO2. Feasibility Rate 2, at 98%, shows a very high rate of data element feasibility.

Table 8. Feasibility Rate (9 Alpha Testing Sites)

Test Sites	Feasibility Rate 1 Initial	Feasibility Rate 2 Revised
Test Site 1	97%	97%
Test Site 2	87%	94%
Test Site 3	97%	100%
Test Site 4	97%	97%
Test Site 5	96%	98%
Test Site 6	91%	100%
Test Site 7	97%	100%
Test Site 8	97%	100%
Test Site 9	90%	99%
Overall	95%	98%

Table 9. Feasibility Rates by Domain (9 Alpha Testing Sites)

Table 9 shows the feasibility rates by domain reflecting the revised specifications.

Test Sites	Data Availability	Data Accuracy	Data Standards	Workflow
Test Site 1	97%	97%	87%	100%
Test Site 2	87%	94%	94%	94%
Test Site 3	97%	100%	100%	100%
Test Site 4	97%	97%	96%	99%
Test Site 5	96%	98%	94%	99%
Test Site 6	91%	100%	100%	100%
Test Site 7	97%	100%	100%	100%
Test Site 8	97%	100%	100%	100%
Test Site 9	90%	99%	96%	100%
Overall	95%	98%	96%	99%

3.5.2 Measure Score Reliability

The signal-to-noise ratio was calculated to assess how well the measure can distinguish the performance of one hospital from another. Results in presented in Table 10 indicate that this reliability analysis yielded a median reliability score of 0.991 (range: 0.982 – 0.997) for any severe obstetric complication and 0.955 (range: 0.916 – 0.983) for severe obstetric complications excluding blood transfusion-only cases.

Table 10. Signal-to-Noise-Reliability, Measure Scores

	# Hospitals	Median	Mean (SD)	Minimum	Maximum	Interquartile Range	
						Q1	Q3
Any Severe Obstetric Complication(s)	8	0.991	0.99 (0.005)	0.982	0.997	0.985	0.993
Severe Obstetric Complication(s) Excluding Blood Transfusion-Only Cases	8	0.955	0.95 (0.023)	0.916	0.983	0.929	0.966

The signal-to-noise reliability results show very high reliability for both outcomes.

Our interpretation of these results is based on standards established by Landis and Koch:[45]

- <0 = Less than chance agreement
- 0 – 0.2 = Slight agreement
- 0.21 – 0.39 = Fair agreement
- 0.4 – 0.59 = Moderate agreement
- 0.6 – 0.79 = Substantial agreement
- 0.8 – 0.99 = Almost Perfect agreement
- 1 = Perfect agreement

3.6 Validity

3.6.1 Data Element Validity

Data element validity testing was completed with 6 Stage 1 Beta testing sites. This included one system of 10 hospitals and five individual hospitals. The minimum number of denominator cases per measured entity was established to achieve sufficient measure score reliability and was determined to be 30 to 36 sampled cases per test site. This includes 30 to 36 charts at each of the individual hospitals and three-to-

four charts for each hospital in the system. 100% of the test sites met the minimum denominator requirement. Overall, the data element agreement rate for all six sites was 90.4%, indicating excellent agreement (Table 11).

Table 11. Data Element Agreement Rates Stage 1 Beta Testing Clinical Adjudication Sites)

