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Maternal Morbidity and Mortality Environmental Scan

FINAL REPORT

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Background

Maternal morbidity and mortality have been identified as primary indicators of women's health and quality of healthcare globally. The Healthy People 2020 target goal for the U.S. maternal mortality rate is 11.4 maternal deaths (per 100,000 live births), but as of 2018, the U.S. rate is 17.4 maternal deaths (per 100,000 live births).[1] This rate is much higher than other high-income countries, with more than 700 women dying annually from pregnancy-related causes. These rates vary by region, state, and across racial and ethnic lines where significant disparities highlight exacerbating differences in rates among non-Hispanic black women (37.1 deaths per 100,000 live births), non-Hispanic white women (14.7 deaths per 100,000 live births), and Hispanic women (11.8 deaths per 100,000 live births).[2] The leading causes of overall maternal mortality can be attributed to increased rates of cardiovascular disease, hemorrhage, and infection.[3,4] Women with poor maternal outcomes are at increased risk for recurrence in their next pregnancy and are at increased risk of chronic illness in later life. For example, women with preeclampsia have an increased risk of cardiovascular disease, and women with gestational diabetes have a sevenfold increased risk of developing type 2 diabetes later in life, as well as an elevated risk of hypertension.[5] The postpartum period presents an opportunity to intervene to improve this trajectory; however, many women still face barriers such as cost, transportation, lack of provider availability, loss of insurance, childcare, psychological distress, challenges communicating with a provider, and health literacy.

In 2003, the measurement of maternal mortality began to improve with the revision of the U.S. death certificate to include what has been referred to as the pregnancy checkbox. Previously, some deaths were not identified as being associated with pregnancy, and mortality rates were therefore considerably underestimated. However, not all states adopted this change at the same time, so implementation was not uniform across the country. It has been difficult for researchers to disentangle implementation issues from true change. However, attributing some of this rise to a decrease in quality of maternal care appears warranted.[6] Between 2000-2014, researchers attributed 20.1 percent of the observed increase to a real increase in maternal mortality, and 79.9 percent of the increase to an improvement in measurement tools.[7] Recent studies indicate that severe maternal morbidity (SMM) affects more than 60,000 women annually in the U.S. with rising trends over the last two decades.[3,8,9] Severe maternal morbidity poses a tremendous risk to the health and well-being of women, and although not all of the causes of the rising rates of morbidity and mortality are clear, it is evident that racial disparities are pervasive. Understanding the causes of maternal morbidity and mortality are vital to improving maternal health outcomes for all populations.

Project Overview

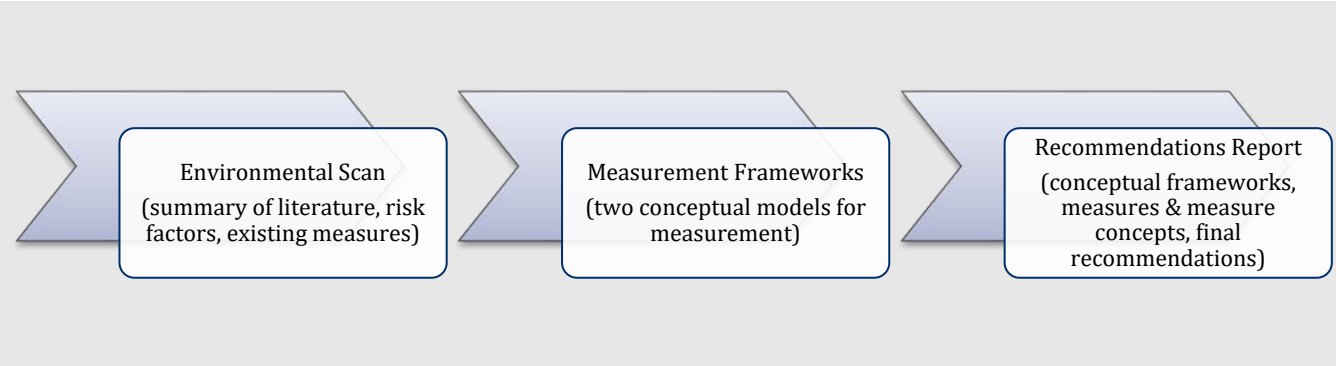
In fall 2019, the National Quality Forum (NQF), with funding from the Center for Medicare & Medicaid Services (CMS), convened a multistakeholder Maternal Morbidity and Mortality Committee (Appendix A) to provide input and guidance on the identification of developed measures and concepts addressing maternal morbidity and mortality. Results of the scan will be used to produce two measurement frameworks: one for maternal morbidity and one for maternal mortality, to help identify areas for measure development and gaps in maternal morbidity and mortality care.

This work will be accomplished over the course of 24 months through eight web meetings with the Maternal Morbidity and Mortality Committee. This scan will add to the existing body of knowledge

around maternal morbidity and mortality measurement by charting the current quality measurement landscape as it pertains to maternal morbidity and mortality. This project will provide recommendations for specific short- and long-term innovative, actionable approaches to improve maternal morbidity and mortality measurement and ultimately improve maternal health outcomes. Maternal health outcomes refer to both maternal morbidity and maternal mortality. The Committee will help identify gaps in measurement in these topic areas in order to spur action in areas of measurement that need additional research and development. The project's purpose is supported by the need to leverage quality measurement to improve maternal health. This project seeks results that will monitor and track maternal morbidity and mortality, reduce preventable causes of these outcomes, and eliminate disparities in maternal health outcomes.

Project Approach

To achieve these goals, NQF staff gathered information on defining maternal morbidity and mortality, identified clinical risk factors, identified other influencing factors (e.g., nonclinical), and identified innovations in measure methodologies and existing measures. The Committee will use the analysis from the environmental scan to: (1) provide input and direction on the development of two conceptual frameworks for analyzing measures to improve the quality of maternal healthcare; and (2) identify measurement gaps and a measure concept for maternal morbidity to include in the forthcoming recommendations report. The image below provides a guide to understanding how the project components are linked.



Environmental Scan Methodology

With parameters established in consultation with the HHS Contracting Office Representatives (CORs), and the Committee, NQF staff completed an environmental scan using the following research questions:

- What are the rates of prevalence and incidence for outcomes related to maternal morbidity and mortality?
- What are the influencing risk factors (medical and nonmedical) associated with maternal morbidity and mortality? What are the influencing risk factors specifically related to health disparities in this area?
- What are the standard processes of maternal care delivery that contribute to improving outcomes or present gaps that can contribute to maternal morbidity and mortality?
- What are the fully developed measures that monitor maternal morbidity and mortality? Which of these measures are in use?

- What are the measure concepts that seek to monitor maternal morbidity and mortality?
- What programs or innovations in measurement methodologies exist on a federal or state level?

NQF scanned known sources such as PubMed and American College of Obstetricians and Gynecologists' (ACOG) Practice Bulletins and Committee Opinions, as well as grey literature and web search engines to identify reports, white papers, guidelines, and other documentation related to maternal health. Staff then reviewed abstracts and articles that were relevant to the project scope and research questions and synthesized the sources. An initial search using terms such as "maternal morbidity measurement," "maternal mortality measurement," and "maternal quality improvement" yielded 346 articles. The 30-person Maternal Morbidity and Mortality Standing Committee was asked to provide up to 10 articles per person that were critical to maternal morbidity and mortality measurement, data collection, or quality improvement initiatives. This yielded an additional 43 papers with four duplicates. After these 385 articles were identified and reviewed, 302 were fully reviewed for their relevance to the environmental scan.

NQF staff also identified more than 130 related measures from the literature search, the NQF Quality Positioning System, the Centers for Medicare & Medicaid Services Measures Inventory, and the CMS Qualified Clinical Data Registry (specifically, the merit-based incentive payment system). Out of the identified measures, 93 were included in the scan. Measures were excluded due to their irrelevance to maternal health or their focus on perinatal health rather than maternal health. With input from the Committee and NQF members, 38 measure concepts were identified in total. A compiled list of measures and measure concepts related to maternal morbidity and mortality (Appendices B and C, respectively).

Defining Maternal Morbidity and Mortality

The relationship between maternal morbidity and mortality is complicated regardless of the indicators or definitions. Maternal morbidity is often thought to be causal on the pathway to maternal mortality, but even that relationship is confounded. A case of placenta accreta spectrum, in which the placenta has invaded the uterus to such a degree that attempting to separate the two would disrupt vascular connections and precipitate a postpartum hemorrhage, might necessitate a hysterectomy as a life-saving intervention. However, performing a hysterectomy would also constitute severe maternal morbidity in any contemporary framework or definition. Yet the hysterectomy is an anticipated outcome of placenta accreta spectrum that could be considered a standard of care.

In contrast, a young healthy patient presenting in labor with her first pregnancy might develop an intrapartum fever and postpartum hemorrhage due to uterine atony. If bleeding increases and she develops disseminated intravascular coagulation and is not responsive to medical management or conservative surgical measures, the obstetric care provider might be prompted to perform a hysterectomy. While potentially lifesaving, the hysterectomy in this case is neither an anticipated outcome nor a standard of care. These two scenarios highlight the challenges of defining severe maternal morbidity and understanding its relationship to maternal mortality at the most basic level.

Diagnoses constituting SMM have classically been considered upstream events preceding maternal mortality, but the occurrence of SMM is also a comparatively rare event. Additional clinical diagnoses and outcomes of interest have a strong association with maternal morbidity and mortality, and warrant

monitoring and consideration as upstream events along the pathway to maternal mortality. Aside from clinical diagnoses of interest, there is emerging interest in novel concepts that incorporate the role of the provider and the patient voice as key outcomes of interest.

Maternal Mortality

The outcome of death seems absolute but defining and identifying maternal mortality in a comprehensive and consistent manner poses a number of challenges. Capturing a maternal mortality requires confirmation of pregnancy with a temporal relationship to death as well as some discernible connection to pregnancy in terms of etiology. As a result, existing measures of maternal mortality, including maternal death, pregnancy-related death, and pregnancy-associated death, contain notable differences.

- Maternal Death: The death of a woman while pregnant or within 42 days of termination of pregnancy, 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.
- Pregnancy-Related Mortality: The death of a woman while pregnant or within one year of termination of pregnancy—regardless of the duration or site of the pregnancy—from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.[4,10]
- Pregnancy-Associated Mortality: All deaths during pregnancy or within one year of termination of pregnancy regardless of cause.[11]

The fundamental differences between the definitions relate to the time frame during which a death after delivery constitutes maternal mortality and the strength of the connection of the cause of death to pregnancy. Definitions that are more limited in time frame and scope may lead to more straightforward identification of maternal mortality that is easier to compare between countries and over time. Definitions encompassing a longer time frame or wider scope in terms of etiology may reveal cases of maternal mortality with a less obvious connection to pregnancy that may otherwise go unnoticed. While the definitions of these terms are consistent between sources, the choice of metric, along with the process to identify deaths and classify the underlying cause, varies according to the definition in use and the reporting entity.

Maternal Death: Definitions from the WHO

Both the World Health Organization (WHO) and the Center for Disease Control and Prevention (CDC) CDC's National Vital Statistics System (NVSS) use the term "maternal death" to identify maternal mortality defined as "the death of a woman while pregnant or within 42 days of termination of pregnancy, 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."[1,12] This definition uses a discrete time period and calls for a more direct connection to pregnancy to identify cases of maternal mortality. Relying on a definition that is more limited in scope aids in the reliability of the outcome in countries with limited resources to dedicate toward surveillance systems. As an adjunct to this definition, the WHO also recognizes an additional category of late maternal deaths. A late maternal death is defined as the death of a woman from direct or indirect causes more than 42 days but less than one year after termination of pregnancy mirroring definitions such as pregnancy-associated death.

For countries using death certificates to identify maternal deaths, the identification of potential cases comes from the use of diagnostic codes set forth in the International Classification of Diseases 10th edition (ICD-10). To improve consistency in the reporting of maternal death, the WHO developed and published *The WHO application of ICD-10 to deaths during pregnancy, childbirth, and the puerperium: ICD-MM*.[12] The ICD-MM framework provides guidance on the identification and classification of the cause of death, antecedent causes, and contributory factors. This approach advocates for inclusion of questions about pregnancy status in death certificates by inquiring about pregnancy at the time of death, pregnancy within the past 42 days, or pregnancy within the past year. This recommendation aims to avoid underreporting of maternal death and to prompt the certifier to consider pregnancy-associated complications as a part of reporting. The ICD-MM goes on to subclassify cases of maternal death as either direct or indirect obstetric deaths.

Direct maternal deaths are those "resulting from obstetric complications of the pregnancy state (pregnancy, labor, and the puerperium), from interventions, omissions, incorrect treatment, or a chain of events resulting from any of the above." The causes of direct maternal deaths include abortion, obstetric hemorrhage, hypertensive disorders, pregnancy-related infection, other obstetric complications, and unanticipated complications of management. Indirect maternal deaths are those "resulting from previous existing disease or disease that developed during pregnancy and which was not due to direct obstetric causes but exaggerated by physiologic effects of pregnancy." Examples of indirect deaths resulting from preexisting disease include cardiac disease or HIV. An example of an indirect death from a new disease aggravated by pregnancy could include infections arising in but not a direct result of pregnancy, such as influenza. Additional categories of note include death during pregnancy, childbirth, and the puerperium (but not maternal death) accounting for coincidental causes thought not to be related to pregnancy.

The direct and indirect maternal death classification is specific to the ICD-MM framework and was initially intended to prioritize interventions for maternal mortality prevention. With an increasing awareness of the breadth of conditions contributing to maternal death, this division between direct and indirect causes may confuse classification and raises concerns about whether or not indirect causes of maternal death are somehow less important than direct causes. These concerns have prompted some to recommend letting go of this classification scheme entirely and focusing efforts on identifying the medical cause of death.[13]

Underscoring this notion, the 2012 ICD-MM guidelines updated the definition of direct death to include suicide under the "Other" category even in cases where the diagnosis of puerperal psychosis or postpartum depression cannot be definitively established. This update also allowed for inclusion of postpartum suicide beyond 42 days as a cause of late maternal death.[12,14] The definition of maternal death may be the most widely used internationally. The evolving classification of maternal death from the WHO reflects the growing recognition of the need to capture maternal mortality beyond the traditional time frames.

Pregnancy-Related and Pregnancy-Associated Mortality: Definitions from the CDC

The CDC oversees two different data systems for tracking measures of maternal mortality in parallel: the NVSS and the Pregnancy Mortality Surveillance System (PMSS).[4,15] The concepts of pregnancy-related and pregnancy-associated death championed by the PMSS adapted the definition set forth by the WHO. Pregnancy-related death is defined as "the death of a woman while pregnant or within 1 year of

pregnancy termination—regardless of the duration or site of the pregnancy—from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes."[4] This definition relies on the connected causality of the WHO definition, but extends the time frame to one year, with a subclassification of late pregnancy-related death for those beyond 42 days. Pregnancy-associated death is defined as "all deaths during pregnancy or within 1 year of pregnancy regardless of cause,"[4] which forms a collection of cases from which to find pregnancy-related death.

The NVSS is another data system overseen by the CDC for tracking maternal mortality measures. These systems are similar in covered topic areas but include separate complexities, leading to differences in the definitions of maternal death and pregnancy-related or pregnancy-associated death, as well as differences in identification and classification. The NVSS is the official source of the U.S. maternal mortality statistics reported for the international community and adopts the WHO definitions of maternal death and late maternal death. The PMSS provides an additional metric of a pregnancy-related mortality that extends the time period of interest from 42 days to one year but still needs to maintain a causative connection to pregnancy. These two definitions are further distinguished from the aforementioned additional metric of a pregnancy-associated mortality. In addition to the different definitions of interest between the PMSS and NVSS, the PMSS serves an additional role of fostering review of pregnancy-related and pregnancy-associated mortality and identifying opportunities for quality improvement.[16,17]

The NVSS uses the death records captured by the National Center for Health Statistics (NCHS) in conjunction with ICD-10 codes to identify cases of maternal mortality. The PMSS was implemented in 1986 to improve ascertainment of pregnancy-related deaths and provide supplemental information about causes of maternal death. This system identifies pregnancy-associated deaths based on a checkbox on the death certificate or from death certificates linked with live birth or fetal death records within the year preceding the death. This information is voluntarily shared from 52 reporting areas including the 50 states, New York City, and the District of Columbia, and reviewed by medical epidemiologists in order to identify pregnancy-related deaths and generate national statistics on pregnancy-related mortality. Epidemiologists also work to classify the underlying cause of death using the definitions set forth in the CDC Pregnancy Mortality Surveillance System (PMSS-MM).[18] The PMSS-MM was developed by the CDC in conjunction with the ACOG Maternal Mortality Study Group to standardize the approach for classifying pregnancy-related deaths.

State-based maternal mortality review committees (MMRCs) use sources similar to the PMSS for identifying pregnancy-associated deaths, and may rely on additional sources for hospital reporting, media reports, and obituaries.[18] MMRCs may have access to additional data beyond that available to PMSS to determine whether or not a pregnancy-associated death is a pregnancy-related death and to comment on cause of death using the PMSS-MM guidelines. MMRCs adopt an additional function beyond the work of PMSS to address preventability and to identify opportunities for improvement as described below.

Maternal Mortality Surveillance: Measures and Methods

The differences in definitions between maternal mortality, pregnancy-related mortality, and pregnancy-associated maternal mortality, coupled with the resources and personnel used in a given country to track and monitor maternal death, account for differences in the outcome measures reported by various organizations. The most commonly used metric internationally is the maternal mortality rate that is

used by the WHO and the U.S. NVSS. A separate measure reported by the CDC's PMSS is the pregnancy-related mortality ratio. Both of these measures rely on the number of live births, as opposed to the number of pregnancies, as the denominator to account for the challenges of ascertaining the numbers of miscarriages or abortions in the population.

- Maternal Mortality Rate (MMR): The maternal mortality ratio refers to the number of maternal deaths during a given time period per 100,000 live births using the aforementioned definition of maternal death: the death of a woman while pregnant or within 42 days of termination of pregnancy, 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. This is the metric reported by most international organizations.

Pregnancy-Related Mortality Ratio (PRMR): The number of pregnancy-related deaths for every 100,000 live births using the aforementioned definition of pregnancy-related mortality: the death of a woman while pregnant or within one year of pregnancy termination—regardless of the duration or site of the pregnancy—from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.

The MMR presented in the background section varies when directly compared to the PRMR data. For example, the U.S. PRMR for 2011-2015 was 17.2 per 100,000 live births. These rates vary by region, state, and across racial and ethnic lines where significant disparities highlight exacerbating differences among non-Hispanic black women (42.8) and American Indian/Alaska Native (32.5) women.[2] Both the MMR and the PRMR show sizable variation in maternal mortality when considering sociodemographic characteristics.