		Test Site 1			Test Site 2			Test Site 3			Test Site 6			Test Site 7			Test Site 9			Total		
	Data Element Name	**Match**	**N**	**Rate**	**Match**	**N**	**Rate**	**Match**	**N**	**Rate**	**Match**	**N**	**Rate**	**Match**	**N**	**Rate**	**Match**	**N**	**Rate**	**Match**	**N**	**Rate**
Demographics	DOB	36	36	100.0 %	31	31	100.0 %	35	35	100.0 %	36	36	100.0 %	30	30	100.0 %	36	36	100.0 %	204	204	100.0 %
	ONC Administrative Sex Code	36	36	100.0 %	31	31	100.0 %	35	35	100.0 %	36	36	100.0 %	30	30	100.0 %	36	36	100.0 %	204	204	100.0 %
	Race	36	36	100.0 %	31	31	100.0 %	35	35	100.0 %	35	35	100.0 %	30	30	100.0 %	36	36	100.0 %	203	203	100.0 %
	Ethnicity	36	36	100.0 %	31	31	100.0 %	35	35	100.0 %	35	35	100.0 %	30	30	100.0 %	36	36	100.0 %	203	203	100.0 %
	Payer	32	36	88.9 %	31	31	100.0 %	35	35	100.0 %	36	36	100.0 %	30	30	100.0 %	36	36	100.0 %	200	204	98.0 %
	Admission Source	34	36	94.4 %	31	31	100.0 %	35	35	100.0 %	36	36	100.0 %	30	30	100.0 %	36	36	100.0 %	202	204	99.0 %
	Discharge Disposition	35	36	97.2 %	30	31	96.8 %	35	35	100.0 %	36	36	100.0 %	30	30	100.0 %	36	36	100.0 %	202	204	99.0 %
Encounter History	Encounter, Performed: Encounter Inpatient	36	36	100.0 %	31	31	100.0 %	35	35	100.0 %	36	36	100.0 %	30	30	100.0 %	36	36	100.0 %	204	204	100.0 %
	Admission Date Time (Relevant Period Start Time)	36	36	100.0 %	30	31	96.8 %	35	35	100.0 %	35	36	97.2 %	1	30	3.3%	36	36	100.0 %	173	204	84.8 %
	Discharge Date Time (Relevant Period End Time)	36	36	100.0 %	31	31	100.0 %	35	35	100.0 %	36	36	100.0 %	30	30	100.0 %	36	36	100.0 %	204	204	100.0 %
	Encounter, Performed: Emergency Department Visit	6	6	100.0 %	12	12	100.0 %	16	16	100.0 %	0	0		0	0		3	3	100.0 %	37	37	100.0 %
	ED Start Date Time (relevant Period)	6	6	100.0 %	12	12	100.0 %	16	16	100.0 %	0	0		0	0		3	3	100.0 %	37	37	100.0 %

		Test Site 1			Test Site 2			Test Site 3			Test Site 6			Test Site 7			Test Site 9			Total		
	ED End Date Time (relevant Period)	6	6	100.0 %	12	12	100.0 %	16	16	100.0 %	0	0		0	0		3	3	100.0 %	37	37	100.0 %
	Encounter, Performed: Preadmission Observation Undelivered Mother	0	0		0	7	0.0%	0	0		9	9	100.0 %	0	29	0.0%	36	36	100.0 %	45	81	55.6 %
	PreAdmObs Start Date Time (relevant Period)	0	0		0	7	0.0%	0	0		9	9	100.0 %	0	29	0.0%	36	36	100.0 %	45	81	55.6 %
	PreAdmObs End Date Time (relevant Period)	0	0		0	7	0.0%	0	0		9	9	100.0 %	0	29	0.0%	36	36	100.0 %	45	81	55.6 %
	Encounter, Performed: Observation Services	25	27	92.6 %	1	1	100.0 %	0	0		1	1	100.0 %	0	0		36	36	100.0 %	63	65	96.9 %
	Obs Start Date Time (relevant Period)	25	27	92.6 %	1	1	100.0 %	0	0		1	1	100.0 %	0	0		36	36	100.0 %	63	65	96.9 %
	Obs End Date Time (relevant Period)	25	27	92.6 %	1	1	100.0 %	0	0		1	1	100.0 %	0	0		36	36	100.0 %	63	65	96.9 %
	Facility Locations: Intensive Care Unit Code	2	2	100.0 %	0	0		5	5	100.0 %	1	1	100.0 %	0	0		0	0		8	8	100.0 %
	ICU Start Date Time	2	2	100.0 %	0	0		5	5	100.0 %	1	1	100.0 %	0	0		0	0		8	8	100.0 %
	ICU End Date Time	2	2	100.0 %	0	0		5	5	100.0 %	1	1	100.0 %	0	0		0	0		8	8	100.0 %
Dx	Diagnosis POA	245	391	62.7 %	397	397	100.0 %	312	312	100.0 %	208	346	60.1 %	319	319	100.0 %	327	328	99.7 %	1808	2093	86.4 %

		Test Site 1			Test Site 2			Test Site 3			Test Site 6			Test Site 7			Test Site 9			Total		
	Diagnosis code	391	391	100.0 %	397	397	100.0 %	312	312	100.0 %	346	346	100.0 %	319	319	100.0 %	328	328	100.0 %	2093	2093	100.0 %
Procedure	Procedure code & date	103	104	99.0 %	140	142	98.6 %	114	115	99.1 %	103	103	100.0 %	93	93	100.0 %	78	79	98.7 %	631	636	99.2 %
Blood	Blood Transfusion code	33	33	100.0 %	27	148	18.2 %	31	31	100.0 %	31	31	100.0 %	10	15	66.7 %	19	20	95.0 %	151	278	54.3 %
	Blood Transfusion start	33	33	100.0 %	25	141	17.7 %	31	31	100.0 %	31	31	100.0 %	10	15	66.7 %	19	20	95.0 %	149	271	55.0 %
	Blood Transfusion end	25	33	75.8 %	24	138	17.4 %	31	31	100.0 %	30	30	100.0 %	5	15	33.3 %	19	20	95.0 %	134	267	50.2 %
Delivery Details	Relevant Date Time Assessment, Performed: Date and time of obstetric delivery	35	36	97.2 %	30	31	96.8 %	34	35	97.1 %	36	36	100.0 %	28	30	93.3 %	36	36	100.0 %	199	204	97.5 %
	Result: Date and time of obstetric delivery	35	36	97.2 %	30	31	96.8 %	34	35	97.1 %	36	36	100.0 %	28	30	93.3 %	36	36	100.0 %	199	204	97.5 %
	Relevant Date Time Assessment, Performed: Delivery date Estimated	34	36	94.4 %	0	31	0.0%	34	35	97.1 %	36	36	100.0 %	28	30	93.3 %	36	36	100.0 %	168	204	82.4 %
	Result: Delivery date Estimated	34	36	94.4 %	30	31	96.8 %	35	35	100.0 %	36	36	100.0 %	30	30	100.0 %	34	36	94.4 %	199	204	97.5 %

		Test Site 1			Test Site 2			Test Site 3			Test Site 6			Test Site 7			Test Site 9			Total		
	Relevant Date Time Assessment, Performed: Estimated Gestational Age at Delivery	35	36	97.2 %	24	30	80.0 %	34	35	97.1 %	36	36	100.0 %	28	30	93.3 %	34	36	94.4 %	191	203	94.1 %
	Result: Estimated Gestational Age at Delivery	36	36	100.0 %	24	31	77.4 %	35	35	100.0 %	36	36	100.0 %	30	30	100.0 %	34	36	94.4 %	195	204	95.6 %
Laboratory Results	Creatinine Result Date Time	0	0		0	0		2	2	100.0 %	0	0		1	1	100.0 %	0	0		3	3	100.0 %
	Creatinine Result	0	0		0	0		2	2	100.0 %	0	0		1	1	100.0 %	0	0		3	3	100.0 %
	PaO2 Result Date Time	0	0		1	1	100.0 %	0	0		0	0		0	0		2	10	20.0 %	3	11	27.3 %
	PaO2 Result	0	0		1	1	100.0 %	0	0		0	0		0	0		2	10	20.0 %	3	11	27.3 %
	Platelet Result Date Time	9	9	100.0 %	4	4	100.0 %	3	3	100.0 %	9	9	100.0 %	8	9	88.9 %	2	2	100.0 %	35	36	97.2 %
	Platelet Result	9	9	100.0 %	4	4	100.0 %	3	3	100.0 %	9	9	100.0 %	8	9	88.9 %	2	2	100.0 %	35	36	97.2 %
	Hemoglobin Result Date Time	117	117	100.0 %	98	99	99.0 %	89	89	100.0 %	108	109	99.1 %	69	92	75.0 %	50	50	100.0 %	531	556	95.5 %
	Hemoglobin Result	117	117	100.0 %	98	99	99.0 %	89	89	100.0 %	108	109	99.1 %	71	92	77.2 %	50	50	100.0 %	533	556	95.9 %
	Hematocrit Result Date Time	117	117	100.0 %	97	99	98.0 %	93	93	100.0 %	108	109	99.1 %	70	92	76.1 %	111	112	99.1 %	596	622	95.8 %
	Hematocrit Result	117	117	100.0 %	98	99	99.0 %	93	93	100.0 %	108	109	99.1 %	70	92	76.1 %	111	112	99.1 %	597	622	96.0 %
	WBC Result Date Time	105	105	100.0 %	97	99	98.0 %	92	92	100.0 %	108	109	99.1 %	70	92	76.1 %	49	49	100.0 %	521	546	95.4 %
	WBC Result	105	105	100.0 %	98	99	99.0 %	92	92	100.0 %	108	109	99.1 %	70	92	76.1 %	49	49	100.0 %	522	546	95.6 %