Maternal Mortality in the United States

The change to ICD-10 in the early 2000s, coupled with reports suggesting up to 30 percent underreporting of maternal mortality, prompted additional linkage studies to explore the estimation of maternal mortality. These studies revealed underreporting of maternal mortality with a range of discrepancies regarding cause of death in the U.S.[19,20] The U.S. Standard Certificate of Death was revised in 2003, and along with this revision came the option to include a series of checkboxes to ascertain pregnancy status prior to the death.[21] This revision occurred in 2003, but the various reporting areas adopted the pregnancy checkbox on a rolling basis between 2003 and 2017.[22] Though all states had included some form of pregnancy checkbox by 2017, the adoption of the *standardized* group of pregnancy checkboxes suggested by the NCHS is still variable.[23] The MMR began to rise in subsequent years out of proportion to other resource-rich countries with a variety of contributing factors used to explain this trend.[24] Possible explanations for this increase included a more accurate reflection of the U.S. MMR reflecting the increasing prevalence of comorbid medical diagnoses in the population or the possibility of measurement error due to the introduction of the pregnancy checkbox.[7,23] Because of uncertainty in the accuracy of estimates, the NVSS halted annual publication of the MMR for 11 years beginning in 2007.[25] The challenges of estimating MMR in a well-resourced country underscore the issues with developing estimates of MMR worldwide.

To what extent the increase in the MMR compared to pre-checkbox estimates reflects better ascertainment of true maternal deaths or increases in maternal death as a consequence of coding error is unknown.[22] A 2018 analysis of maternal deaths occurring in 2012 in Texas suggests that at least some

component of misclassification is present.[26] These authors reported an MMR of 38.4 per 100,000 live births using the standard method championed by NVSS compared to an MMR of 14.6 per 100,000 live births using an enhanced method reviewing supplemental sources of available data to confirm pregnancy status. Subsequent analyses of the impact of the pregnancy checkbox on the MMR by the NVSS team estimates suggest that the checkbox resulted in an MMR increase of 9.6 deaths per 100,000 live births (95 percent confidence interval 8.6-10.6).[22] Further analyses about the impact of the pregnancy checkbox on MMR shows a differential impact for women age 40 and older, non-Hispanic black women, and for specific causes of maternal mortality.[22] These subgroups of women had increasing MMRs with pregnancy checkbox implementation compared to stable estimates of the MMR in the presence or absence of the checkbox for other subgroups of women. These findings are also supported by a separate 2016 analysis, confirming there is a need for more accurate reporting of pregnancy status on death certificates.[27]

The inclusion of standardized checkboxes still varies between states, but the presence of a checkbox was consistent enough to prompt the NVSS to resume publication of the MMR. In 2020, NVSS reported the U.S. MMR to be 17.4 deaths per 100,000 live births.[25] A MMR of 17.4 deaths per 100,000 live births situates the U.S. between Russia (17 per 100,000) and Ukraine (19 per 100,000) on the WHO list of maternal mortality rankings.[28] The MMR for countries of similar resources hovers in the high single digits (7 per 100,000 in Germany and the United Kingdom, and 8 per 100,000 in France) to low double-digit range (10 per 100,000 in Canada). The slight differences in measurements between countries are unlikely to explain such striking differences in the MMR between the U.S. and its resource-rich countries.[7] This comparison to other countries, coupled with striking disparities in the MMR for different subsets of women, underscores the urgency of addressing maternal mortality in the United States.

Maternal Mortality: Prevalence/Incidence and Other Indicators

Causes of Maternal Mortality

The challenge of addressing U.S. maternal mortality is underscored by an examination of the causes of maternal death alone and by a comparison to other countries based on the definition in use. Hemorrhage remains the leading direct cause of maternal death worldwide (27.1 percent), followed by hypertension (14.0 percent), sepsis/infection (10.7 percent), other direct causes (9.6 percent), abortion (7.9 percent), and embolism (3.2 percent).[29] Maternal death due to indirect causes parallels the magnitude of death due to hemorrhage, at 27.5 percent. The relative contribution of each cause of maternal death varies vastly according to the resources available in the country, with hemorrhage becoming a less prevalent cause in developed countries compared to developing countries (16.3 percent vs. 27.1 percent).

In comparison, the most recent estimates from the PMSS report cardiovascular disease as the leading cause of pregnancy-related death in the United States. Causes of pregnancy-related death in the United States cannot be directly compared to causes of maternal death worldwide due to differences in the classification scheme. From a data standpoint, the PMMS definition includes deaths up to one year after termination of pregnancy and 75.7 percent of deaths due to cardiovascular conditions and cardiomyopathy occur after 42 days after delivery. The prevalence of cardiovascular death in the pregnancy-related death statistics versus the prevalence of hemorrhage in the maternal death statistics highlights the changing diagnoses contributing to maternal mortality over the varying time periods captured by a given definition. The PMSS data has demonstrated a decreasing contribution of

hemorrhage to pregnancy-related death over time, concurrent with an increasing relative contribution of cardiovascular disease as a cause of pregnancy-related mortality in the United States.[4] The differing etiology in the U.S. compared to international population likely reflects not only differences in classification of maternal mortality but variations in both, alongside medical and nonmedical risk factors for disease.

Cardiovascular Disease

Cardiovascular disease (CVD) is the leading cause of pregnancy-related mortality, with cardiovascular conditions accounting for 15.7 percent of pregnancy-related deaths in the most recent estimates from the PMMS from 2011 to 2016. Peripartum cardiomyopathy is captured as a distinct cause of death in the PMSS separate from CVD. If this cause of death due to CVD is combined with the 11 percent of deaths due to cardiomyopathy, CVD becomes a clear leading cause of maternal mortality in the U.S.[4,30] As previously discussed, the differences between the findings in the U.S. and international population are attributed not only to medicine but also to measurement.

Measurement caveats aside, the increasing prevalence of pregnant patients with medical risk factors for cardiac disease such as increasing maternal age and a higher prevalence of hypertension and obesity lends biologic plausibility to this trend.[31–34] Advances in cardiovascular care have allowed women with congenital heart disease to survive to reproductive age with reasonable cardiovascular health and the ability to support a pregnancy, accounting for additional medical risk factors for cardiovascular death.[35] Maternal mortality reviews reveal provider- and hospital-level risk factors such as delayed recognition of clinical decompensation or failure to seek referral to risk-appropriate care as influencing factors in cases of cardiac-related death with greater frequency than those with noncardiac death.[36,37] A combination of measurement, medical risk factors, and nonmedical risk factors may explain the differing contribution of CVD to maternal death in the U.S., though the magnitude of its effect remains. From a data standpoint, the PMMS definition includes deaths up to one year after termination of pregnancy, and 24.6 percent of deaths due to cardiovascular conditions and cardiomyopathy occur after 42 days after delivery.

Infection

Infection is a consistent contributor to pregnancy-related mortality in the U.S., ranging between 10-13 percent, with most recent estimates from the PMSS at 12.5 percent.[38] Pregnancy itself is an immune-tolerant state with physiologic modifications, challenging the early recognition and diagnosis of infection or sepsis in pregnancy using the criteria set forth for nonpregnant patients.[39–41] Risk factors for infection vary according to the source of infection, but nonmedical risk factors for adverse outcomes in the setting of infection include delayed diagnosis and failure to initiate appropriate antibiotic therapy.[42] The 4.7 percent of deaths due to sepsis seen in developed countries with more medical resources compared to the 10.7 percent rate of death in developing countries likely underscores the importance of early recognition and medically appropriate response in this cause of maternal mortality.[43]

Hemorrhage

Though the relative contribution of hemorrhage to pregnancy-related mortality has steadily decreased from 28.7 percent to 11 percent since the advent of PMMS in 1987, the absolute rate of hemorrhage-associated morbidity and mortality is on the rise. Rates of postpartum hemorrhage increased 27 percent from 1994 to 2006.[44] This decrease in the percentage of pregnancy-related death due to hemorrhage therefore reflects an increase in other causes more than a decrease in hemorrhage-associated mortality.

Medical factors contributing to hemorrhage-associated mortality include the rising cesarean delivery rate via its interaction with repeat cesarean deliveries and placenta accreta spectrum, as well as an increasingly complex patient population with comorbid risk factors like advancing maternal age and obesity, which limit physiologic reserve and challenge surgical approaches.[40,41,45] Available evidence suggests that changes in patient comorbidities are insufficient to account for increasing rates of postpartum hemorrhage. Rates of postpartum hemorrhage in cesarean delivery have an inverse relationship to provider surgical volume, underscoring the impact of the provider on maternal outcomes.[46] Black people have been identified as facing greater risk for progression to severe maternal morbidity in the face of postpartum hemorrhage, capturing the influence of nonmedical risk factors in hemorrhage outcomes.[47] The interaction between nonmedical risk factors, including provider and hospital-level risk factors, on hemorrhage-associated morbidity and mortality is complex and likely varies by the etiology of the hemorrhage. Regardless of risk factors for disease, hemorrhage is often identified as the most preventable cause of maternal death with inadequate preparedness, delayed recognition, and inappropriate response as consistent domains for potential quality improvement identified in reviews of hemorrhage-associated mortality. [48]

Thromboembolic Events

Thromboembolic events including thrombotic pulmonary embolism and amniotic fluid embolism account for a substantial but stable percentage of maternal mortality at 9 percent and 5.6 percent, respectively. These etiologies are somewhat unique, as they are examples of severe maternal morbidity without intervening diagnoses along the pathway to maternal mortality. Patient comorbidities limiting physiologic reserve or options for intervention as well as delays in diagnosis or intervention may impact which patients suffer from mortality associated with these events.[49,50] The differences in percentages of death due to embolism in developed regions (13.8 percent) versus developing regions (3.1 percent) may reflect differences in patient comorbidities, or simply highlight the impact of other etiologies of maternal death on the relative contribution.

Hypertension and Cerebrovascular Accidents

Hypertensive disorders of pregnancy such as preeclampsia have a decreasing relative contribution to maternal mortality (6.9 percent), while cerebrovascular accidents as a cause of maternal death are on the rise (7.4 percent). Delayed diagnosis of hypertensive disorders of pregnancy alongside inappropriate treatment of severe hypertension contribute to end-organ impacts of the disease manifesting as cases of stroke or other cerebrovascular accidents in the most serious form.[51] Not all cerebrovascular accidents are a consequence of hypertension, but the contribution of hypertension to the pathophysiology of puerperal cerebrovascular disorders makes them likely to have significant overlap on the causal pathway to maternal mortality.[52,53]

Other Conditions

This category typically reflects other non-cardiovascular medical conditions, such as cancer or anesthesia complications, underscoring the increasing complexity of the U.S. obstetric population.[54] Anesthesia complications are separated as a cause of maternal mortality in the PMSS data, and account for an increasingly low percentage, at 0.3 percent. As will be discussed in maternal morbidity, the steady decrease in this percentage despite increasing maternal complexity is a testament to the continued improvements in anesthesia care. In contrast, the category of “other conditions” as a whole has risen to 13.9 percent with this aggregate category accounting for the second-highest percentage of pregnancy-

related mortality behind cardiovascular conditions.[4] "Other" deaths, along with those due to cardiovascular conditions, would likely fall under the category of "indirect obstetric death." Countries employing the WHO classification scheme estimate that "Other" deaths account for 27.5 percent of deaths worldwide.[29]

Accidental and Incidental Causes: Suicide, Overdose, and Intimate Partner Violence

Increasing awareness of the contribution of maternal mental health and substance use disorders add further complexity to identification and classification of maternal mortality. Current definitions of maternal mortality specifically exclude death due to accidental or incidental causes. Historically, and in many countries, deaths due to suicide, overdose, or trauma have fallen outside of this framework. As previously discussed, the publication of the ICD-MM from the WHO reframed cases of maternal death due to suicide as direct causes of maternal death.[12]

Historically, the review of pregnancy-associated death attributable to suicide, drug overdose, homicide, and unintentional injury in reports of maternal mortality in the U.S. MMRCs has been variable.[55] Contemporary MMRCs review suicide and overdose as pregnancy-associated deaths more consistently with a growing awareness of their contribution to pregnancy-related deaths.[18] In a state-specific analysis from the Maternal Mortality Review Committee in Colorado, up to 30 percent of pregnancy-associated deaths were related to self-harm.[56] In state-based analysis from Utah, 26 percent of maternal deaths were drug-induced, defined as intentional or unintentional consumption of illicit substances or diverted medications leading to death.[57] In both of these analyses, pregnancy-associated deaths due to suicide or drug-induced death were most often encountered in the year postpartum and were far more common than other causes of pregnancy-associated deaths 43 days to one year after the end of pregnancy.[55,56,58] For those MMRCs that review deaths of this nature, a proportion of them are determined to be causally related to pregnancy, meeting the required evidence to deem mental health conditions as a leading cause of pregnancy-related death.

Specifically, suicide has been considered a relatively rare event during the perinatal period; however, some mental disorders (e.g., postpartum depression, bipolar disorder, postpartum psychosis, etc.) have shown a higher risk of suicidal ideation, suicide attempt, or suicide. Suicides in the perinatal period are more likely to occur among women who are or have the following: less likely to be receiving any active treatment at the time of death; of younger maternal age; unpartnered as their relationship status; unplanned pregnancies; non-Caucasian, with shorter illness duration, preexisting, and/or current psychiatric diagnosis. Experiencing intimate partner violence—including emotional abuse, physical abuse, and/or sexual violence—is associated with suicidal thoughts during pregnancy and after childbirth.[59] A complete screening of mothers' mental health should also take into account thoughts of suicide and thoughts about harming infants. Clinicians should carefully monitor and attempt early identification of related clinical manifestations, potential risk factors, and symptoms that raise alarm related to suicide.[59]

Intimate partner violence being a separate but related issue is defined as: physical or sexual violence, stalking, or psychological abuse by a spouse or a current or former partner.[60] Though most forms are likely to be underreported, current estimates are that 40 percent of women experience some form of sexual violence over the course of their lives, and 20 percent experience physical violence from an intimate partner. The effects of this are typically aggravated in pregnancy, with an increased risk of poor pregnancy outcomes and an increase in pregnancy-associated mortality in the forms of homicide and

suicide.[61] Women who experience intimate partner violence are likely to have less control over contraceptive choices and are more likely to have an unintended pregnancy.[62] Unemployment, unplanned pregnancy, low level of partner education, and fear of partner are predictors for verbal abuse during pregnancy, while low education level in women, unplanned pregnancy, living with an unemployed partner, and experiencing two or more pregnancy-related health problems are associated with psychological abuse.[63] Despite evidence that screening for intimate partner violence leads to interventions that reduce both depressive symptoms and violent episodes, screening rates remain low.[64]

Medical risk factors for these mood disorders or substance use disorders either predate pregnancy or develop within pregnancy. The interaction between patient concerns about medication use in pregnancy and limitations in access to providers willing to provide medically appropriate therapy such as antidepressants, methadone, or buprenorphine is complex. Patient- and provider-level considerations, coupled with the known overlap and societal stigma associated with these medical diagnoses, further complicate the understanding of nonmedical risk factors for these causes of death.

Similar to suicide and overdose, the review of deaths due to homicide and unintentional injury by MMRCs is variable. As a result, parallel analyses for the contribution of homicide or trauma to death surrounding pregnancy is lacking. Pregnancy itself is a risk factor for intimate partner violence.[61] This knowledge, coupled with the fact that unintentional injuries are the leading cause of death for U.S. women 20-44 years of age, suggests that these could be important unexplored causes of maternal mortality. This change in the maternal mortality classification framework by the WHO, coupled with increasing awareness of the contribution of these comorbidities to severe maternal morbidity and mortality in the United States, highlights the complexity of identifying and classifying maternal mortality.

Maternal Morbidity

Considering the controversy in defining a seemingly straightforward outcome like maternal mortality, it is even less surprising that a universally accepted definition of maternal morbidity is lacking. Though there are a variety of potential outcome measures that may warrant consideration, contemporary conversations of maternal morbidity often center on those outcomes that may potentially be on the causal pathway toward maternal mortality. Despite concerns about rising maternal mortality in the U.S., it is still a comparatively rare event. Monitoring maternal morbidity often encountered upstream of cases of maternal mortality provides an opportunity to track significant outcomes with the imperative to address maternal mortality. Though other outcome measures may constitute morbidity and have associated processes designed to prevent them, contemporary definitions of maternal morbidity emphasize outcomes more proximal to maternal mortality.

The most commonly encountered definition of maternal morbidity in the United States is one of severe maternal morbidity, whereas internationally the notion of near-miss morbidity prevails.[65,66] In the United States, a subsection of maternal morbidity may also meet The Joint Commission's definition for a sentinel event. The Joint Commission defines a sentinel event as a patient safety event (not primarily related to the natural course of a patient's illness or underlying condition) that reaches a patient and results in any of the following: death, permanent harm, or temporary harm.[67] Though there is general agreement on the concepts of both near-miss and severe maternal morbidity, the specific details informing each definition vary by organization. Furthermore, the way these events are identified and tracked vary according to the organization and its intended use in the population of interest. Consistent features of each of these definitions are that maternal morbidity is unanticipated, of significant clinical

consequence, and exists on a continuum with, or is potentially causal on the pathway to maternal mortality. Near-miss morbidity and severe maternal morbidity are not the same and are not the only outcomes that could be considered maternal morbidity. Each term has relative merits and challenges depending on the intended use. The widespread use of these concepts, coupled with the hallmark features captured in their definitions, makes them the most relevant to consider in a conversation linked to maternal mortality.

Near-Miss Morbidity: Definitions from the WHO

The concept of near-miss morbidity is championed by the WHO, and is defined as conditions or events that would have resulted in a maternal death during pregnancy, childbirth, or within 42 days after delivery if not for significant medical intervention.[68] Once again, the specific criteria for what constitutes a near-miss morbidity vary but are generally conceptualized as evidence of severe organ system dysfunction, need for major intervention, or a severe category of a disease.

Conditions constituting severe complications include severe postpartum hemorrhage, severe preeclampsia, eclampsia, and sepsis or severe systemic infection, and uterine rupture. Critical interventions are defined as the use of any blood products including blood transfusion, interventional radiology for uterine artery embolization, laparotomy (other than cesarean delivery including hysterectomy), and admission to the intensive care unit (ICU). Organ dysfunction includes evidence of cardiovascular, respiratory, renal, coagulation, hepatic, neurologic, and uterine dysfunction. Criteria to establish evidence of organ dysfunction for each of these systems varies, and relies on clinical diagnoses, vital sign criteria, laboratory abnormalities, or the need for a medical or procedural intervention.[69] As an example, cardiovascular dysfunction can be identified by clinical diagnoses such as shock or cardiac arrest, evidence of hypoperfusion as defined by an elevated laboratory value of lactate or evidence of acidosis based on a low pH, or by interventions including the continuous use of vasopressors or need for cardiopulmonary resuscitation. In the absence of specific diagnostic criteria, the final determination of the presence of near-miss morbidity is left to the judgment of the clinician completing the assessment.

The reliance of the WHO definition on more granular data including vital sign and laboratory information often requires an independent collection system limiting the use of this definition to funded research studies. The absence of a standardized definition challenges its use in epidemiologic studies relying on existing data sources—particularly when examining large data sets for rare outcomes. The conditions captured as near-miss morbidity parallel those captured in the U.S. severe maternal morbidity definition, but the sources of data and potential use differ significantly.

Severe Maternal Morbidity: Definitions from the CDC and AIM

Severe maternal morbidity includes unexpected outcomes of labor and delivery that result in significant short- or long-term consequences to a woman's health.[65,70,71] This definition is accepted by the CDC, ACOG, the Society for Maternal-Fetal Medicine (SMFM), and the Alliance for Innovation on Maternal Health (AIM) put forth by the National Partnership for Maternal Safety. Despite general agreement on the concept of severe maternal morbidity across these organizations, the specific diagnoses and procedures that constitute SMM have varied historically between the groups.