		Test Site 1			Test Site 2			Test Site 3			Test Site 6			Test Site 7			Test Site 9			Total		
	Glucose Result Date Time	19	19	100.0 %	16	32	50.0 %	31	31	100.0 %	27	28	96.4 %	1	9	11.1 %	16	28	57.1 %	110	147	74.8 %
	Glucose Result	19	19	100.0 %	16	32	50.0 %	31	31	100.0 %	27	28	96.4 %	1	9	11.1 %	16	28	57.1 %	110	147	74.8 %
	Bicarbonate Result Date Time	0	11	0.0%	6	6	100.0 %	27	27	100.0 %	0	26	0.0%	5	6	83.3 %	14	14	100.0 %	52	90	57.8 %
	Bicarbonate Result	0	11	0.0%	6	6	100.0 %	27	27	100.0 %	0	26	0.0%	5	6	83.3 %	14	14	100.0 %	52	90	57.8 %
Vital Signs	Relevant Date Time Physical Exam, Performed: Oxygen saturation in Arterial blood by Pulse oximetry (%)	4	35	11.4 %	19	27	70.4 %	34	34	100.0 %	34	34	100.0 %	29	29	100.0 %	31	31	100.0 %	151	190	79.5 %
	Result: Oxygen saturation	34	35	97.1 %	21	27	77.8 %	34	34	100.0 %	34	34	100.0 %	29	29	100.0 %	31	31	100.0 %	183	190	96.3 %
	Relevant Date Time Physical Exam, Performed: Heart rate (BPM)	12	36	33.3 %	19	31	61.3 %	35	35	100.0 %	31	35	88.6 %	28	30	93.3 %	36	36	100.0 %	161	203	79.3 %
	Result: Heart rate	36	36	100.0 %	23	31	74.2 %	35	35	100.0 %	31	35	88.6 %	28	30	93.3 %	36	36	100.0 %	189	203	93.1 %
	Relevant Date Time Physical Exam, Performed: Systolic blood	12	36	33.3 %	19	31	61.3 %	35	35	100.0 %	31	35	88.6 %	28	30	93.3 %	36	36	100.0 %	161	203	79.3 %

		Test Site 1			Test Site 2			Test Site 3			Test Site 6			Test Site 7			Test Site 9			Total		
	pressure (mmHg)																					
	Result: Systolic blood pressure	36	36	100.0 %	23	31	74.2 %	35	35	100.0 %	31	35	88.6 %	28	30	93.3 %	36	36	100.0 %	189	203	93.1 %
	Relevant Date Time Physical Exam, Performed: Respiratory rate (breaths per minute)	10	36	27.8 %	19	31	61.3 %	35	35	100.0 %	22	24	91.7 %	29	30	96.7 %	36	36	100.0 %	151	192	78.6 %
	Result: Respiratory rate	35	36	97.2 %	23	31	74.2 %	35	35	100.0 %	22	24	91.7 %	29	30	96.7 %	36	36	100.0 %	180	192	93.8 %
	Relevant Date Time Physical Exam, Performed: Body temperature (degrees Fahrenheit or degrees Celsius)	7	36	19.4 %	19	31	61.3 %	35	35	100.0 %	29	32	90.6 %	29	30	96.7 %	36	36	100.0 %	155	200	77.5 %
	Result: Body temperature	36	36	100.0 %	23	31	74.2 %	35	35	100.0 %	29	32	90.6 %	29	30	96.7 %	36	36	100.0 %	188	200	94.0 %
	TOTALS	2447	2780	88.0 %	2343	2900	80.8 %	2472	2477	99.8 %	2369	2594	91.3 %	1935	2243	86.3 %	2423	2476	97.9 %	13989	15470	90.4 %

3.6.2 Measure Score Validity

Measure score validity testing was completed in the same 6 Stage 1 Beta testing sites. Table 12 displays the PPV (agreement rate) for the numerator among delivery encounters clinically adjudicated in Stage 1 Beta testing. The PPV rate was 100% at Test Sites 1, 2, 3, 6, and 7, and 70% at Test Site 9, with an overall PPV of 94.74%. In almost all delivery encounters with a numerator event adjudicated, the delivery encounters with a severe obstetric complication in the EHR data were shown to have a severe obstetric complication in the chart abstracted data, indicating strong measure validity. Although we do not always expect perfect agreement, as we expect some degree of human error in entering and matching values, we consider these PPV to show excellent measure score validity. The absence of a perfect PPV does not threaten validity as we do not expect any systematic error in this small amount of disagreement across hospitals that might bias the measure results.

Table 12. Agreement Statistics for Measure Numerator between EHR Extraction and Manual Chart Abstraction (PPV) (Stage 1 Beta Testing, 6 Test Sites)

Test Sites	# Of Numerator Events Verified by Clinical Adjudication	# Of Numerator Events from EHR	Positive Predictive Value (PPV)
Test Site 1	20	20	100%
Test Site 2	16	16	100%
Test Site 3	20	20	100%
Test Site 6	20	20	100%
Test Site 7	18	18	100%
Test Site 9	14	20	70.00%
Across 6 Sites	108	114	94.74%

Table 13 displays the sensitivity, specificity, and negative predictive value (NPV). Specificity and sensitivity are high. Sensitivity is 100% in all reliability test sites and specificity is 100% in Test Sites 1, 2, 3, 6, and 7 and 62.5% in Test Site 9. This means that the probability of the EHR data detecting a true severe obstetric complication during a delivery hospitalization based on the abstracted data ('gold standard') is 100% (sensitivity). The probability of the EHR data accurately identifying that no severe obstetric complication occurred during a delivery hospitalization based on abstracted data ranged from 62.5% to 100% and was 90.48% across test sites (specificity). NPV was 100% in all test sites, indicating the EHR data indicated a severe obstetric complication did not occur, and 100% of the time the chart abstraction confirmed a harm did not occur.

Table 13. Measure Score Validity Statistics for Sample Between EHR Extraction and Manual Chart Abstraction (Sensitivity, Specificity, NPV)

Test Sites	Sensitivity	Specificity	Negative Predictive Value (NPV)
1	100%	100%	100%
2	100%	100%	100%
3	100%	100%	100%
6	100%	100%	100%
7	100%	100%	100%
9	100%	62.50%	100%
Across 6 Sites	100%	90.48%	100%

Table 14 provides the measure outcomes agreement rates and kappa scores for the Stage 1 Beta testing clinical adjudication sites. These data indicate overall 91.2% agreement with a kappa score of .881, indicating excellent agreement.

Table 14. Measure Outcome Agreement Rates

Test Site	N	Agreement Rate	kappa
1	36	97.2%	.963
2	31	83.9%	.786
3	35	94.3%	.922
6	36	97.2%	.963
7	30	96.7%	.953
9	36	77.8%	.703
Total	204	91.2%	.881

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Appendix A: Acknowledgement Details

We would like to acknowledge the expertise from our clinical consultant who has offered invaluable guidance to inform clinical and methodological decisions for the Severe Obstetrics Complications eCQM.