Historically, the CDC selected a list of 25 diagnosis and procedure codes from the International Classification of Diseases, Ninth Revision (ICD-9) constituting SMM.[71] With the publication of the ICD-10, this list was revised to 21 indicators excluding diagnosis codes for internal injuries, intracranial injuries,

and operations on the heart and pericardium along with cardio monitoring in the pared list. Though the list of diagnoses and procedures constituting SMM decreased, the number of ICD codes increased dramatically with the transition to ICD-10, with ongoing refinement in the list of codes warranting inclusion. These indicators include 16 diagnosis codes and five procedure codes. Historically, the AIM list of SMM indicators consisted of 16 of the ICD-10 diagnosis codes included on the CDC list, but only included the procedure codes for blood transfusion and not other product transfusion.[72] Recent collaborative efforts involving the CDC, AIM, the California Maternal Quality Care Collaborative (CMQCC), the Agency for Healthcare Research and Quality (AHRQ), and the Health Resources and Services Administration (HRSA) have aligned their efforts to generate and maintain a consistent list of ICD-10 codes constituting SMM.[72]

The decision to perform a transfusion in the definition of SMM is challenging. Transfusion can be a reliable indicator of morbidity in cases of postpartum hemorrhage or other categories of morbidity and can predispose patients to other causes of morbidity. Yet an isolated clinically indicated blood transfusion does not necessarily constitute the clinical severity as other diagnoses or procedures constituting SMM. These concerns, coupled with the impact of the expansion of ICD-10 codes to reflect transfusion on SMM estimates, lead many entities to report SMM with and without transfusion. Regardless of the definition of SMM in use, details on the specific diagnoses and procedures constituting SMM align with the general framework put forth by the WHO's near-miss morbidity framework as outlined below.

Reliance on ICD coding, as opposed to direct clinical and laboratory data, is a key difference in the definitions of SMM and near miss-morbidity as previously discussed. ICD-10 codes are often used for hospital administrative reasons including billing, underscoring their ubiquitous nature and the importance of their use. Using ICD-10 codes to identify SMM ensures the ability to capture SMM indicators at each hospital regardless of the resources and personnel available to track SMM. These codes may lack granularity in data or consistency in diagnosis, but their stability across years and standardization across centers ensure the availability of a consistent metric over time and between hospitals, respectively.[73] But this approach also limits the outcomes that can be captured to those diagnoses and procedures that are coded as a part of ICD-10.

Severe Maternal Morbidity: Definitions from ACOG and SMFM

In 2016, ACOG and SMFM endorsed an Obstetric Care Consensus statement supporting the standard concept of SMM, but also provided additional guidance on diagnoses or procedures meeting that definition.[65,72] The purpose of the statement was not to create a comprehensive definition of SMM but to propose outcomes and complications warranting review at the facility level through a quality improvement lens within facilities. Using The Joint Commission's definition of a sentinel event, they proposed the use of transfusion of four or more units of packed red blood cells or ICU admission as screening criteria for potential cases of SMM, but encourage each center to adopt their own list of outcomes warranting further detailed review.

Maternal Morbidity: Prevalence/Incidence and Other Indicators

Indicators of Maternal Morbidity

Whether relying on the ICD-10 diagnosis and procedure codes proposed by the CDC or AIM to identify severe maternal morbidity across the population or employing the ACOG/SMFM definition for in-

hospital review, the general features of a severe and unanticipated complication of clinical consequence are at the heart of severe maternal morbidity. A standardized list of indicators of SMM offers consistency for large epidemiologic studies, while facility-based criteria may support more meaningful quality improvement efforts at the level of the clinician or hospital. Regardless of the SMM framework at play, the varying availability of diagnostic criteria for many of these clinical entities means that the final determination of the outcome of interest in many scenarios is still left to the judgment of the clinician completing the assessment. Variability in diagnosis, coupled with the diversity of patient populations in terms of both medical and nonmedical risk factors, results in a wide range of incidence and prevalence estimates. The spectrum of medical resources and personnel available across the range of clinical settings where deliveries take place also challenges meaningful comparisons across populations. The aforementioned clinical definitions or diagnosis and procedure codes constituting SMM vary somewhat but parallel the WHO near miss-morbidity framework of evidence of end-organ dysfunction, severe disease manifestations, and the need for critical intervention.

End-Organ Dysfunction

Cardiovascular Dysfunction

Diagnosis codes included in the CDC and AIM list of SMM indicators capturing cardiac manifestations of disease include acute myocardial infarction, aneurysm, heart failure or arrest during a procedure, and acute heart failure or pulmonary edema.[74] The absolute rates of these maternal outcomes are low, ranging from 0.2 to 1.1 per 10,000 deliveries, but have demonstrated a 100 percent increase over the past 20 years.[3] Notable outliers to this trend include acute heart failure or pulmonary edema, with prevalence of 2.4 per 10,000 deliveries, as well as heart failure or arrest during a surgery or procedure, as both of these have shown a decreasing prevalence over the same time period.[75,76] Risk factors for adverse cardiac events include advancing maternal age and maternal obesity, but the strongest risk factor is underlying maternal cardiovascular disease. Cardiovascular conditions are now the leading cause of mortality in the United States (15.3 percent), with cardiomyopathy accounting for 10.8 percent of deaths.[30,77]

In the spectrum of cardiovascular indicators, acute heart failure and pulmonary edema warrant special consideration. Pulmonary edema can be cardiogenic or noncardiogenic in nature but is often encountered as a downstream consequence secondary to another obstetric cause more so than a primary cardiac process.[78] While the clinical presentation of acute heart failure can represent a distinct pathophysiologic process, as in the case of peripartum cardiomyopathy or decompensation of baseline cardiovascular disease, as in the case of patients with maternal congenital heart or other cardiovascular disease, it is most often encountered as severe manifestations of other obstetric processes. Classic examples of diseases with severe manifestations resulting in pulmonary edema include preeclampsia with severe features or severe postpartum hemorrhage leading to transfusion-associated circulatory overload.[79–81] Medical risk factors for the development of this complication will therefore vary according to the etiology.

Adult Respiratory Distress Syndrome (ARDS)

ARDS is a clinical syndrome characterized by the development or worsening of findings on chest imaging on both sides of the lungs within a week of clinical insult accompanied by objective evidence of hypoxia in the absence of cardiac dysfunction or volume overload.[82] The absence of cardiac dysfunction separates this entity from the pulmonary edema associated with acute heart failure, with ARDS often

occurring secondary to either a primary pulmonary infection or as a consequence of sepsis. Transfusion-associated acute lung injury (TRALI) is an ARDS-variant secondary to an exaggerated immune response to transfusion of blood and other blood components. Therefore, risk factors for postpartum hemorrhage are also predisposing conditions for this entity.[83] Other rare but possible etiologies of ARDS potentially encountered in an obstetric population include drug overdose, inhalation injury, or pancreatitis. The increasing prevalence in the varying etiologies of ARDS may contribute to its increase over time, with current estimates at 6.1 per 10,000 deliveries, making risk factors for postpartum hemorrhage relevant predisposing conditions for this entity.[83,84]

Acute Renal Failure

Acute renal failure is variably defined, but consensus definitions typically highlight a rise in the serum creatinine from baseline or the presence of decreased urine output as defined by less than 0.5 mL/kg/hour.[85] Given the typically normal baseline creatinine in the obstetric population, an absolute creatinine cutoff has been proposed ranging from 2.0 mg/dL in the ACOG/SMFM guidelines and 3.5 mg/dL in the WHO criteria.[65] The addition of diuretics to promote urine output in oliguric patients as well as the need for renal replacement therapy such as dialysis is highlighted in these guidelines. Acute renal failure rarely occurs in isolation and can be a manifestation of another disease process such as preeclampsia with severe features—a consequence of renal hypoperfusion in cases of sepsis or postpartum hemorrhage, or a pregnancy-associated consequence of baseline chronic kidney disease. As a result, the rate of renal failure has increased by 300 percent over the past 20 years, with current estimates at 5.2 per 10,000 deliveries.[29]

Disseminated Intravascular Coagulation (DIC)

DIC is a clinical syndrome characterized by dysregulation of the normal coagulation cascade leading to consumption of clotting factors and resultant coagulopathy. DIC is estimated to occur in 7.2 per 10,000 deliveries but has been associated with up to 25 percent of maternal deaths.[86] Obstetric hemorrhage is both a risk factor for DIC and a clinical consequence of the syndrome. Obstetric disorders such as amniotic fluid embolism and acute fatty liver of pregnancy have a strong association with the disorder, but it is more commonly encountered in the setting of sepsis, placental abruption, or preeclampsia based on the relative rarity of the aforementioned diseases.

Puerperal Cerebrovascular Disorders

Puerperal cerebrovascular disorders include a variety of neurologic insults that may be independent processes exacerbated by the physiology of pregnancy or distinct obstetric syndromes. These diagnoses encompass both hemorrhagic and ischemic strokes, hypertensive encephalopathy, and the neurologic manifestations of hallmark diseases like preeclampsia as in the case of disorders like the posterior reversible encephalopathy syndrome (PRES).[87] Prothrombotic disorders such as the antiphospholipid antibody syndrome, chronic hypertension, and preeclampsia are all medical risk factors for the disease.[88] The rate of these disorders is estimated at 0.9 per 10,000 deliveries, with a relative decline over time. Yet cerebrovascular accidents account for 7.6 percent of cases of maternal mortality.[30]

These clinical syndromes often present with clinical neurologic manifestations, including coma or paralysis, that overlap with the neurologic dysfunction captured in near-miss morbidity. A notable exception is the absence of status epilepticus, which is a distinct clinical entity characterized by prolonged seizure activity or recurrent seizures in a discrete time period. Maternal epilepsy is the

primary risk factor for this state, and seizures in pregnancy need to be distinguished from eclampsia or as a secondary consequence of a separate neurologic process such as stroke.[89]

Severe Disease Manifestations

Eclampsia

Eclampsia is defined as the occurrence of new-onset generalized tonic-clonic seizures or coma in a woman with preeclampsia or gestational hypertension.[79] Rates of eclampsia in high resource countries are estimated at two per 10,000 delivery hospitalizations. Risk factors for eclampsia mirror those of risk factors for preeclampsia with severe features, with a substantial risk reduction provided by the use of magnesium sulfate for seizure prophylaxis.[90–92] Preeclampsia with severe features is included on the WHO's list of near-miss morbidity, without the requirement of eclampsia or evidence of end-organ dysfunction meeting the degree of severity required to constitute SMM.[69,93]

Sepsis

Sepsis is a clinical syndrome characterized by the body's response to infection.[43] Sepsis is most often identified by abnormalities in vital signs or labs accompanying evidence of infection.[39] The consensus definition of sepsis in the general population continues to evolve, with the most recent iterations failing to account for the physiologic modifications of pregnancy that result in significant overlap between normal pregnancy vital signs and those defining sepsis in the nonpregnant population.[94] The incidence of sepsis in pregnant women is estimated at 2.4 per 10,000 deliveries. Sepsis is an extreme manifestation of infection and one possible diagnosis along the pathway to infection-associated mortality. Infection from all causes, with or without associated sepsis, reliably accounts for 12 percent of cases of maternal mortality both worldwide and in the United States, with risk factors for this condition mirroring those of the specific infection.

Shock

Shock is a physiologic state of reduced oxygen delivery, increased oxygen consumption, or inadequate oxygen delivery.[95] Shock can be considered a form of organ dysfunction, but always occurs secondary to another pathophysiologic process, making it also a severe manifestation of a disease. Common types of shock in obstetrics include hypovolemic, cardiogenic, and distributive, and the medical risk factors for type of shock reflect the risk factors for the associated disease state.[96] Hemorrhage is a common cause of hypovolemic shock, reflecting insufficient blood volume affecting adequate oxygen delivery.[97] Cardiogenic shock is a manifestation of underlying cardiovascular disease, reflecting the inability of a diseased heart to generate adequate cardiac output to permeate tissues due to cardiomyopathy, arrhythmia, or mechanical causes such as valvular disease.[98] Distributive shock reflects the severe peripheral vasodilation commonly encountered in septic shock, with anaphylactic shock and neurogenic shock as notable exceptions.

Sickle Cell Disease with Crisis

Sickle cell disease with crisis refers to a range of clinical manifestations exhibited in women with sickle cell disease ranging from vaso-occlusive pain crises to unique clinical syndromes such as the acute chest syndrome characterized by respiratory distress.[99] The underlying pathophysiology for all of these manifestations is sickling of red blood cells in states of decreased oxygen tension leading to occlusion of vessels and thrombosis. Rates of this morbidity are low, at 0.5 per 10,000 deliveries in the general population, but the prevalence of crisis in hemoglobin sickle cell disease in pregnancy has been reported

to be as high as 40 percent.[100] Pregnancy itself is a risk factor for this disease state due to the metabolic demands, venous stasis, and hypercoagulable state.

Air and Thrombotic Embolism

Embolic complications of pregnancy are most commonly encountered as venous thromboembolism (VTE), including deep venous thrombosis (DVT) and pulmonary embolism (PE).[101] Changes in the coagulation profile in normal pregnancy, coupled with venous stasis, account for the hypercoagulable state of pregnancy. Additional medical risk factors for VTE include the presence of an inherited or acquired thrombophilia, obesity, multiple pregnancy and predelivery hospitalization.[102,103] It's been found that black people have a greater nonmedical risk for VTE, while the impact of differences in the care provided on this outcome are poorly understood.[104] The CDC estimates the incidence of air and thrombotic embolism to be 0.9 per 10,000 delivery hospitalizations, but estimates of prevalence of VTE across pregnancy ranges from one in 500 to one in 2,000 pregnancies, which is similar to estimates in European countries. The risk of VTE is increased throughout pregnancy but is highest in the postpartum state. Increasing use of pharmacologic VTE prophylaxis may account for the relatively stable incidence of these complications over time, despite increasing medical complexity.[105] Despite this stable incidence, pulmonary embolism is the seventh-leading cause of maternal mortality, accounting for 9 percent of maternal deaths.[30]

Amniotic Fluid Embolism (AFE)

AFE is a clinical diagnosis of exclusion characterized by sudden cardiovascular collapse with comorbid respiratory insufficiency and often accompanied by evidence of DIC.[106,107] The absence of fever solidifies the diagnosis. The clinical criteria rely on timing of the presentation within 30 minutes of placental delivery as the underlying pathophysiology is classically thought to be an aberrant reaction to fetal debris released into the maternal circulation. An absence of studies comparing the laboratory or autopsy findings in cases of AFE to those in other pregnant patients challenges the understanding of the pathophysiology and subsequent medical risk factors.[108] Despite these challenges, the incidence has remained remarkably stable over time between 0.2 to 0.4 per 10,000 delivery hospitalizations.

Severe Anesthesia Complications

Severe anesthesia complications include diagnosis codes reflecting cardiopulmonary or central nervous system complications of anesthesia while during labor and delivery.[109] Rates of this morbidity are low, estimated at 0.3 per 100,000 delivery hospitalizations, with common examples including aspiration pneumonitis or epidural hematoma. This SMM indicator has shown the largest decrease; 87 percent over the past 20 years despite an increasing medical complexity of the patient population reflecting the contribution of the provider to these outcomes.[110]

Critical Interventions

Transfusion

Reports compiling the various indicators of severe maternal morbidity often do so with and without blood transfusion, as previously described. The rate of SMM including transfusions is estimated at 144 per 10,000 delivery hospitalizations and drops to 35 per 10,000 delivery hospitalizations when this metric is excluded.[84] When included in the composite measurement, blood and blood component transfusions make up the majority of cases of SMM, and is most often encountered in the setting of postpartum hemorrhage.[111,112] Definitions of postpartum hemorrhage vary, but the need for transfusion

can be thought of as an objective measure reflecting the severity of hemorrhage independent of etiology.[113,114] Risk factors for transfusion mirror those for hemorrhage, and include comorbid diagnoses (such as multiple pregnancy or prolonged labor) that increase the risk of uterine atony, placenta accreta spectrum (such as prior cesarean delivery), obstetric trauma (such as operative vaginal delivery or fetal macrosomia) or coagulopathy (such as maternal clotting disorders like von Willebrand's disease or preeclampsia with comorbid thrombocytopenia).[115] Nonmedical risk factors for hemorrhage and transfusion similarly vary by etiology, with provider delivery volume and hospital delivery volume showing an inverse association with postpartum hemorrhage.[116] Though the relative contribution of postpartum hemorrhage to maternal mortality has decreased over time, the absolute rate of transfusions have increased to 122.3 per 10,000 deliveries—a 400 percent increase over the past 20 years.[30,77] This increase may reflect a variety of factors, including the rising cesarean delivery rate, increasing complexity of the patient population, and appropriate use of transfusion for hemodynamic support in cases of postpartum hemorrhage.[117] The CDC and AIM definitions of SMM consider transfusion alone to be an outcome, while the ACOG/SMFM criteria account for the number of units transfused and the presence of concurrent procedures for hemorrhage management in their examples.[69,71,72]

Hysterectomy

Hysterectomy is a surgery to remove the uterus that is often performed in response to postpartum hemorrhage. Though hysterectomy is most often an unanticipated outcome of labor and delivery, for patients with placenta accreta spectrum, this may represent the standard of care.[118,119] The motivation for hysterectomy in this patient population is to remove the uterus with the placenta in situ to avoid disrupting the irregular vascular connections between the placenta and uterus that can precipitate massive hemorrhage. Hysterectomy may also be the definitive management strategy for uterine rupture, which is considered a distinct near-miss event by the WHO.[69]

The CDC and AIM indicators do not consider uterine rupture or other surgical interventions for postpartum hemorrhage management in their definition. The WHO considers uterine artery embolization—a procedure performed in interventional radiology to treat postpartum hemorrhage by decreasing blood supply to the uterus—as a distinct near-miss event. ACOG and SMFM adopt a similar perspective toward uterine artery embolization, and also consider other procedures, such as placement of a device for uterine balloon tamponade or return to the operating room, as SMM when present with a comorbid transfusion.[65] The need for laparotomy (other than cesarean delivery) is another notable procedural inclusion by both the WHO and ACOG/SMFM and can be performed for an indication of postpartum hemorrhage or for the management of another procedural complication not identified at the time of the index surgery.

The most recent estimates of peripartum hysterectomy cite a rate of 10.4 per 10,000 delivery hospitalizations, which is an increase from estimates of the past. This increase in rates of hysterectomy persists despite increasing rates of uterine balloon tamponade and uterine artery embolization for hemorrhage management, likely due to the changing medical risk factors of the population.[120] Medical risk factors for hysterectomy reflect the risk factors for hemorrhage as above, with an increasing prevalence of placenta accreta spectrum accounting for some of the aforementioned increase. Placenta previa with prior cesarean delivery is a strong risk factor for placenta accreta spectrum and hysterectomy—warranting special attention.[45] The presence of antepartum hemorrhage, placental abruption, fibroids, and stillbirth are notable medical risk factors for hysterectomy identified in

otherwise low-risk women.[115] Patients delivered at high-delivery volume hospitals with high rates of hysterectomy are at an increased risk of peripartum hysterectomy likely reflecting the referral patterns directing high-risk women to delivery centers equipped with the resources and personnel to manage their anticipated needs.[121]

Ventilation and Temporary Tracheostomy

Mechanical ventilation refers to the use of invasive or noninvasive ventilatory support to provide adequate oxygenation and ventilation. This morbidity is often a result of aforementioned clinical diagnoses such as ARDS, pulmonary edema, TRALI, transfusion-associated circulatory overload (TACO), aspiration, or cerebrovascular accidents. Patients with prolonged courses of mechanical ventilation are at risk of needing a temporary tracheostomy as a part of the management of chronic respiratory failure.