Elliot K. Main, MD

Medical Director, California Maternal Quality Care Collaborative (CMQCC) and Clinical Professor, Obstetrics and Gynecology at Stanford University

Technical Expert Panel

We would like to acknowledge the contributions of our TEP. The TEP members brought a diverse range of expertise and provided feedback for consideration in the development of the Severe Obstetric Complications eCQM.

Table A1. Technical Expert Panel Members

Name	Affiliation	Location
Suzanne McMurtry Baird, DNP, RN	Co-Owner and Nursing Director, Clinical Concepts in Obstetrics, LLC	Brentwood, TN
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Name	Affiliation	Location
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Patient Working Group

We would also like to thank members of our Patient Working Group for their personal and insightful perspectives on key measure aspects of measure development and decisions.

Table A2. Patient Working Group Members

Patient Expert Name	Location
Leah Bahrencu	Austin, TX
Marianne Drexler	Durham, NC
Nikki Montgomery	Euclid, OH
Katie Silwa	Hagerstown, MD
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Kayleigh Summers	Pottstown, PA
Kim Sandstrom	Ocala, FL

Note: Acknowledgment of input does not imply endorsement

Appendix B: Glossary

Acute care hospital: A hospital that provides inpatient medical care for surgery and acute medical conditions or injuries. Short-term acute care hospitals provide care for short-term illnesses and conditions. In contrast, long-term acute care hospitals generally treat medically complex patients who require long-stay hospital-level care, which is generally defined as an inpatient length of stay greater than 25 days.

Case mix: The particular illness severity and demographic characteristics of patients with encounters/admissions at a given hospital.

Cohort: The encounters used to calculate the measure after inclusion and exclusion criteria have been applied.

Comorbidities: Medical conditions the patient had in addition to their primary reason for admission to the hospital.

Complications: Medical conditions that may have occurred because of care rendered during hospitalization.

Outcome: The result of a broad set of healthcare activities that affect patients' well-being. For the Severe Obstetric Complications eCQM, the outcome is the number of inpatient hospitalizations for patients who experience SMM diagnoses not present on admission during a delivery hospitalization.

Risk-adjustment variables: Patient demographics and comorbidities used to standardize rates for differences in case mix across hospitals.

Appendix C: Value Sets for Severe Obstetric Complications eCQM Specifications

Table C1 outlines the Value Sets that are used to define the measure specifications. The Value Set Authoring Center is the authoritative data source for Value Sets and Organizational Object Identifiers (OIDs).

Table C1. Value Set Name and OID for measure numerator, denominator, and risk adjustment

Measure Specification	Value Set Name	Code System	OID
Numerator	Severe Maternal Morbidity Procedures	Grouping[a]	2.16.840.1.113762.1.4.1029.256
	Severe Maternal Morbidity Diagnoses	Grouping	2.16.840.1.113762.1.4.1029.255
	Indicator-specific value sets		
	Acute Heart Failure	Grouping	2.16.840.1.113762.1.4.1029.351
	Acute Myocardial Infarction	Grouping	2.16.840.1.113883.3.666.5.3011
	Aortic Aneurysm	Grouping	2.16.840.1.113762.1.4.1029.344
	Cardiac Arrest/Ventricular Fibrillation	Grouping	2.16.840.1.113762.1.4.1029.345
	Heart Failure/ Arrest Related to Procedure or Surgery	Grouping	2.16.840.1.113762.1.4.1029.348
	Disseminated Intravascular Coagulation	Grouping	2.16.840.1.113762.1.4.1029.346
	Shock	Grouping	2.16.840.1.113762.1.4.1029.354
	Renal (Acute Renal Failure Grouping)	Grouping	2.16.840.1.113762.1.4.1029.342
	Adult Respiratory Distress Syndrome	Grouping	2.16.840.1.113762.1.4.1029.367
	Pulmonary Edema	Grouping	2.16.840.1.113762.1.4.1029.350
	Sepsis	Grouping	2.16.840.1.113762.1.4.1029.353

Measure Specification	Value Set Name	Code System	OID
	Air and Thrombotic Embolism	Grouping	2.16.840.1.113762.1.4.1029.356
	Amniotic Fluid Embolism	Grouping	2.16.840.1.113762.1.4.1029.343
	Eclampsia	Grouping	2.16.840.1.113762.1.4.1029.347
	Severe Anesthesia Complications	Grouping	2.16.840.1.113762.1.4.1029.352
	Puerperal Cerebrovascular Disorder	Grouping	2.16.840.1.113762.1.4.1029.349
	Sickle Cell Disease with Crisis	Grouping	2.16.840.1.113762.1.4.1029.355
	Blood Transfusion	Grouping	2.16.840.1.113762.1.4.1029.213
	Conversion of Cardiac Rhythm	Grouping	2.16.840.1.113762.1.4.1029.357
	Hysterectomy	Grouping	2.16.840.1.113762.1.4.1029.358
	Tracheostomy	Grouping	2.16.840.1.113762.1.4.1029.359
	Ventilation	Grouping	2.16.840.1.113762.1.4.1029.360
	Hemorrhage	Grouping	2.16.840.1.113762.1.4.1029.258
Denominator	Delivery Procedures	Grouping	2.16.840.1.113762.1.4.1045.59
Denominator Exclusions			
Risk Adjustment	Anemia	Grouping	2.16.840.1.113762.1.4.1029.323
	Asthma	Grouping	2.16.840.1.113883.3.117.1.7.1.271
	Autoimmune Disease	Grouping	2.16.840.1.113762.1.4.1029.311
	Bariatric Surgery	Grouping	2.16.840.1.113762.1.4.1029.317
	Bleeding Disorder	Grouping	2.16.840.1.113762.1.4.1029.287

Measure Specification	Value Set Name	Code System	OID
	BMI	Grouping	2.16.840.1.113762.1.4.1029.290
	Cardiac Disease	Grouping	2.16.840.1.113762.1.4.1029.341
	Gastrointestinal Disease	Grouping	2.16.840.1.113762.1.4.1029.338
	Gestational Diabetes	Grouping	2.16.840.1.113762.1.4.1029.269
	HIV	Grouping	2.16.840.1.113762.1.4.1029.272
	Hypertension	Grouping	2.16.840.1.113762.1.4.1029.332
	Mental Health Disorder	Grouping	2.16.840.1.113762.1.4.1029.314
	Multiple Pregnancy	Grouping	2.16.840.1.113762.1.4.1029.284
	Neuromuscular Disease	Grouping	2.16.840.1.113762.1.4.1029.308
	Obstetric VTE	Grouping	2.16.840.1.113762.1.4.1029.363
	Other Preeclampsia	Grouping	2.16.840.1.113762.1.4.1029.329
	Placental Accreta Spectrum	Grouping	2.16.840.1.113762.1.4.1029.302
	Placental Abruption	Grouping	2.16.840.1.113762.1.4.1029.305
	Placenta Previa	Grouping	2.16.840.1.113762.1.4.1110.37
	Preexisting Diabetes	Grouping	2.16.840.1.113762.1.4.1029.275
	Preterm Birth	Grouping	2.16.840.1.113762.1.4.1029.299
	Previous Cesarean	Grouping	2.16.840.1.113762.1.4.1029.278
	Pulmonary Hypertension	Grouping	2.16.840.1.113762.1.4.1029.281
	Renal Disease	Grouping	2.16.840.1.113762.1.4.1029.335

Measure Specification	Value Set Name	Code System	OID
	Severe Preeclampsia	Grouping	2.16.840.1.113762.1.4.1029.327
	Substance Abuse	Grouping	2.16.840.1.113762.1.4.1029.320
	Thyrotoxicosis	Grouping	2.16.840.1.113762.1.4.1029.296
	Heart Rate	LOINC	8867-4
	Systolic Blood Pressure	LOINC	8480-6
	Hematocrit	LOINC	2.16.840.1.113762.1.4.1045.114
	White Blood Cells Count Lab Test	LOINC	2.16.840.1.113762.1.4.1045.129
	Long-term Anticoagulant Use	Grouping	2.16.840.1.113762.1.4.1029.366
	Economic Housing Instability	Grouping	2.16.840.1.113762.1.4.1029.292

a. Grouping of ICD10 and SNOMEDCT value sets