Conversion of Cardiac Rhythm, Cardiac Arrest (Including Ventricular Fibrillation)

Conversion of cardiac rhythm can occur as a part of cardiopulmonary resuscitation in cases of cardiac arrest or as a part of the management of a cardiac arrhythmia leading to hemodynamic instability.[122] Cardioversion can be achieved with the use of electrical cardioversion, as in the case of ventricular fibrillation, ventricular tachycardia, or even atrial fibrillation, or can use a pharmacologic agent encountered in cases of supraventricular tachycardia requiring adenosine or atrial fibrillation treated with amiodarone.[123] This complication occurs in 1.1 of 10,000 delivery hospitalizations, but is increasing with time as cardiovascular disease becomes the leading cause of maternal mortality in the United States.

ICU admission is not specifically included in the CDC or AIM indicators, as in the WHO criteria, but can often be assumed in cases of cardioversion or mechanical ventilation. The ACOG/SMFM guidelines provide general guidance on scenarios in which ICU admission would constitute SMM listing admission for diagnostic procedures or therapy (such as cardioversion) as meeting criteria for SMM.

Additional Maternal Outcomes of Interest

Cesarean Deliveries

As of 2017, roughly one in three women[124,125] in the U.S. gives birth by cesarean delivery. ACOG guidelines advise that providers promote vaginal delivery unless otherwise indicated or a patient requests discussion.[126] Cesarean delivery is a risk factor associated with increased risk of overall SMM, amniotic fluid embolism, hemorrhage, infection, prolonged healing time, placental abnormalities, and maternal mortality.[124,127,128] Each subsequent cesarean delivery can increase the risk of these outcomes as well, which will be discussed below. An additional concern with the frequency of cesareans in the U.S. is the potential overuse of medical healthcare, which results in higher costs to patients and to society.[129]

Although cesarean deliveries increase the risk of adverse outcomes, there is no current agreement on an optimal cesarean delivery rate for a health system. Across the U.S., non-risk-adjusted cesarean rates vary over a large range, from 7.1-69.9%.[124] Some researchers feel that risk-adjusted cesarean rates, which account for differences across sites of delivery, are a more appropriate measure of quality, because they account for comorbidities in the mother, some of which indicate cesarean as the standard of care. Research has indicated that hospitals with below average rates of risk-adjusted cesarean deliveries in turn have higher rates of maternal and neonatal complications. Hospitals with above

average rates of risk-adjusted cesarean deliveries do not have above average adverse outcomes, but they also do not have an above average improvement in positive outcomes.[129]

There are some populations that are more likely to have a cesarean delivery but defining this population is challenging. For example, ACOG lists labor dystocia, abnormal or indeterminate fetal heart rate, and fetal malpresentation, multiple gestation, and suspected fetal macrosomia as leading clinical indications for primary cesarean delivery.[124] It is therefore understandable that pregnancy complicated by multiple gestation or with a fetus with risk factors for abnormalities in the fetal heart rate tracing may be at higher risk for cesarean delivery. Studies associating factors such as maternal age and body mass index with cesarean delivery are less clear. Whether the higher odds of cesarean delivery in these populations is due to biology or a reflection of provider stigma and bias is unknown. For example, one motivation to avoid primary cesarean delivery is to avoid the morbidity associated with multiple repeat cesarean deliveries. This motivates an obstetrician to have a lower threshold for cesarean delivery for women with advancing age. However, after an analysis of 3 million deliveries, one nationwide payer has also found that cesarean rates differ significantly by geography. Even after identifying that different regions had similar rates of birth complications, some geographic areas had as much as double the rate of cesarean deliveries as others.[130,131]

Trial of labor after cesarean section (TOLAC), vaginal birth after cesarean (VBAC, i.e., a successful TOLAC), and operative vaginal deliveries are meant to help reduce rates of cesareans and reduce the risks associated with them, as listed above. However, they are also not without risks. A prior cesarean puts a TOLAC candidate at increased risk of uterine rupture; successful VBAC rates remain low.[132] As of 2017, the VBAC rate increased slightly from the prior year to 12.8 percent; however, there has not been a sizable increase in this rate over the last decade.[125,133] Although operative delivery increases the risks of perineal tears,[133,134] 53-79 percent of women will sustain some type of laceration at vaginal delivery, and ACOG has suggested that lacerations are not an adequate measure of quality due to the lack of uniform definitions and association with nonmodifiable risk factors.[135,136]

Intensive Care Unit Admissions

Admission to an ICU is known to be a marker of the most intense cases of SMM, also considered maternal near-misses, and was the most common SMM indicator for peripartum mortality.[137,138] Among more than 19 million live births in the U.S. between 2012-2016, approximately .15 percent of women were admitted to an ICU.[137] Black women and Hispanic women were more likely to be admitted to the ICU. So were women age 35 and older, women with a preexisting comorbidity such as diabetes or hypertension, as well as women with preeclampsia, preterm delivery, scheduled cesarean, induction of labor, prior preterm birth, STI during pregnancy, pregnancy complications, women without a high school degree, and those enrolled in the Special Supplemental Program for Women, Infants, and Children (WIC) or Medicaid. Gestational age, parity, and interpregnancy interval were also associated with ICU admission.[137,138] One study found maternal obesity to be an independent risk factor for ICU admission, with risk of ICU admission increasing alongside increasing BMI and the highest risk of ICU admission occurring in those with the highest BMI of 50 kg/m^2 or greater.[138]

Surgical Site Infections

Surgical site infection (SSI) is the third-largest contributor to in-hospital maternal mortality in the U.S., although morbidities associated with SSIs has been decreasing.[58,139] Although there are intervention

bundles for SSI outside of obstetrics, work on a bundle specific to obstetric situations is still in progress.[140] Rates of SSI vary depending on certain population characteristics. For example, patients with nonprivate insurance are at greater risk of SSI than patients with private insurance (14.8 per 100,000 births). Women who are ≥40 years old (8.0 per 100,000 births) and non-Hispanic black women (4.6 per 100,000 births) are also at increased risk.[139] Research has also shown that women who are obese or have diabetes are also at increased risk of abdominal surgical infection.[58] These infections are also a large contributor to prolonged hospitals stays and readmission rates, discussed below.

Maternal Mental Health: Postpartum Depression and Post Traumatic Stress Disorders

Mental illnesses, or disorders that affect one's mood, thinking, or behaviors, can arise during pregnancy and/or following childbirth. Suicide has been considered a relatively rare event during the perinatal period; however, some mental disorders (e.g., postpartum depression, bipolar disorder, postpartum psychosis, etc.) increase risk of suicidal ideation, suicide attempt, or suicide completion. These illnesses may predate conception but can be exacerbated during pregnancy. Generally, the peripartum period (including conception, pregnancy, and postpartum) may be a period of considerable vulnerability to major depressive disorders and affective disorders as it is frequently associated with the onset, and/or an unwanted occurrence of, a psychiatric illness. Overall, approximately 10-15 percent of newly delivered women experience a major depressive episode; while around 50% of women with a previous mood disorder and 70 percent with a family history of postpartum psychosis will develop a relapse and/or recurrence following a subsequent delivery.[141] Women with mental health issues are also at greater risk for developing substance use disorders (SUDs), or loss of the ability to control one's use of a drug or medication. SUD during pregnancy was approximately 5 percent in 2011, and research indicated that there was an increase in opioid use specifically between 2000 and 2009.[142] Although opioid use in pregnancy is rare (the national prevalence was 0.39 percent in 2011,[143] it significantly increases the risk of maternal death during hospitalization, cardiac arrest, placental abruption, and increased length of stay.[144] Between 2010-2012 in California, drug-related deaths were second only to obstetric-related problems as a leading cause of death.[145] In Utah between 2005-2014, drug-related deaths were the leading cause of pregnancy-associated death.[57]

Studies show that screening for maternal depression in the perinatal period is inconsistent across practices, and never occurs at some. Screening approaches also lack consistency, and available evidence shows that screenings focus mainly on postpartum depression at the exclusion of other anxiety disorders. Family physicians were more likely to feel responsible for addressing perinatal mental health than obstetricians, but report being resistant to validated screening tools, relying instead on intuition to recognize signs of postpartum depression.

Family physicians in particular also tend to choose medication over referral to counseling services for women experiencing perinatal depression and act mainly when the patient's voicing of how serious her condition outweighs physician concerns of risks to the child. Several studies have shown that physicians rarely refer pregnant women to additional treatment for maternal depression, even if they are on antidepressants.[146] In midwifery settings, similar problems have been identified. A lack of clarity around the appropriate scope of intervention and system-level barriers exacerbate these issues and raise uncertainties about identifying next steps for the proper management of perinatal mental health issues.[147]

Postpartum Depression

With the growing appreciation of the role of suicide and overdose to maternal mortality, major depression is a psychiatric disorder with an increasing importance in the conversation around severe maternal morbidity and mortality. Beginning in adolescence, women are twice as likely as men to experience major depression during their lifetime. Three-fourths of all lifetime cases of major depression start by age 24; women between the ages of 25 and 44, relative to older or younger ages, have the highest prevalence of major depression, placing women of reproductive age at high risk of experiencing depression during pregnancy. Pregnancy and postpartum depression are associated with an increased risk for developing depressive symptoms in women. Postpartum depression affects approximately 10-15 percent of women and impairs mother-infant interactions that in turn are important for child development. Maternal attachment, sensitivity, and parenting style are essential for a healthy maturation of an infant's social, cognitive, and behavioral skills, and depressed mothers often display less attachment, sensitivity, and more harsh or disrupted parenting behaviors, which may contribute to reports of adverse child outcomes in children of depressed mothers.

Maternal postpartum depression (PPD), one of the most common and disabling complications of childbearing, is often underdiagnosed and undertreated. PPD and non-perinatal major depression share the same diagnostic criteria: a combination of depressed mood, loss of interest, anhedonia, sleep and appetite disturbance, impaired concentration, psychomotor disturbance, fatigue, feelings of guilt or worthlessness, and suicidal thoughts, which are present during the same two-week period and are a change from previous functioning. These symptoms must cause clinically significant distress or impaired functioning that are not attributable to a substance or to another medical condition. PPD symptoms also include mood disorders, anxiety, irritability, feeling overwhelmed, and obsessional worries or preoccupation—often about the baby's health, feeding, and bathing safety. Suicidal thoughts are extremely common, affecting about 20 percent of women with PPD symptoms. Some women with PPD also have thoughts of harming their child. Thoughts of intent or desire to harm the child need to be distinguished from obsessional symptoms, where the woman has a thought or an image of harming herself or her child but is highly distressed by this thought or image and has no intent of acting on it.[148]

Most of the studies showed that African American and Hispanic women had a higher odds ratio of reported PPD. This higher risk can be attributed to lack of social support, access, trust, past depression, and other factors. However, one study found that although African Americans are more likely to report symptoms of postpartum depression, they are less likely to seek treatment due to cultural stigma regarding mental illness.[149]

In the U.S., black and Latina women have a disproportionately higher prevalence of PPD, 35-67 percent, compared to 10-15 percent in the general population, largely based on women of European decent. The disproportionately higher exposure to psychosocial stressors (e.g., low social support, trauma exposure) experienced by black and Latina women has been implicated in their increased vulnerability for PPD. Although the risk factors for PPD are considered multifactorial, current literature has consistently identified the significant role of social support. Many studies suggest that lack of social support is an important risk factor for PPD, whereas the presence of social support can protect against PPD.[150]

Trauma and Post Traumatic Stress Disorder

A traumatic event, or series of events, is defined by the Substance Abuse and Mental Health Services Administration (SAMHSA) as one that "is experienced by an individual as physically or emotionally

harmful or life threatening and has lasting adverse effects on the individual's functioning and mental, physical, social, emotional, or spiritual well-being."[151] When a mother experiences a severe morbidity as described above, it is likely that she has been exposed to trauma. For example, the WHO definition of a near-miss event includes events that would have resulted in death had intervention not been available. As a life-threatening event, this meets the definition of a traumatic event. Although research into the prevalence of trauma during pregnancy and postpartum is scarce, and many studies were conducted with data gathered prior to the implementation of the quality improvement programs described in this scan, research has found the prevalence is around 2.7-29.4 percent.[152,153] Women with preexisting mental health conditions or those who receive an emergency cesarean section were at increased risk of experiencing birth as traumatic.[154]

Post-traumatic stress disorder (PTSD) is a psychiatric disorder that can occur after a person experiences a traumatic event. Research in this area as it relates to pregnancy outcomes is also scarce, but a meta-analysis has shown that in the prenatal period, the mean prevalence of PTSD is 3 percent, while the mean prevalence of PTSD in the postpartum period is 4 percent,[155] but other research has placed it as high as 9 percent.[154] Risk factors for PTSD include prior PTSD diagnosis, poor perceived social supports, and poor quality of interaction with medical staff. Similar to PPD, postpartum PTSD may negatively affect mother-infant interactions. Women who suffer from PTSD are also highly likely to experience PPD.[152,154]

Women can experience trauma during the spectrum of maternal care, but prior trauma also has implications for the health of a woman over her lifetime.[156,157] Public health research has linked childhood trauma with birth outcomes in infants. For example, in one study, each experience of childhood trauma was significantly associated with an average reduction in an infant's birthweight, of 16.33 grams.[158] However, it should be noted that these outcomes may be mediated by other factors associated with childhood trauma, such as an increased risk of smoking and other behavioral factors. These results have implications for the relationship between trauma prior to pregnancy and maternal health, but more research is needed to describe a relationship. Nonetheless, trauma experienced prior to pregnancy, as a significant contributor to a woman's health and wellbeing throughout her life course, is relevant to improving maternal morbidity and mortality outcomes. It also speaks to the importance of identifying risk factors in the prenatal period, as prior mental health diagnoses are significantly associated with these postpartum outcomes.

Postpartum Hospital Readmissions

Maternal hospital readmissions, or postpartum hospitalizations, occur when a woman experiences obstetric-related complications following delivery and is admitted to a hospital for care. These types of readmissions have increased by 27 percent over the past 10 years.[159] Studies have shown nearly double the risk of postpartum rehospitalization for women who experience SMM at delivery.[160] Many studies have shown that experiencing SMM increases a woman's risk of postpartum rehospitalization. Roughly 14 percent of postpartum readmissions include SMM, and 18 percent of all SMM occur as postpartum readmissions.[159] A 2019 Massachusetts study found that SMM increased a woman's risk of readmission in the year postpartum for women with no chronic conditions. Approximately 1 percent of women with no chronic conditions experience an observational stay within one year postpartum, and 2.8 percent experience one inpatient stay postpartum. Among deliveries to women with SMM, which represented 99 per 10,000 deliveries, 4.5 percent had to be readmitted within six weeks postpartum, as compared to

1.1 percent for those with no initial experience of SMM. At one year, 7.7 percent of those who had experienced SMM had been readmitted at some point, compared to 2.7 percent of those without SMM.[160] This rate of SMM in this study was 99 per 10,000 deliveries.[160]

A 2018 review using data from the National Inpatient Sample of the Healthcare Cost and Utilization Project, the largest publicly available inpatient database in the U.S., identified a postpartum readmission rate of 1.6 percent among more than 27.6 million delivery hospitalizations from 2006-2012. But postpartum readmission rates vary by demographic. This same study found postpartum readmissions complicated by SMM to be most prevalent in the South, which is consistent with other studies showing higher rates of SMM in the South as well as the Northeast. Rates were also higher for women age 35 and older, non-Hispanic black women, and women with preexisting conditions.[159] A California study found that women with SMM at readmission were more likely to have had SMM at delivery, to have delivered by cesarean, to have some type of pregnancy complication, or to have a preexisting comorbidity. Those who were readmitted postpartum with SMM were more likely to be older, non-Hispanic, black, more educated, with private insurance, and have a pregnancy with multiples.[161] In fact, black women are more likely to experience postpartum readmission, to suffer a SMM at readmission, and to suffer life-threatening complications.[162]

The most common specific primary diagnoses associated with postpartum readmission were hemorrhage and/or retained products of conception (15.3 percent), hypertensive disorder (12.2 percent), thrombotic event (12.1 percent), uterine infection (7.1 percent), and wound infection or breakdown (5.9 percent). These specific indicators are also the leading contributors to maternal mortality.[159]

Postpartum fragmentation of care, when the readmission is to a different hospital than the initial point of care, is also associated with increased risk of SMM during readmissions. It has additionally been shown to increase costs and length of stay. Data from the 2010-2014 Nationwide Readmissions Database showed that 15.4 percent of 60-day postpartum readmissions included fragmented care. Fragmented readmissions resulted in a mean of more than half a day added length of stay, and approximately 40 percent higher mean total readmission costs. Women younger than age 25, using public insurance, and coming from lower ZIP code income quartiles, were associated with a higher risk of postpartum fragmentation. Conversely, cesarean section, multiple gestation, hypertension (gestational or chronic), and delivery at larger hospitals, teaching hospitals, and nonmetropolitan hospitals were associated with a decreased risk of fragmentation.[163]

Failure to Rescue

Challenges of accounting for the varying clinical scenarios leading to an outcome deemed SMM, along with the confounding influence of medical and nonmedical risk factors for disease, have prompted evolving concepts for understanding maternal outcomes. The concept of failure to rescue is a quality indicator from the general surgery literature with potential applications in obstetrics.[164] Failure to rescue is defined as the death of a patient after one or more potential treatable complications. Applying this framework to obstetrics failure to rescue has been defined as death in the setting of severe maternal morbidity.[165] Future iterations of this definition could include death in the setting of severe obstetric complications, such as postpartum hemorrhage or preeclampsia with severe features, as well. By limiting the population of interest to those experiencing a severe outcome, this framework helps neutralize the impact of some of the nonmodifiable risk factors for the disease while focusing attention on aspects of the process of care with the potential to impact the patient's trajectory. Novel outcome measures such as failure to rescue, coupled with other process measures, may provide additional information to inform a contemporary understanding of maternal mortality.

Patient-Centered Outcomes

A 2014 study of women's perceptions before and after elective induction of labor (IOL) found that clinicians were the voice of authority, and women did not actively participate in assessing their choice of care, leading to varying levels of satisfaction with the birthing process. Women reported "minimal dialogue" with their provider and largely described encounters as "brief," without the opportunity to discuss questions or concerns. Most women reported not being made aware prenatally of the risks of IOL until arriving at the hospital for the scheduled procedure, and post-induction interviews reinforced their feelings of having been ill-informed.[166] Implicit bias and other influencing factors are discussed below.

Influencing Risk Factors for Maternal Morbidity and Mortality

Influencing factors related to maternal morbidity and mortality include both clinical and nonclinical components across the continuum of care—individual level (age, education, knowledge, beliefs, behaviors), societal/community factors (social network, built environment, housing), hospital factors (implicit bias, cultural competence, communication), and system-level factors (access, structural racism, policy). These factors are interrelated and contributors to each other. In traditional models of care, medical risk factors are more notably mentioned. Specific to maternal morbidity and mortality, the focus is on the limited time period in the hospital for delivery and in the immediate postpartum period. Contemporary explorations of maternal morbidity and mortality emphasize the importance of the pregnancy and childbirth experience along the continuum of a woman's life.[167,168] This notion underscores the need to broaden the viewpoint to include a comprehensive assessment of medical as well as nonmedical risk factors to better understand the larger context of influencers and contributors for adverse outcomes beyond traditional hospital risk factors. Examining the complex interaction between a patient, her medical diagnoses, and her interactions with both the healthcare system and prehospital environment appropriately situates maternal morbidity and mortality along the continuum of a woman's life. Adopting a framework that first considers nonmedical influencing factors supports a comprehensive assessment that is well-situated to prioritize health equity and address disparities in outcomes and care.

Health and Healthcare Disparities

The term "health disparity" is defined differently throughout the literature. It is often used interchangeably with similar terms like "health inequity," "health inequality," or "racial/ethnic differences." All of these terms imply a varying understanding of what constitutes a disparity. The HHS Office of Minority Health describes a health disparity as "a particular type of health difference that is closely linked with social, economic, and/or environmental disadvantage" (based on individuals' gender, age, race, and/or ethnic group, etc.). Healthcare disparities are defined as "differences in the quality of care that are not due to access-related factors or clinical needs, preferences, and appropriateness of interventions" (i.e., differences based on discrimination and stereotyping).[169]

There is also an important distinction between health equality and health equity as it relates to health outcomes and resource distribution. The Human Rights Commission defines equality as the distribution of the same resources and opportunities to every individual across a population. On the contrary, equity is defined by the WHO as the customized distribution of resources across a population to ensure no subset of groups are at a particular disadvantage over others in achieving their maximum potential.[170] Although several terms are used to describe health disparities, the common thread is that they are differences based on modifiable, socially determined factors. Disparities have been found among a wide range of health outcomes and in exposure to environmental hazards and other risks, as well as within the delivery of healthcare services. The CDC report, *Health Disparities and Inequalities Report – United States, 2013,* found racial and ethnic disparities in mortality due to heart disease and stroke, socioeconomic disparities in the prevalence of diabetes, disparities in suicide rates based on gender, and many others. The *2015 National Healthcare Quality and Disparities Report* found disparities in healthcare related to race, ethnicity, and socioeconomic status (SES) that persist across all National Quality Strategy (NQS) priorities.[171]

Racial and ethnic disparities are closely linked to the high U.S. pregnancy-related mortality rates. Black women are dying from pregnancy-related causes at a rate of three to four times higher than white women.[172] This disparity in pregnancy-related mortality, defined within one year of pregnancy caused by a pregnancy complication, a chain of events initiated by pregnancy, or the aggravation of unrelated conditions by the physiologic effects of pregnancy, has existed for over a century, and has actually widened over the last hundred years. Currently, maternal death represents the largest racial disparity in outcomes among all the conventional population perinatal health measures. Non-Hispanic black women have had the fastest rate of increase in maternal deaths between 2007 and 2014, and have maternal death rates up to 12 times higher in some cities than non-Hispanic white women.[8] The rates of severe maternal morbidity are also 1.7 times higher for Native Americans/Native Alaskans compared with white women in data from seven states. With these alarming trends, 60 percent of pregnancy-related deaths in the United States are thought to be preventable.[2] A CDC review of maternal deaths across nine states found that the deaths were related to clinician, facility, community, and system factors, such as inadequate training, missed or delayed diagnosis of complications, poor communication, and lack of coordination between clinicians.[2]

Profound disparities in birth outcomes also persist in the United States, most significantly in the non-Hispanic black population. The overall infant mortality rate (IMR) in the United States is 5.96 infant deaths per 1,000 live births, yet the IMR for non-Hispanic blacks is 11.11 infant deaths per 1,000 live births.[173] Black infants die before one year of life at more than twice the rate of white infants. While the IMR is only one marker of birth outcomes, it is regarded as one of the most important indicators of the

health of a nation as it encompasses several health indicators such as maternal health, access to healthcare, and public health practices.

A study that looked at discharge and birth data sets in New York City estimated that Hispanic and non-Hispanic white differences in delivery location may contribute to up to 37 percent of the ethnic disparity in severe maternal morbidity rates in area hospitals.[174] Hispanic versus non-Hispanic white mothers are more likely to deliver at hospitals with higher risk-adjusted severe maternal morbidity rates, and these differences in site of delivery may contribute to excess morbidity among Hispanic mothers. If Hispanic mothers delivered in the same hospitals as non-Hispanic white women, a simulation model estimated that they would experience 485 fewer severe morbid events, leading to a reduction of the Hispanic severe maternal morbidity rate from 2.74 percent to 2.28 percent, removing 36.5 percent of the Hispanic-white disparity in severe maternal morbidity. By ethnic subgroup, Puerto Rican women would experience 131 fewer severe morbid events, foreign Mexican women would experience 93 fewer events, and foreign Dominican women would experience 114 fewer events.[174]

If quality of care were improved in New York City hospitals such that morbidity in the worst-performing hospitals was reduced to the average of other New York City hospitals, 306 Hispanic and 145 non-Hispanic white severe morbid events could be averted and the Hispanic-white disparity would be narrowed by 13 percent.[174] If the SMM rates of the middle and highest morbidity quartiles of hospitals were reduced to the average of the remaining hospitals, 1,139 Hispanic and 446 non-Hispanic white morbid events could be avoided, and the Hispanic-white disparity would be narrowed by 54 percent.[174]

Race and Racism

Race and racism are the root cause of race-based health disparities and often lead to social, economic, and environmental disadvantages. Racism is defined as an "organized system within societies that cause avoidable and unfair inequalities in power, resources, capacities and opportunities across racial or ethnic groups." Race is a social construct that does not describe genetic or biological differences in human beings. While there is great interest in understanding how social factors contribute to poor health outcomes, there is also reluctance in identifying racism as a root cause of racial health inequities and adverse maternal outcomes. Race-based disparities are a result of more than the basic differences between people from different racial categories; they are the result of a foundation of racial injustice that has permeated all levels of the healthcare system. This foundation has created a system of interlocking factors to maintain power and privilege to the detriment of others.[174,175] A systematic review and meta-analysis of racism as a determinant of health showed the impacts of racism on health in the early 1980s and called for further research on the topic. Additional studies in the mid-1990s and early 2000s found consistent evidence for associations between racism and mental health outcomes and physical health outcomes.[170]

Racism can and has occurred at different levels—incorporated in racist attitudes, beliefs, or world ideologies, through interactions between individuals and at a system level through control of and access to resources within a society. The impact of racism on health is equally multilayered and forges down different pathways that include the following: lack of access to employment, housing, and education, exposure to risk factors, cognitive and emotional distress and associated psychopathology, lack of healthy behaviors, and an increase in unhealthy behaviors and physical injury as a result of racially motived violence.

Racial disparities within maternal care and the impact on birth outcomes are a significant public health concern. Factors associated with racism have been considered as a mechanism underlying these disparities. Racial/ethnic disparities in preterm birth are well-documented, yet clear reasons why this continues is not fully explored. Studies examining the link between antenatal depression and the risk for preterm birth have shown non-White women to be at an increased risk. In addition, the emotional effect of experiences with racism may also contribute to the risk of preterm birth.

Ultimately, racism constitutes a severe threat to a person's health and wellbeing through chronic stress, and operates at individual, interpersonal, and structural levels, systemically perpetuating health disparities.

Systemic Racism

Systemic racism refers to the policies and practices rooted within macrolevel systems, institutions, and processes that interact with one another and reinforce inequities among racial/ethnic groups. Systemic racism is separate from interpersonal or internal racism and manifests in two ways: structural and institutional racism.[176]

Structural Racism

Structural racism is defined as a systematic approach used to influence laws and process to unequally allocate access to goods, opportunities, and services in society by racial group. Research consistently shows that higher exposures to structural racism is associated with adverse birth outcomes (e.g., preterm birth and low birth weight) among black women even after controlling for socioeconomic characteristics. Support from local governments is needed to continuously monitor social determinants of health outcomes, such as structural racism, and track the distribution of resources to improve equality among racial groups.[177]

Institutional Racism

Institutional racism is defined as racial discrimination derived from individuals carrying out the orders of others who are prejudiced or of a prejudiced society. Within the traditional medicine and public health community, concepts of institutional racism are not seen as underlying causes of health inequities. However, currently in the United States, forms of racism are magnified, as witnessed by the multiple police shootings of unarmed African American men and women, leading to activist movements such as Black Lives Matter.[178] This specific example calls attention to the role that institutions (e.g., law enforcement) play as contributors to the overall health of communities of color.

Discrimination

Discrimination classifies people into groups and further feeds into the uneven distribution of power, privilege, and superiority within a society. It can encourage certain attitudes, behaviors, and unfair treatment, and is based on stereotypes. There are different forms of discrimination—racial/ethnic discrimination, ageism, sexism, and classism. And when discriminatory forms are combined (i.e., multiple discrimination), people are exposed to different levels of discrimination including individual, institutional, and cultural, and this creates a bigger system of oppression and marginalization.[179]

Research has shown that discrimination is associated with increased risk of health problems during pregnancy and after birth, including postpartum depression.[179] Discrimination can take different forms, such as denial of women’s rights, fewer opportunities for higher education, and increased violence. In

addition, women who lack social support or who live in areas lacking services or resources tend to experience discrimination.

Differences in the experience of discrimination may also exist by race/ethnicity. In one study, 45 percent of white adolescents, 41 percent of black adolescents, and 33 percent of Hispanic adolescents reported feeling stigmatized by their pregnancy.[180] Other stigmas such as low socioeconomic status may also be applied to pregnant teens and young women, in addition to discrimination associated with their race, ethnicity, sex, and age. For example, childbearing African American women describe overhearing racist comments in the workplace and being treated with disrespect and distrust in stores. Pregnant teens and young women report experiencing traditional gender role stereotyping, demeaning comments, and sexual objectification in their everyday lives.

Discrimination and similar practices have led to mistrust between black and brown people and their healthcare providers. Historically inhumane policies such as forced sterilization and child separation have set the stage for a lifetime of distrust between the healthcare system and black and brown communities and have impacted the future course of treatments and contributed greatly to poor maternal health outcomes.[181]

Taken together, it is important to study experiences based on race and ethnicity as well as other possible stigmas to best understand the role of discrimination on health outcomes and specifically adverse birth outcomes. Experiences of discrimination are perceived across a continuum.[180]

Residential Segregation

Racial residential segregation—the geographical separation of racial groups in a residential context—is considered a primary cause of racial disparities. Racial segregation started in the late 19th century by census block but changed to the neighborhood level by the middle of the 20th century. White and affluent families were purposely separated from poor African American residents within each neighborhood. Furthermore, during the mid-1940s, suburban development spread across the United States and many affluent families moved. This suburbanization was also influenced by the social ideologies of racial residential segregation, which stemmed from Black Codes and Jim Crow laws. Black Codes were laws designed to limit the freedom of African Americans and ensure their availability as a cheap labor force after the emancipation of slavery. Additionally, Jim Crow laws enforced racial segregation and second-class citizenship for African Americans until the beginning of the civil rights movement in the 1950s.[182]

Racial residential segregation was further perpetuated through zoning laws and mortgage insurers or guarantors who continually denied African Americans and other individuals of color homeownership in most suburban subdivisions. Therefore, communities of color were relegated toward older and declining houses and received less support from public services in the city and urban areas. The quality of services and amenities, such as parks and playgrounds, access to healthcare, and developed infrastructure, depend on the decisions of local stakeholders and systems and were put in place to assure communities of color remained disinvested and disadvantaged. The historical context of residential segregation provides the background to understanding health determinants, which are directly related to the limited availability of affordable housing, decreased walkability, as well as increased crime. Among communities of color in particular, health inequities such as exposure to underserved social and physical

environments, absence of healthy foods, higher risk of violence and crime, and limited housing choices are the long-term negative health effects of displacement.

Implicit Bias

Current research shows that healthcare providers may unknowingly influence and contribute to healthcare disparities through their own cultural stereotypes about individuals, which can lead to unintended biases in decision making. These can shape a provider's thoughts, opinions, and behaviors in medical treatments and care for patients of different races, ethnicities, and other characteristics. As opposed to explicit prejudices (e.g., believing that women are not as competent surgeons as men, or that men are unemotional), implicit bias occurs without conscious awareness and is frequently at odds with one's personal beliefs. A review of the literature suggests that implicit bias against black, Hispanic/Latinx, and dark-skinned individuals is present among many healthcare providers of different specialties, levels of training, and levels of experience. Implicit bias toward people of color may indeed interact with other characteristics such as gender, age, sexual orientation, national origin, and disability status to produce differential treatment outcomes. Indeed, healthcare providers also face challenges that impact decision making, such as the uncertainty and the time pressures that surround the diagnostic process, which may promote reliance on stereotypes.

In addition, healthcare professional training emphasizes group-level information, like population risk factors, and may expose trainees to minorities in unfavorable circumstances of illness or addiction, reinforcing stereotypes. A provider's vast knowledge of scientific data may create a strong belief in their personal objectivity, promoting bias in decision making. The contribution of implicit bias to healthcare disparities could be reduced if all physicians acknowledged their susceptibility to such bias and deliberately practiced perspective-taking for each individual being treated. Implicit bias appears to be more frequently associated with patient/provider interactions and relationships, which also suggests that these interactions could be used as a pathway to improving communication and patient outcomes in terms of adherence to treatment and health status.[183]

National guidelines recommend universal implicit bias training as a targeted intervention to reduce health disparities, but the extent to which these guidelines are followed is unknown. This lack of accountability for the lower quality of care reported by under-represented minorities contributes to ongoing systemic racism and disparities in outcomes. The aforementioned guidelines cite the need for a system to allow patients, their families, and providers to report episodes of discrimination, racism, and disrespect. But once again the availability of such systems, their actual use by already-marginalized patients, and the extent to which these complaints are followed up is unknown. Developing a system that holds providers and hospitals accountable for behaviors and policies that promote ongoing racism or exacerbate poor maternal health outcomes is needed.[184,185]

Language Barriers in Healthcare

Barriers in language between a healthcare provider and patient have a significant impact on the quality and equity of healthcare. Health disparities such as unequal treatment, lack of access to services, and lack of adherence to treatment plans are all related to language barriers and greatly influence health outcomes. A recent study conducted in six hospitals in the U.S. found that adverse events occurred more frequently among patients with limited proficiency in English than among those who were proficient in English.[186]

Language barriers impact healthcare delivery in three ways—miscommunication, increase of costs, and application of translation tools.[187] Miscommunication between medical providers (e.g., physicians and nurses) and patients has been shown to reduce overall satisfaction for the patient and provider and can be a source of stress for both parties. An increase in indirect healthcare costs is another impact; many patients are more likely to consume unnecessary healthcare services and experience more adverse events. If a patient has difficulty understanding their diagnosis, medical complications, or treatment plans, they are more likely to revisit the medical facilities for continued assistance. Finally, to overcome language barriers, some institutions provide interpreter services, which are needed and helpful, but also present challenges in terms of access and financial burden. Studies have shown that the use and availability of interpreter services can vary greatly by institution and location.[187] The appropriate use of interpreter services does improve patient satisfaction and adherence to treatment plans.

Health Literacy

While language barriers are one contributing factor, health literacy is another and is independent of the native language of the patient. Health literacy is generally defined as a set of skills and competencies that enable people to obtain and interpret health information and apply their knowledge to inform health-related decision making.[188] Studies have also consistently demonstrated that a low health literacy is impacted by cultural views and practices, which can shape opinions on health and healthcare. Levels of health literacy can be associated with less of an understanding of certain specific topics and a lack of seeking follow-up care. Specific to maternal health, low literacy can be associated with several factors that occur over the lifespan from preconception to the postnatal phase. This would include a lack of clarity on when during a menstrual cycle pregnancy is possible, lower understanding of the transmission mechanism of various sexually transmitted infections, and an increased likelihood of inadequate next steps following an abnormal pap smear. Women who are pregnant may not fully understand the importance of vitamin supplements and could be more likely to attribute harm to medications used during pregnancy.[189] While a patient's reading and education level are part of the contributing factors to low literacy, it is also important to mention the lack of consistent systematic approaches to assist with building knowledge and skills, and to improve health literacy across different healthcare sectors

Rural Communities

Rural residents may face health challenges related to geographic barriers to care, healthcare provider shortages, poverty, lower educational attainment, and other demographic factors. In maternal and child health, these disparities may be evidenced by the health risks and behaviors of new mothers, the health of infants born to these mothers, and the care received by mothers and infants. The geographic and demographic realities of rural life may also interact around health-related issues. Lower socioeconomic status is generally associated with poorer health, regardless of rurality of residence, and greater distance to primary care has been associated with later diagnosis of serious health conditions in rural communities. Rural dwellers also face challenges specifically in the area of maternal and child health. Teenage birthrates, neonatal mortality, and adverse birth outcomes (e.g., low birth weight and prematurity) have all been found to be higher in rural areas as compared to urban areas in a number of studies.[190]

The reasons for differences in health outcomes for rural residents are multifactorial. Prepregnancy maternal demographics (age, race, marital status, and income), prepregnancy maternal behaviors (smoking, alcohol consumption, and body weight), and prenatal behaviors (smoking, alcohol consumption, weight gain, and seeking prenatal care) can all have an impact on the health of the

pregnant women, the course of pregnancy (development of hypertension or gestational diabetes and the risk of cesarean section birth), and the health of newborns. Postpartum maternal behaviors such as smoking and breastfeeding can affect the newborn's health. One study showed that while approximately 75 percent of rural women gave birth at local hospitals, rural women with preterm births and clinical complications, as well as those without local access to higher-acuity neonatal care, were more likely to give birth in nonlocal hospitals.[190]

Social Determinants of Health

Social determinants of health (SDOH) are among the most influential factors that affect the health of individuals. The National Academy of Medicine describes these factors as the conditions in which people are born, live, learn, work, play, worship, and age.[191] A number of studies have attempted to assess the impact of social factors on health, and it is estimated that medical care is responsible for only 10-15 percent of preventable mortality in the U.S., and half of all deaths in the U.S. involve behavioral causes.[192] There are widely observed associations between health indicators and the level of an individual's socioeconomic resources—typically, income, education, and occupation. In American and European data, this association often follows a pattern of health improving incrementally as social position rises.[192] "Your ZIP code is a better predictor of your health than your genetic code," is an assertion that acknowledges the overwhelming variance of health and life expectancy among individuals and communities in specific geographical neighborhoods due to socioeconomics, race, ethnicity, and other SDOH. Growing recognition of the benefits of connecting healthcare with non-health services that can address SDOH has led to numerous initiatives. For instance, some states have even implemented a "health in all policies approach," which prioritizes health as a key outcome of policymaking. Private organizations have also begun to address SDOH through community partnerships.[193]

Housing Insecurity and Lack of Safe/Healthy Housing

Among low-income families with children, housing instability strongly correlates with severe food insecurity. According to the U.S. Department of Housing and Urban Development (HUD), in 2015, 8.3 million renters were classified as having worst-case needs or as having experienced housing instability. Worst-case housing needs are defined as renter households with very low incomes (not more than half of the median income in their area) that lack housing assistance and have severely inadequate housing or severe housing cost burdens exceeding half of their income. The link between housing instability and lower health outcomes has been demonstrated in several studies. Stress, worry, self-efficacy, and the emotional/mental state of an individual related to housing instability affect an individual's health, which can lead to poorer health outcomes. In addition, the quality and characteristics of housing have also been linked to health conditions, including asthma, lead poisoning, and hypertension.[182]

The Built Environment

The built environment plays an important role in the dynamics of disease and individual health. The built environment is defined as physical spaces, including buildings, streets, homes, schools, parks, playgrounds, and other infrastructures where people live, work, and play. Ideally, the built environment should support and facilitate the capacity to maintain a healthy lifestyle; however, it can also have an indirect influence on behaviors and transmission of disease. One of the most striking examples of how the built environment can affect health is from the history of urban planning. Zoning within communities was introduced to segregate residential spaces from commercial and industrial uses. These efforts to configure the built environment to control infectious disease in the late 1800s and early 1900s ultimately contributed to chronic diseases in the 21st century. Now low-income and minority

neighborhoods are often “food deserts,” characterized by the abundance of liquor stores and fast-food restaurants but with a dearth of grocery stores. Other factors such as mental health and social isolation are both linked to the physical aspects of the built environment and are equally as important when addressing health outcomes.[194]

Food Insecurity

The United States Department of Agriculture (USDA) estimates that nearly 12 percent of U.S. households were classified as food insecure in 2016; 7.4 percent were classified as having low food security; and 4.9 percent as very low. The majority of food-insecure households (31.6 percent) had children and were headed by a single woman. On average, food-insecure households had incomes 185 percent below the poverty threshold (poverty line was $24,339 for a family of four in 2016). Beyond data collected by the federal government, Feeding America, a nonprofit network of 200 food banks, regularly conducts and compiles research to understand the characteristics and lives of individuals who are food insecure.[193]

Hospital Factors

Several studies have investigated the theory that prevalence of various maternal morbidities treated by a hospital is associated with the labor and delivery outcomes at that hospital, although the possible associations are not conclusive. A study of delivery hospitalizations from 1998-2010 across the U.S. found no significant differences in maternal outcomes for high volume hospitals, but low delivery volume was associated with increased risk of SMM and “failure to rescue.” The study noted that high and moderate volume hospitals saw higher rates of patients with higher risk of SMM, but the relationship between these factors is not clear. It is possible those at greater risk of SMM seek out health systems with higher volume for care. “Institutional readiness” to address certain causes of maternal morbidity that are considered very preventable may also be more important to a hospital’s response than the volume of such deliveries they encounter, especially for conditions such as hemorrhage, hypertension, and VTE. However, the risk for failure to rescue increased as hospital volume increased, though the cause is unclear and warrants further research to determine if this association is sound.[165]

Lower volume rural hospitals tend to have higher rates of postpartum hemorrhage than higher volume rural hospitals.[195] A 2011 study using a representative sample of U.S. hospitals found that teaching status, birth volumes, and geography represented a difference in postpartum hemorrhage rates across hospitals, though birth volume and geography especially are likely to be proxies.[196] Lower birth volume in urban teaching hospitals was associated with lower odds of postpartum hemorrhage. Conversely, the lowest volume rural and nonteaching hospitals had much greater odds of postpartum hemorrhage. Rural hospitals experienced 31 percent greater odds of postpartum hemorrhage than urban teaching hospitals. While causal factors are undetermined, the findings imply a need for greater clinical management of postpartum hemorrhage focused on certain categories of hospital.[196]

Hospital-level contributions to maternal outcomes are not only linked to overall delivery volume. Nearly 75 percent of black women in the U.S. deliver at only 25 percent of delivery hospitals, while roughly 18 percent of white women deliver at those same hospitals. Studies of intrahospital differences show that racial and ethnic disparities in care and outcomes persist in both mainly black-serving and mainly white-serving hospitals,[197] though black women delivering at hospitals that mainly serve black women have the highest risk of SMM.[198]

System Factors

Lack of coordinated care, time, and financial barriers related to employment structures, and social behaviors such as immigration status and lack of English proficiency are a few examples of barriers on a systems level that can contribute to poor maternal health outcomes.[199] Many women in rural settings experience limited access to adequate obstetric services. As of 2014, 45 percent of all rural communities had no hospital obstetric services, and 9 percent of rural counties had experienced a loss of all hospital obstetric services within a 10-year period. These deficiencies were more likely to affect counties with a higher percentage of non-Hispanic black women of reproductive age; those with lower median household incomes; and those whose states used more restrictive income eligibility criteria for pregnant women seeking Medicaid.[200] Interviews with women who were referred for postpartum depression found that postpartum care-seeking behaviors may be impacted by certain health system barriers, such as normalizing or downplaying of symptoms by clinicians, disconnected pathways for care, and interventions that some women find unacceptable (e.g. recommending medication as the best option, which can then discourage these women from pursuing further care).[201] Lack of child care or transportation can prevent women from receiving sufficient care at any stage of the life cycle, but especially during prenatal and postpartum care when appointments occur more frequently.

Maternity leave policies in the U.S. have also had a demonstrative impact on women's postpartum health. In the year following delivery, an increase in available leave is associated with a decrease in depressive symptoms up to six months postpartum. Longer leave was also slightly associated with improved physical health.[202] Compared to taking unpaid leave or no leave at all, women who utilized paid maternity leave had 51 percent decreased odds of rehospitalization at 21 months postpartum.[203]

Standard Processes for Maternal Care Delivery

While much progress has been made during the past two decades in maternal care and insurance coverage of births in health facilities, reductions in neonatal mortality remain slow, and maternal mortality has increased.[4] Attention has shifted to the quality of care, as poor quality of care contributes to maternal morbidity and mortality. In addition, there is a complex relationship between patient experience of care and subsequent pregnancy outcomes. Maternal quality of care requires the use of effective clinical and nonclinical interventions, strengthened health infrastructure, and expanded knowledge and awareness of health providers. Standard processes for maternal care delivery can be broad and conceptual, such as those identified by the WHO, or more specifically, such as the Alliance for Innovation on Maternal Health's Patient Safety Bundles. Standards of care that impact maternal morbidity and mortality span the life course from preconception to postpartum.

Preconception

Preconception care standards can include standards of care for all women, as reproductive health is an inherent piece of any well-woman visit. This care includes the interventions that are meant to modify and improve women's health through prevention and management.[204] The goal of preconception care is to optimize a woman's health prior to conception and between pregnancies to reduce complications during subsequent pregnancies. As mentioned above, many chronic medical conditions put women at greater risk of complications during and after pregnancy, and management of these prior to pregnancy can be beneficial.[205] Preconception care standards include the following:

- Any encounter with a patient of reproductive age is an opportunity to give counseling on improving health to optimize reproductive and obstetric outcomes.
- Improving the health of a patient prepregnancy has the potential to improve their reproductive health and the health of their pregnancy.
- The goal of this counseling is to reduce risk of adverse outcomes and promote healthy pregnancy.
- Patient should be assessed for updating vaccinations; should receive screening for sexually transmitted infections, other infectious diseases, intimate partner violence, substance use disorders, genetic conditions; should receive counseling on behavioral health issues; and patients' medications should be reviewed.[205]

Prenatal

Prenatal care standards generally refer to care that is offered to an individual mother during her pregnancy,[206] but it should be noted that there are also many models for group prenatal care where mothers and their partners, or multiple mothers, receive guidance all together. Group prenatal care is generally delivered to a small cohort of women who are due around the same week. The most well-known model of group prenatal care is the CenteringPregnancy model. There are a number of forms, but all of them focus on providing education, increasing feelings of support and self-efficacy, and providing mothers with the tools they need to monitor their own health during pregnancy.[207] These models may not be available to all patients due to availability and barriers to access, such as ineligibility for reimbursement through Medicaid or other insurance. One-on-one prenatal care standards stress an optimal number of prenatal visits as well as the timing of these visits. It is recommended that women who are at low risk for pregnancy complications receive 12-14 prenatal care visits. These visits are to be monthly until 28 weeks gestation and increase to every two weeks at 32 weeks gestation through the period of delivery.[208]

However, research on the standards for prenatal care is ongoing and vast. There is a great deal of interest from patients, providers, and advocates to make improvements and changes to these standards.[208] These improvements include acknowledging the different needs of low-risk and high-risk pregnancy patients; the increased need for integration of social supports; reducing the needed number of visits for low-risk pregnancy patients to reduce low-value care; and incorporating research into patient preferences for prenatal care. The American College of Nurse-Midwives (ACNM) also stresses the inclusion of standards for educational and social supports into group prenatal care visits.[209]

World Health Organization Standards: Recommendations on Antenatal Care

The WHO has established standards of care and measures of quality to improve outcomes for women receiving prenatal (antenatal) care.[210] For the purposes of these standards, the WHO defines antenatal care as "the care provided by skilled health-care professionals to pregnant women and adolescent girls in order to ensure the best health conditions for both mother and baby during pregnancy." This encompasses the definition of prenatal care. Implementation of these standards depends on the physical infrastructure, human resources, knowledge, skills, and capacity to deal with both normal pregnancies and complications that require prompt, life-saving interventions. The WHO standards relevant to maternal care are listed below:

- Nutritional interventions

    - Counseling about healthy eating and maintaining a healthy weight
    - Daily or intermittent iron and folic acid supplementation to prevent maternal anemia and puerperal sepsis
    - Daily calcium supplementation to reduce the risk of preeclampsia
- Maternal and fetal assessment
    - Full blood count testing or onsite hemoglobin testing to diagnose anemia during pregnancy
    - Clinical enquiry about the possibility of intimate partner violence where there is a capacity to provide further support
    - Screen for hyperglycemia to diagnose gestational diabetes mellitus or diabetes mellitus in pregnancy
    - Enquire about tobacco use, alcohol use, and exposure to second-hand smoke
    - Perform one ultrasound exam prior to 24 weeks gestation
- Preventative measures
    - Oral pre-exposure prophylaxis (PrEP) containing tenofovir disoproxil fumarate (TDF) should be offered as an additional prevention choice for pregnant women at substantial risk of HIV infection as part of combination prevention approaches.
- Interventions for common physiologic symptoms
    - Nonpharmacologic options for relief of nausea, to prevent and relieve heartburn, and for the relief of leg cramps
- Health system interventions to improve utilization
    - Promote self-sufficiency by encouraging women to retain copies of their own case notes
    - Encourage involvement of midwives throughout the care continuum
    - Offer group care as an alternative to individual care and encourage participatory learning and action, especially in rural settings with lower access to services
    - Include options for home visiting, particularly in rural settings with lower access to services and transportation
    - Care models should include no less than an eight-visit minimum

Labor and Delivery

Labor and delivery standards of care have received the greatest attention and research. The WHO and AIM patient safety bundles mentioned above have contributed to the care standards for labor and delivery. Work continues to increase and improve upon the standards for this period of care.

World Health Organization Standards: Improving Quality of Maternal and Newborn Care

The WHO has established standards of care and measures of quality to improve outcomes for women during the time of childbirth and newborn care within health facilities. These evidence-based practices define what is required in order to achieve high quality care and reflect the overall quality of services provided. Again, implementation of these standards depends on the physical infrastructure, human resources, knowledge, skills, and capacity to deal with both normal pregnancies and complications that require prompt, life-saving interventions. The WHO standards are listed below:

- Every woman and newborn receive routine, evidence-based care, and management of complications during labor, childbirth, and the early postnatal period, according to WHO guidelines.

- The health information system enables use of data to ensure early, appropriate action to improve the care of every woman and newborn.
- Every woman and newborn with condition(s) that cannot be dealt with effectively with the available resources is appropriately referred.
- Communication with women and their families is effective and responds to their needs and preferences.
- Women and newborns receive care with respect and preservation of their dignity.
- Every woman and her family are provided with emotional support that is sensitive to their needs and strengthens the woman's capability.
- For every woman and newborn, competent, motivated staff are consistently available to provide routine care and manage complications.
- The health facility has an appropriate physical environment with adequate water, sanitation, energy supplies, medicines, supplies, and equipment for routine maternal and newborn care and management of complications.

Within each of the standards, quality statements provide further specifications and cover thematic areas such as routine care during childbirth, including monitoring of labor and newborn care at birth and during the first week; management of preeclampsia, eclampsia and its complications; management of difficult labor with safe, appropriate medical techniques; management of postpartum hemorrhage; newborn resuscitation; management of preterm labor, birth and appropriate care for preterm and small babies; and management of maternal and newborn infections.

The Joint Commission Standards on Maternal Care

The Joint Commission has recently introduced two new standards for perinatal safety. These standards are meant to address prevention, early recognition, and timely treatment of maternal hemorrhage and severe hypertension/preeclampsia.[211] Specifically, both standards follow similar recommendations, which include using an evidence-based tool for assessment; developing written evidence-based procedures for the management of maternal hemorrhage and severe hypertension/preeclampsia; ensuring the obstetric unit has a standardized, secured, and dedicated hemorrhage supply kit; and providing education to all staff and providers who treat pregnant and postpartum patients about hospital procedures. It is also equally important to review cases of hemorrhage and severe hypertension/preeclampsia that meet criteria established to evaluate the effectiveness of care and treatment.

Alliance for Innovation on Maternal Health (AIM) Patient Safety Bundles

The HRSA funded AIM to create maternal safety bundles that include guidance on evidence-based or informed practices for maternity care. Bundles comprise 10-13 best practices organized into four domains: readiness, recognition, response, and reporting and system learning. The bundles ensure that healthcare organizations are prepared for maternal events, understand the risk for these events, develop systems for early warning signs, and universally implement a given protocol across providers in response to an event. The current set of bundles includes the following:

- Maternal Venous Thromboembolism
    - Apply a standardized tool to assess VTE risk at time points designated under "Readiness" and to identify appropriate patients for thromboprophylaxis, provide patient education,

and provide healthcare provider education regarding risk assessment tools and recommended thromboprophylaxis.

- Obstetric Care for Women with Opioid Use Disorder
    - Assess all pregnant women for substance use disorders (SUDs), screen and evaluate all pregnant women with opioid use disorder for commonly occurring comorbidities, and match treatment response to each woman's stage of recovery and/or readiness to change.
- Obstetric Hemorrhage
    - Assessment of hemorrhage risk (prenatal, on admission, and at other appropriate times), measurement of cumulative blood loss, and active management of the third stage of labor (department-wide protocol).
- Reduction of Peripartum Racial/Ethnic Disparities
    - Provide staff-wide education on implicit bias, provide convenient access to health records without delay, and establish a mechanism for patients, families, and staff to report inequitable care.
- Safe Reduction of Primary Cesarean Birth
    - Implement standardized admission criteria; triage management, education, and support for women presenting in spontaneous labor; offer standardized techniques of pain management and comfort measures; use standardized methods in the assessment of the fetal heart rate status; adopt protocols for timely identification of specific problems for patients who can benefit from proactive intervention before labor to reduce the risk for cesarean birth.
- Severe Hypertension in Pregnancy
    - Standard protocol for measurement and assessment of blood pressure and urine protein for all pregnant and postpartum women; standard response to maternal early warning signs including listening to and investigating patient symptoms and assessment of labs; and facility-wide standards for educating prenatal and postpartum women on signs and symptoms of hypertension and preeclampsia.[212]

While AIM bundles provide numerous guidelines for preparation, provision of quality care, and harm prevention, elements of the topics cross between inpatient and outpatient care and can be difficult to fully execute and measure. The Committee also expressed concern about inadequacy of bundle topics, specifically the bundle on Obstetric Care for Women with Opioid Use Disorder, which notably excludes other types of substance use disorders.

Postpartum Care

Postpartum standards of care begin immediately after delivery. Guidelines from ACOG suggest that the first postpartum visit take place between three to eight and no later than 12 weeks after delivery. Contact should be established no later than three weeks after delivery. Then, providers will conduct a physical, social, and psychological well-being exam and screen for postpartum depression, domestic violence, discuss contraception and birth spacing, review nutritional and exercise needs, discuss breastfeeding and diabetes if needed.[213] As at other times during the life course, when screening for depression and other mental health issues, providers should be prepared to either initiate therapy or refer patients to appropriate behavioral health services.[141] AIM patient safety bundles, as described above, also provide guidance on standards of postpartum care.

Alliance for Innovation on Maternal Health (AIM) Patient Safety Bundles

- Postpartum Care Basics for Maternal Safety: From Birth to the Comprehensive Postpartum Visit
    - Every woman is respected as the expert of her own needs, is empowered to trust her instinct and is encouraged to access care as early and frequently as needed in the weeks following birth. She is also encouraged to review her postpartum care plan with her provider prior to discharge from maternity care, revising as needed and attending a comprehensive postpartum visit.
    - Every clinical setting determines guidelines for patient education; discharge from inpatient maternity care; indications for early postpartum visits; coordination of ongoing care between inpatient and outpatient settings; screenings for and treatment of common morbidities, including mental health issues; and ensuring that each woman has identified a source of ongoing primary healthcare.
- Postpartum Care Basics for Maternal Safety: Transition from Maternity to Well-Woman Care
    - Every healthcare team obtains and documents a comprehensive personal and family health history; assesses if a woman of childbearing age presenting for care is currently breastfeeding or has been pregnant in the past year; formulates a reproductive health plan; engages the woman in discussions that support shared decision; screens for and treats common medical and behavioral health morbidities; and assesses ongoing medical issues, genetic conditions, chronic diseases, and recovery from birth.
    - Every woman treated knows how to access her maternity care and birth records to inform future healthcare for herself and her child. She reviews and revises, as needed, her interpregnancy plan of care with her healthcare provider and team and attends a subsequent well-woman visit, scheduled at an interval tailored to her needs.

Innovations in Measure Methodologies

Federal initiatives to drive quality improvement in maternal morbidity and mortality

There have been multiple federal initiatives implemented with the goal of driving improvement in maternal health outcomes; the majority of which are funded by HRSA or CDC. As the primary federal agency responsible for improving access to quality of care and services for those who are economically or medically vulnerable or geographically isolated, HRSA funds states and territories to run a variety of programs aimed at improving access to care for mothers and children, as well as reducing inequities in care delivery. CDC's Division of Reproductive Health focuses on improving reproductive, maternal, and infant health. Programs with a significant contribution to available data are described below. Table 5 in Appendix D provides a full list of federally funded programs with a focus on maternal health.

Title V Maternal and Child Health Services Block Grant Program

The Title V Maternal and Child Health Services Block Grant Program is a federal/state partnership under the prevue of HRSA, supports healthcare and public health services and systems to mothers, children, and their families in 59 states and jurisdictions. Program goals include improved access to quality healthcare, delivery of prenatal/postnatal care, and preventive/primary care for children, implementation of family-centered coordinated care for children with special healthcare needs, and health promotion efforts. The allocation of federal funding is determined in part based on the proportion of low-income children in a state versus nationally. In 2015, a three-tiered performance measure framework was introduced that holds a state accountable for demonstrated progress in

addressing its state-identified maternal and child health (MCH) priority needs. Of the 15 national performance measures included in this framework, four are related to women/maternal health.

- NPM 1: Well-Woman Visit
- NPM 2: Low-Risk Cesarean Delivery
- NPM 13.1: Preventive Dental Visit - Pregnancy
- NPM 14.1: Smoking - Pregnancy

Of the 25 national outcome measures, five relate specifically to maternal, prenatal, and/or postpartum health.

- NOM 1: Early Prenatal Care
- NOM 2: Severe Maternal Morbidity
- NOM 3: Maternal Mortality
- NOM 7: Early Elective Delivery
- NOM 24: Postpartum Depression

By law, states conduct a statewide needs assessment every five years. The highest MCH priority needs identified by a state inform the development of the state's five-year action plan.[214]

Alliance for Innovation on Maternal Health

As described above, AIM is a "national data-driven maternal safety and quality improvement initiative," under the purview for HRSA, that works with state-based teams to engage hospitals and health systems in improving maternal outcomes across the country. Hospitals in participating states may choose to align with AIM in order to access eight maternal safety bundles designed to identify appropriate and timely responses that healthcare teams can take in response to maternal complications. Each state enrolled in AIM chooses which maternal safety bundle(s) to adopt within their participating hospital and, by collecting and submitting data, grow their abilities to benchmark their performance and record improvement. As of April 2020, there are 33 states enrolled in AIM and approximately 1,400 hospitals participating in the implementation of maternal safety bundles. Each of the states is in various phases of the implementation process, with 22 states implementing the bundle on Obstetric Hemorrhage, 15 implementing the bundle on Severe Hypertension in Pregnancy, seven implementing the bundle on Obstetric Care for Women with Opioid Use Disorder, and four implementing the bundle on the Safe Reduction of Primary Cesarean Birth.[29]

Enhancing Reviews and Surveillance to Eliminate Maternal Mortality

CDC has made 24 awards, funding 25 states and cities under the Enhancing Reviews and Surveillance to Eliminate Maternal Mortality (ERASE MM) Program. This program supports the coordination and management of MMRCs—state and local multistakeholder committees that review women's deaths during or within a year of pregnancy to determine which deaths are pregnancy-related. These committees look to specifically answer the following questions: 1) Was the death pregnancy-related? 2) What was the underlying cause of death? 3) Was the death preventable? 4) What were the factors that contributed to the death? 5) What are the recommendations and actions that address those contributing factors? 6) What is the anticipated impact of those actions if implemented?

Many states release annual reports to describe their trends in maternal mortality data and suggest policy initiatives to reduce maternal mortality; though states with smaller data sets may wait and combine several years of data before producing a report. The reports typically point to existing programs that engage in quality improvement and/or measurement that are run by the state as a means to address issues identified within the report. However, states' reports are quite varied in what they choose to report and how they report it. In some cases, the MMRC recommends programs that are still under development or do not yet exist and recommends their development for use by the state. In other cases, the MMRC recommends programs that already exist but need additional attention or promotion to reach the intended population. The CDC's Maternal Mortality Review Information Application (MMRIA) was developed as a reporting tool and repository to standardize the collection of data about women's lives and deaths to facilitate review by MMRCs. The purposes of the standardization are the following: 1) to create a repository of similarly collected and defined abstracted data to aid in individual state case review; and 2) to have a standardized data set for states to share data with the CDC in order to improve understanding of the factors leading to pregnancy-related deaths; identify deaths that may have been preventable; and identify the multilevel changes that need to be implemented to prevent future deaths.

Perinatal Quality Collaboratives

Perinatal Quality Collaboratives (PQCs) are state or multistate networks that identify processes integral to maternal and infant health that should be improved, and work to implement changes that enhance quality of care. While many states have a PQC, or are in the process of developing one, CDC currently only funds 13 states to improve perinatal care quality, including reduction in racial ethnic disparities, geographic disparities, cesarean births for low-risk pregnancies, and severe pregnancy complications from hemorrhage and high blood pressure. As an increasing number of states implement PQCs by receiving funding and technical assistance, CDC and the National Institute for Children's Health Quality have collaborated to form a National Network of Perinatal Quality Collaboratives (NNPQC). This collaborative assists states in developing PQCs and making measurable improvements to these and other maternal and neonatal health outcomes.

CDC Levels of Care Assessment Tool

The CDC Levels of Care Assessment Tool (CDC LOCATe) is designed to help standardize definitions and thresholds used in monitoring levels of care nationwide, in order to systematize the assessment of maternal and neonatal levels of care. The standardized data collected using this tool allows for a clearer understanding of opportunities to strengthen systems of maternal and neonatal care. CDC LOCATe data is used by a variety of public health and clinical care stakeholders at state and local levels, including PQCs.

Pregnancy Risk Assessment Monitoring System

The Pregnancy Risk Assessment Monitoring System (PRAMS) is a collaborative surveillance system between the CDC and state health departments to collect data on maternal attitudes at all stages of pregnancy in order to review the impact of current policies and programming and to identify current issues, thereby providing the data support to act to reduce adverse outcomes. The original PRAMS questionnaire, known as Phase 1, was developed and implemented in 1987. The most recent questionnaire, revised and implemented in 2016, is Phase 8. PRAMS questionnaires are randomly sent to women who have recently given birth, and address items such as frequency of prenatal and postnatal care, quality of prenatal care, preexisting conditions, and certain behavioral and lifestyle characteristics

of both mother and partner. The core PRAMS questionnaire contains 52 questions, including demographic questions, though some respondents would answer fewer questions due to skip logic. In addition to the core questionnaire, states have the option to choose from an additional 200 standard questions, which include SDOH and other indicators of interest, as well as to create their own additional state-specific questions. The questionnaires are currently available in English and Spanish.

Current core PRAMS questions that address morbidities include the following:

- During your most recent pregnancy, did you have any of the following health conditions? (Yes responses include gestational diabetes (diabetes that started during this pregnancy), high blood pressure (that started during this pregnancy), preeclampsia or eclampsia, depression, or other state-added options.)
- In the 12 months before you got pregnant with your new baby, did any of the following people push, hit, slap, kick, choke, or physically hurt you in any other way? (Yes responses include "my husband or partner," "my ex-husband or ex-partner," another family member, someone else.)
- During your most recent pregnancy, did any of the following people push, hit, slap, kick, choke, or physically hurt you in any other way? (Yes responses include "my husband or partner," "my ex-husband or ex-partner," another family member, someone else.)
- Since your new baby was born, how often have you felt down, depressed, or hopeless? (Response options are: always, often, sometimes, rarely, never.)
- Since your new baby was born, how often have you had little interest or little pleasure in doing things you usually enjoyed? (Response options are: always, often, sometimes, rarely, never.)

State and Regional Initiatives to Drive Quality Improvement in Maternal Morbidity and Mortality

Many state initiatives are supported by federal funding from the programs described above. The AIM, PQC, and MMRC initiatives in each state are vital to understanding maternal morbidity and mortality in these states, and to developing measurement and quality initiatives to address the issues described above. By the end of 2019, 46 states, territories, and districts had established MMRCs, or partnered with another state for maternal mortality review. Forty states had established PQCs, 13 of which receive funding from the CDC's Division of Reproductive Health.[215] Only half of states, districts, and territories have implemented AIM initiatives.

Although we cannot explore all state and regional initiatives relevant to maternal morbidity and mortality measurement and quality improvement here, we have highlighted a few select programs that focus on different stages of a woman's life course from the perspective of pregnancy. These are preconception care, prenatal care, labor and delivery care, and puerperium and postnatal care.

Preconception Initiatives

HRSA funds the Preconception Collaborative Improvement and Innovation Network (CoIIN), a project led by the University of North Carolina-Chapel Hill that is a part of the broader Infant Mortality CoIIN initiative. In its third and final year, this project facilitates the development of women-centered, clinician-engaged, and community-involved approaches to the well-woman visit in order to improve the preconception health status of women of reproductive age, particularly low-income women and women of color. The Preconception CoIIN specifically works with teams in California, Delaware, North Carolina, and Oklahoma to improve knowledge, attitudes, and behaviors around preconception health and to

support providers in implementing preconception health screening during the well-woman visit and in providing quality preconception care.

Preconception health refers to the health of women and men during their reproductive years, which are the years they can have a child.[216] It focuses on taking steps now to protect the health of a baby they might have sometime in the future. The health status of a woman prior to pregnancy has a large impact on the health of her pregnancy and her risk of developing complications.

Preconception healthcare is the medical care a person receives from the doctor or other health professionals that focuses on the parts of health that have been shown to increase the chance of having a healthy baby. Ensuring all women are healthy and receive quality care is important because almost half (48 percent) of pregnancies in the United States are unplanned and therefore at risk of adverse outcomes. A separate environmental scan of preconception screening tools and interventions revealed that very few have been rigorously evaluated or tested.[216] More research is needed to specify a definition of "quality preconception care," but validated screening tools that identify risk factors and programs designed to address those risks are essential.[216]

Not only is the quality of preconception care vital, but research has also indicated that improved access is also required in order to reduce health inequities. The New York City Department of Health and Mental Hygiene released a comprehensive report on SMM in the city between 2008-2012. The report contains several recommendations for reducing SMM, one of which is to improve the overall health of women.[217] Preconception care is one component of monitoring and, if needed, improving the health of women prior to pregnancy or between pregnancies as recommended by the New York City report.

Prenatal Initiatives

There are very few measures to indicate quality prenatal care in the United States. The Center for Medicaid and CHIP Services (CMCS) uses measures of timeliness of prenatal care. The most frequently cited tools are the Kotelchuck Index and the Kessner Index, both of which measure adequacy through the timing and number of prenatal visits, though the Kessner Index is no longer in widespread use. There is no widespread measurement of additional detail about the content and quality of visits.

The CenteringPregnancy program was developed by the Centering Healthcare Institute and seeks to disseminate more detailed guidance on quality prenatal care while using an innovative group care model. Since 2017, South Carolina's Medicaid program has provided coverage for these services. With site approval run by the Centering Healthcare Institute, quality assurance is partly achieved through a certification system. Providers must become certified by the institute and are then able to deliver CenteringPregnancy programming. An evaluation of the impacts of using Medicaid dollars to pay for CenteringPregnancy in South Carolina to improve maternal morbidity and mortality is ongoing. Most studies that are currently available assess birth outcomes, such as percentage of preterm birth, NICU admissions, and low-birthweight births. While there are no metrics exclusively related to maternal morbidity or mortality, it would be possible to monitor for SMM in South Carolina women who participated in CenteringPregnancy versus those who did not, based on Medicaid claims data.

Labor and Delivery Initiatives

The majority of programming designed to measure and reduce maternal morbidity and mortality is centered on labor and delivery. In addition to the AIM bundles detailed above, one of the most often

cited initiatives is the CMQCC. Many states look to this initiative in order to determine the best course of action for reducing maternal morbidity and mortality in their populations. Of particular note are the CMQCC quality improvement toolkits, which present best practices and guidelines for reducing preventable deaths in California hospitals. Toolkits have been developed to address substance exposure, maternal sepsis, maternal venous thromboembolism, responses to cardiovascular disease, reducing primary cesareans, responses to obstetric hemorrhage, responses to preeclampsia, and eliminating elective deliveries prior to 39 weeks gestational age. Hospitals and other states look to the CMQCC for guidance on improving the quality of maternity care, especially during birthing procedures. For example, Iowa's most recent MMRC report evaluated programmatic changes to help improve care quality for mothers and suggested that hospitals in the state begin implementing CMQCC's Cardiovascular Disease Toolkit.

ACNM has developed and runs the Healthy Birth Initiative: Reducing Primary Cesareans Project. Its aim is to encourage system changes at the hospital and provider levels to reduce the incidence of primary cesarean sections. The program includes a learning collaborative where ACNM helps hospitals implement one of several care models, support systems change, track data and maintain a registry, and promote continuing education.[218]

Other states have programs that seek to implement recommendations from federal programs. For example, the Alaska PQC has initiated a program called the Alaska AIM Hypertension Initiative. This program seeks to measurably reduce hypertension-related severe maternal morbidity through use of one of AIM's safety bundles. The program will be integrated into hospital and birthing facilities within Alaska, following a collaborative quality improvement model of implementation. Hospitals and the Alaska PQC will work together to review data and best practices for reducing severe maternal hypertension.

Puerperium and Postnatal Initiatives

Programming in this stage of maternal care is wide and varied but does not often involve explicit measurement of maternal morbidity and mortality. For example, some states offer home visiting programs to help parents adjust to postpartum life with a newborn, many of which are supported through the Maternal, Infant, and Early Childhood Home Visiting (MIECHV) program. These programs have the potential for improving maternal morbidity measurement as home visitors interact one-on-one with mothers, their newborns, and potentially their partners, and can gather data at these visits. However, there are no state programs utilizing this method that have been evaluated rigorously.

Other postnatal programming includes new legislation from the state of Louisiana. In 2018, the state implemented legislation to create a pilot project to improve outcomes associated with Neonatal Opioid Withdrawal Syndrome. Although the program's rationale focuses on infant health, provision of medication-assisted treatment for mothers and a trauma-informed approach to care highlight that it seeks to improve maternal morbidity and mortality rates associated with opioid use disorder. Results of the pilot have not yet been compiled, but the creation of this legislation, which seeks to improve the quality of care for women experiencing substance use, is highlighted here because it is an additional technique that states can use to address and reduce maternal morbidity and mortality outcomes. In a similar vein, Illinois has identified prescription monitoring programs as a powerful tool in improving the care of mothers with substance use disorders. These measurement programs offer tools to improve care

coordination and identify past opiate prescriptions or drug-seeking behaviors associated with substance use disorder, so they are extremely relevant to providing quality maternal care.

Environmental Scan Findings

NQF distinguishes between a measure and a measure concept. A **measure** is defined as a fully developed metric that includes detailed specifications and may have undergone scientific testing. A fully developed measure identifies what should happen (what is being measured), who should be measured (population), where measurement should happen (setting), when it should happen (time), and how it should occur. It is important to note that the Committee is not recommending specific measures for immediate implementation and use. A **measure concept** is an idea for a measure that includes a description of the measure, ideally including a planned target and population.

NQF endorsement is achieved through a multi-month review process using committees of subject matter and measure methodology experts that also involves the measure's developers. Final endorsement status of a proposed measure is ultimately determined by the NQF Consensus Standards Approval Committee. Endorsement is valid for three years, after which time a measure must be resubmitted with updated data for full review.

A measure can lose endorsement for a number of reasons. The evidence supporting the measure may have changed, new testing data provided may no longer support the reliability or validity of the measure, or the measure steward may no longer be interested in maintaining the measure's endorsement, among others. For the purposes of this scan, NQF has investigated the general circumstances around why a measure may have lost endorsement. During subsequent work to create the measure frameworks, if the Committee identifies those measures which are no longer-endorsed, yet still critical to improving measurement and maternal health outcomes, NQF will conduct detailed investigations into those measures.

The Committee discussed appropriate subdomains by which to categorize measures of maternal morbidity and mortality, measure concepts, and identify gaps. Four subdomains were identified that capture both the stages of pregnancy and delivery, and also reflect the need for quality measurement throughout the life cycle: preconception, prenatal, labor and delivery, and postpartum.

Existing Measures of Maternal Morbidity and Mortality

Maternal Morbidity

NQF performed a search of existing databases that are common for identifying measures for quality improvement and reviewed major accountability programs to compile a list of quality measures currently in use and currently or previously endorsed by NQF (see Table 1). Identified measures were categorized into four subdomains: preconception, prenatal, labor and delivery, and postpartum. Of the 27 total measures identified, only six currently carry NQF endorsement. Of the nine measures that are no longer endorsed by NQF, seven of them were withdrawn by the developer during their maintenance of endorsement, and two of them did not pass NQF's Evidence criteria during their maintenance of endorsement. A complete list of measures can be found in Appendix B.

The Committee identified three preconception measures that focus on contraceptive use and well visits, and eight prenatal measures that focus largely on the timing and frequency of prenatal visits as well as

screening for certain behaviors and conditions. Of the prenatal measures, five were previously endorsed by NQF but no longer hold endorsement.

Nine measures were identified relating to labor and delivery, and five measures were identified relating to the postpartum period. These measures focused on maternal depression, postpartum visits to a clinician, and contraceptive use.

Maternal Mortality

The scan of existing measures only revealed two current measures of maternal mortality: from the National Vital Statistics System (maternal mortality rate per 100,000 live births), and from the CDC PMSS (pregnancy-related maternal mortality ratio per 100,000 live births).

Table 1. Summary of Maternal Morbidity and Mortality Measure Database Scan Results*

	Database		
Search Term	**QPS**	**CMIT**	**QCRD**
Maternal	88	18	0
Maternal Morbidity	0	76	0
Maternal Mortality	0	171	0
Pregnancy	63	71	2
Perinatal	63	13	0

**Number of measures identified by search term and database are not mutually exclusive. For the list of measures that have been vetted, with duplicates removed, please see Appendix B.*

Measure Concepts and Gaps in Maternal Morbidity and Mortality Measurement

During web meetings, the Committee also identified important measure concepts that do not yet have associated measures. These are measures that may be under development or evaluation, or they may be ideas for future development. A full list of identified measure concepts can be found in Appendix B, Table 2 and Appendix C, Table 4. Given the dearth of existing measures, measure concepts are particularly important for improving maternal morbidity and mortality measurement and outcomes. Reports from MMRCs, PQCs, and departments of public health also often pointed to gaps in measurement and the ability to measure. Needed measure concepts and gaps in measurement discussed by the Committee are discussed below.

Maternal Morbidity

Measures of maternal prenatal and postnatal care often only gather the number of visits and the timing of visits. However, it is also important to know what is happening inside the birth facility and at the bedside in order to assess quality of care. Measures must also assess care that takes place before a woman is admitted to the hospital for delivery, during delivery, after discharge, and outside in her

community. Measures of respectful maternal care and use of care coordination could add to the existing indices of prenatal care to improve measurement of maternal morbidities.

The Committee highlighted gaps in provider education, specifically on cultural competency, principles of antiracist care, implicit bias, addressing the needs of the lesbian, gay, bisexual, transgender, and queer or questioning community, and postpartum mood disorders including PTSD. Measures to collect information on maternal mental health, maternal substance use, provider education and competencies, evidence of domestic violence, and other measures beyond the hospital are also lacking and would have an impact on addressing and potentially reducing these maternal morbidities.

Maternal Mortality

Maternal mortality that takes place during delivery or at a hospital can be reliably captured, but this scan has identified some issues, detailed above, with capturing maternal mortality outside of the hospital. This scan has also identified practices that are meant to reduce incidence of maternal mortality, such as topic-specific toolkits that lay out best practices, and the Committee has suggested using these existing tools to enhance measurement in this area.

Although The Joint Commission currently monitors mortality through the sentinel event process and is working to develop measures that identify whether prevention of SMM efforts are in place to reduce mortality,[211] it does not yet measure how often these prevention of SMM protocols are implemented consistently. Measuring protocol adherence is important for improving quality of care, and the Committee suggested exploring measurement of adherence to The Joint Commission and other protocols and measurement of the reasons for nonadherence to those protocols. The Committee felt that, although they were developed as a quality improvement resource, the Patient Safety Bundles are a potential measurement source. However, there are gaps in the collection of data on influencing factors, such as implicit bias and racism. The Committee noted that these bundles are helpful for measurement; however, collection does not happen consistently across facilities. The maternal safety bundles outcome and process metrics are not easy to analyze as a whole and require tremendous resources from the healthcare organization. Quality measures designed to collect this data could promote the use of safety bundles.

Additional considerations for stratification of measures by race and ethnicity must also be discussed in all measure concepts. This information has regularly been unavailable from the majority of data sources used in measure development and is reported to be inconsistently collected across hospitals and health systems. Reports that self-reported race/ethnicity questions are often not completed on patient surveys suggests that the medical community may need to consider additional ways to encourage capture of this information. Any new data sources created to aid in measurement must also prioritize obtaining this information. Finally, the Committee also recommended measures to examine the financial impacts of maternal mortality, as maternal mortality adds many costs to health systems, insurers, and individuals and their families.

Next Steps

Findings from this report and subsequent conversations with the Maternal Morbidity and Mortality Committee will contribute to the development of two measurement frameworks and a recommendations report on maternal morbidity and mortality measurement in the U.S. These

measurement frameworks will be roadmaps for how to use performance measurement to reduce maternal morbidity and mortality and improve outcomes. Frameworks are conceptual models that will help identify what is important to measure in the topic area, how measurement should take place, whose performance should be measured, the types of care settings in which measurement is needed, when measurement should occur, and which organizations or individuals should be included. Frameworks are also a structure for organizing existing measures, identifying gaps in measurement, and prioritizing future measurement development needs.

The two measurement frameworks developed to address maternal morbidity and maternal mortality will be included in the final recommendations report. The recommendations report will analyze, synthesize, and integrate recommendations of specific long- and short-term approaches to maternal morbidity and mortality measurement, including the following:

- How to use measurement to improve outcomes
- Innovative actionable approaches to improving measurement
- How measures may be used across disparate state systems
- How measures may be risk-adjusted for national comparisons

Short-term approaches should enhance current outcomes, and long-term approaches will consider a five-year time frame. The final recommendations report will be completed and released by fall 2021.

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Appendices

Appendix A: Committee Members, Federal Liaisons, and NQF Staff

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Appendix B: Maternal Morbidity Measure Array

Table 1: Maternal Morbidity Measures

(Available measure information varied by database.)

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
0024	Weight Assessment and Counseling for Nutrition and Physical Activity for Children/Adolescents (WCC-CH)	Percentage of patients three to 17 years of age who had an outpatient visit with a primary care physician (PCP) or an OB/GYN and who had evidence of the following during the measurement year: - Body mass index (BMI) percentile documentation - Counseling for nutrition - Counseling for physical activity	Preconception
NQF 2903	Contraceptive Care – Most and Moderately Effective Methods	The percentage of women aged 15-44 years at risk of unintended pregnancy that is provided a most effective (i.e., sterilization, implants, intrauterine devices or systems (IUD/IUS)) or moderately effective (i.e., injectables, oral pills, patch, ring, or diaphragm) method of contraception.	Preconception
NQF 2904	Contraceptive Care – Access to LARC	Percentage of women aged 15-44 years at risk of unintended pregnancy that is provided a long-acting reversible method of contraception (i.e., implants, intrauterine devices or systems (IUD/IUS).	Preconception
Behavioral Risk Factor Surveillance System	Well-Woman Visit	Percent of women, ages 18 through 44, with a preventive medical visit in the past year	Preconception
Medicaid	Adolescent Well-Care Visits (AWC-CH)	Intermediate Outcome	Preconception
Medicare Part C Star Rating, Marketplace	Adult BMI Assessment	Process	Preconception

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
Quality Rating System (QRS), Medicaid			
0032	Cervical Cancer Screening (CCS)	Percentage of women 21–64 years of age who were screened for cervical cancer using either of the following criteria: - Women age 21–64 who had cervical cytology performed every three years. - Women ages 30–64 who had cervical cytology/human papillomavirus (HPV) co-testing performed every five years.	Preconception
0033	Chlamydia Screening in Women (CHL)	The percentage of women 16–24 years of age who were identified as sexually active and who had at least one test for chlamydia during the measurement year.	Preconception
0575	Comprehensive Diabetes Care: Hemoglobin A1c (HbA1c) Control (<8.0%)	The percentage of patients 18-75 years of age with diabetes (type 1 and type 2) whose most recent HbA1c level is <8.0% during the measurement year.	Preconception
0018	Controlling High Blood Pressure	The percentage of patients 18 to 85 years of age who had a diagnosis of hypertension (HTN) and whose blood pressure (BP) was adequately controlled (<140/90) during the measurement year.	Preconception
0059	Diabetes Care Blood Sugar Controlled	The percentage of patients 18-75 years of age with diabetes (type 1 and type 2) whose most recent HbA1c level during the measurement year was greater than 9.0% (poor control) or was missing a result, or if an HbA1c test was not done during the measurement year.	Preconception

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
2607	Diabetes Care for People with Serious Mental Illness: Hemoglobin A1c (HbA1c) Poor Control (>9.0%) (HPCMI-AD)	The percentage of patients 18-75 years of age with a serious mental illness and diabetes (type 1 and type 2) whose most recent HbA1c level during the measurement year is >9.0%.	Preconception
1814 (No Longer Endorsed)	Epilepsy: Counseling for Women of Childbearing Potential with Epilepsy	All female patients of childbearing potential (12–44 years old) diagnosed with epilepsy who were counseled or referred for counseling for how epilepsy and its treatment may affect contraception OR pregnancy at least once a year.	Preconception
1659	Influenza Immunization	Inpatients ages six months and older discharged during October, November, December, January, February, or March who are screened for influenza vaccine status and vaccinated prior to discharge if indicated.	Preconception
0522 (No Longer Endorsed)	Influenza Immunization Received for Current Flu Season	Percentage of home health episodes of care during which patients received influenza immunization for the current flu season.	Preconception
0421/0421e	Preventive Care and Screening: Body Mass Index (BMI) Screening and Follow-Up Plan	Percentage of patients aged 18 years and older with a BMI documented during the current encounter or during the previous twelve months AND with a BMI outside of normal parameters, a follow-up plan is documented during the encounter or during the previous twelve months of the current encounter	Preconception
0041/0041e	Preventive Care and Screening: Influenza Immunization	Percentage of patients aged six months and older seen for a visit between October 1 and March 31 who received an influenza immunization OR who reported	Preconception

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		previous receipt of an influenza immunization	
0418/0418e	Preventive Care and Screening: Screening for Depression and Follow-Up Plan	Percentage of patients aged 12 years and older screened for depression on the date of the encounter or 14 days prior to the date of the encounter using an age appropriate standardized depression screening tool AND if positive, a follow-up plan is documented on the date of the eligible encounter	Preconception
MIPS Program	Preventive Care and Screening: Screening for High Blood Pressure and Follow-Up Documented	Process	Preconception
Medicaid Promoting Interoperability Program for Eligible Professionals, MIPS Program	Preventive Care and Screening: Screening for High Blood Pressure and Follow-Up Documented (eCQM)	Process	Preconception
1406	Risky Behavior Assessment or Counseling by Age 13 Years	The percentage of children with documentation of a risk assessment or counseling for risky behaviors by 13 years of age. Four rates are reported: Risk Assessment or Counseling for Alcohol Use, Risk Assessment or Counseling for Tobacco Use, Risk Assessment or Counseling for Other Substance Use, Risk Assessment or Counseling for Sexual Activity.	Preconception
1507	Risky Behavior Assessment or Counseling by Age 18 Years	The percentage of adolescents with documentation of assessment or counseling for risky behavior by the age of 18 years. Four rates are reported: Risk Assessment or Counseling for Alcohol Use, Risk Assessment	Preconception

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		or Counseling for Tobacco Use, Risk Assessment or Counseling for Other Substance Use, and Risk Assessment or Counseling for Sexual Activity.	
MIPS Program	Non-Recommended Cervical Cancer Screening in Adolescent Females	Process	Preconception
0502	Pregnancy test for female abdominal pain patients.	Percentage of female patients aged 14 to 50 who present to the emergency department (ED) with a chief complaint of abdominal pain for whom a pregnancy test ordered	Preconception
0476	PC-03 Antenatal Steroids	This measure assesses patients at risk of preterm delivery at >=24 and <34 weeks gestation receiving antenatal steroids prior to delivering preterm newborns. This measure is a part of a set of five nationally implemented measures that address perinatal care (PC-01: Elective Delivery, PC-02: Cesarean Birth, PC-04: Health Care-Associated Bloodstream Infections in Newborns, PC-05: Exclusive Breast Milk Feeding; Beginning 1/1/2019 PC-06 Unexpected Complications in Term Newborns will be added).	Prenatal
0608	Pregnant women that had HBsAg testing.	This measure identifies pregnant women who had a HBsAg (hepatitis B) test during their pregnancy.	Prenatal
0606	Pregnant women that had HIV testing.	This measure identifies pregnant women who had an HIV test during their pregnancy.	Prenatal

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
0607	Pregnant women that had syphilis screening.	This measure identifies pregnant women who had a syphilis test during their pregnancy.	Prenatal
0016	Prenatal Blood Group Antibody Testing	Percentage of patients who gave birth during a 12-month period who were screened for blood group antibodies during the first or second prenatal care visit.	Prenatal
0015	Prenatal Blood Groups (ABO), D (Rh) Type	Percentage of patients who gave birth during a 12-month period who had a determination of blood group (ABO) and D (Rh) type by the second prenatal care visit.	Prenatal
Medicaid	Behavioral Health Risk Assessment (for Pregnant Women) (BHRA-CH) - Maternal Care	Patient Reported Outcome	Prenatal
0651	Ultrasound determination of pregnancy location for pregnant patients with abdominal pain	Percentage of pregnant patients who present to the ED with a chief complaint of abdominal pain and or vaginal bleeding who receive a trans-abdominal or trans-vaginal ultrasound.	Prenatal
NQF 0582 (No Longer Endorsed)	Diabetes and Pregnancy: Avoidance of Oral Hypoglycemic Agents	This measure identifies pregnant women with diabetes who are not taking an oral hypoglycemic agent.	Prenatal
NQF 1391 (No Longer Endorsed)	Frequency of Ongoing Prenatal Care (FPC)	The percentage of Medicaid deliveries that had the following number of expected prenatal visits: • less than 21 percent of expected visits. • 21 percent–40 percent of expected visits. • 41 percent–60 percent of expected visits. • 61 percent–80 percent of expected visits.	Prenatal

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		• greater than or equal to 81 percent of expected visits.	
NQF 0014 (No Longer Endorsed)	Prenatal Anti-D Immune Globulin	Percentage of D-negative, unsensitized patients who gave birth during a 12-month period who received anti-D immune globulin at 26-30 weeks gestation.	Prenatal
NQF 0012 (No Longer Endorsed)	Prenatal Screening for Human Immunodeficiency Virus (HIV)	Percentage of patients who gave birth during a 12-month period who were screened for HIV infection during the first or second prenatal care visit.	Prenatal
National Vital Statistics System	Early Prenatal Care	Percentage of pregnant women who receive prenatal care beginning in the first trimester	Prenatal
Pregnancy Risk Assessment Monitoring System	Preventive Dental Visit – Pregnancy	Percent of women who had a preventive dental visit during pregnancy	Prenatal
National Vital Statistics System	Smoking – Pregnancy	Percent of women who smoke during pregnancy	Prenatal
Medicare Part C Star Rating	Statin Therapy for Patients with Cardiovascular Disease	Process	Prenatal
National Vital Statistics System	Low-Risk Cesarean Deliveries	Percent of cesarean deliveries among low-risk first births	Labor & Delivery
HCUP – State Inpatient Databases	Severe Maternal Morbidity	Rate of severe maternal morbidity per 10,000 delivery hospitalizations	Labor & Delivery
CMS Hospital Compare	Early Elective Delivery	Percent of non-medically indicated early elective deliveries	Labor & Delivery
NQF 0652 (No Longer Endorsed)	Rh immunoglobulin (Rhogam) for Rh negative	Percent of Rh-negative pregnant women aged 14-50 years at risk of fetal blood exposure who	Labor & Delivery

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
	pregnant women at risk of fetal blood exposure.	receive Rh-Immunoglobulin in the emergency department.	
NQF 0471	PC-02: Cesarean Birth (PC02-CH)	Percentage of nulliparous women with a term, singleton baby in a vertex position delivered by cesarean birth (C-section)	Labor & Delivery
NQF 0470	Incidence of Episiotomy	Percentage of vaginal deliveries (excluding those coded with shoulder dystocia) during which an episiotomy is performed.	Labor & Delivery
NQF 0473 (No Longer Endorsed)	Appropriate DVT prophylaxis in women undergoing cesarean delivery	Current ACOG and SMFM recommendations call for the use of pneumatic compression devices in all women undergoing cesarean delivery who are not already receiving medical VTE prophylaxis.	Labor & Delivery
NQF 0472 (No Longer Endorsed)	Appropriate Prophylactic Antibiotic Received Within One Hour Prior to Surgical Incision – Cesarean section.	Percentage of patients undergoing cesarean section who receive appropriate prophylactic antibiotics within 60 minutes of the start of the cesarean delivery, unless the patient is already receiving appropriate antibiotics	Labor & Delivery
NQF 0469/0469e	PC-01: Elective Delivery (PC01-AD)	This measure assesses patients with elective vaginal deliveries or elective cesarean births at >= 37 and < 39 weeks of gestation completed.	Labor & Delivery
NQF 1746 (No Longer Endorsed)	Intrapartum Antibiotic Prophylaxis for Group B Streptococcus (GBS)	Percentage of pregnant women who are eligible for and receive appropriate intrapartum antibiotic prophylaxis (IAP) for GBS	Labor & Delivery
2726	Prevention of Central Venous Catheter (CVC)-	Percentage of patients, regardless of age, who undergo central venous catheter (CVC) insertion for whom CVC was	Labor & Delivery

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
	Related Bloodstream Infections	inserted with all elements of maximal sterile barrier technique, hand hygiene, skin preparation and, if ultrasound is used, sterile ultrasound techniques followed	
0500	Severe Sepsis and Septic Shock: Management Bundle (Composite Measure)	This measure focuses on adults 18 years and older with a diagnosis of severe sepsis or septic shock.	Labor & Delivery
0333	Severity-Standardized ALOS - Deliveries	Standardized ALOS for deliveries	Labor & Delivery
0269	Timing of Prophylactic Antibiotics - Administering Physician	Percentage of surgical patients aged 18 years and older who receive an anesthetic when undergoing procedures with the indications for prophylactic parenteral antibiotics for whom administration of a prophylactic parenteral antibiotic ordered has been initiated within one hour (if fluoroquinolone or vancomycin, two hours) prior to the surgical incision (or start of procedure when no incision is required)	Labor & Delivery
0349	Transfusion Reaction Count (PSI 16)	The number of medical and surgical discharges with a secondary diagnosis of transfusion reaction for patients ages 18 years and older or obstetric patients. Excludes cases with a principal diagnosis of transfusion reaction or cases with a secondary diagnosis of transfusion reaction that is present on admission.	Labor & Delivery
0345	Unrecognized Abdominopelvic Accidental Puncture or Laceration Rate	Accidental punctures or lacerations (secondary diagnosis) during a procedure of the abdomen or pelvis per 1,000 discharges for patients ages 18 years and older that require a	Labor & Delivery

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		second abdominopelvic procedure one or more days after the index procedure	
0366	Pancreatic Resection Volume (IQI 2)	The number of hospital discharges with a procedure of partial or total pancreatic resection for patients 18 years and older or obstetric patients. Excludes acute pancreatitis admissions.	Labor & Delivery
0361	Esophageal Resection Volume (IQI 1)	Number of discharges with a procedure for esophageal resection	Labor & Delivery
0351	Death Rate among Surgical Inpatients with Serious Treatable Complications (PSI 04)	In-hospital deaths per 1,000 surgical discharges, among patients ages 18 through 89 years or obstetric patients, with serious treatable complications (shock/cardiac arrest, sepsis, pneumonia, deep vein thrombosis/ pulmonary embolism or gastrointestinal hemorrhage/acute ulcer). Includes metrics for the number of discharges for each type of complication. Excludes cases transferred to an acute care facility. A risk-adjusted rate is available. The risk-adjusted rate of PSI 04 relies on stratum-specific risk models. The stratum-specific models are combined to calculate an overall risk-adjusted rate.	Labor & Delivery
0357	Abdominal Aortic Aneurysm (AAA) Repair Volume (IQI 4)	The number of hospital discharges with a procedure for abdominal aortic aneurysm (AAA) repair for patients 18 years and older or obstetric patients. Includes optional metrics for the number of	Labor & Delivery

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		discharges grouped by rupture status and procedure type.	
0347	Death Rate in Low-Mortality Diagnosis Related Groups (PSI02)	In-hospital deaths per 1,000 discharges for low mortality (< 0.5%) Diagnosis Related Groups (DRGs) among patients ages 18 years and older or obstetric patients. Excludes cases with trauma, cases with cancer, cases with an immunocompromised state, and transfers to an acute care facility. [NOTE: The software provides the rate per hospital discharge. However, common practice reports the measure as per 1,000 discharges. The user must multiply the rate obtained from the software by 1,000 to report in-hospital deaths per 1,000 hospital discharges.]	Labor & Delivery
MIPS Program	Maternity Care: Elective Delivery or Early Induction Without Medical Indication at < 39 Weeks (Overuse)	Outcome	Labor & Delivery
0138	National Healthcare Safety Network (NHSN) Catheter-associated Urinary Tract Infection (CAUTI) Outcome Measure	Standardized Infection Ratio (SIR) of healthcare-associated, catheter-associated urinary tract infections (UTI) will be calculated among patients in bedded inpatient care locations, except level II or level III neonatal intensive care units (NICU). This includes acute care general hospitals, long-term acute care hospitals, rehabilitation hospitals, oncology hospitals, and behavior health hospitals.	Labor & Delivery
0139	National Healthcare Safety Network (NHSN) Central line-associated Bloodstream	Standardized Infection Ratio (SIR) and Adjusted Ranking Metric (ARM) of healthcare-associated, central line-	Labor & Delivery

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
	Infection (CLABSI) Outcome Measure	associated bloodstream infections (CLABSI) will be calculated among patients in bedded inpatient care locations. This includes acute care general hospitals, long-term acute care hospitals, rehabilitation hospitals, oncology hospitals, and behavioral health hospitals.	
0450	Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate (PSI 12)	Perioperative pulmonary embolism or proximal deep vein thrombosis (secondary diagnosis) per 1,000 surgical discharges for patients ages 18 years and older.	Labor & Delivery
2681	Perioperative Temperature Management	Percentage of patients, regardless of age, who undergo surgical or therapeutic procedures under general or neuraxial anesthesia of 60 minutes duration or longer for whom at least one body temperature greater than or equal to 35.5 degrees Celsius (or 95.9 degrees Fahrenheit) was achieved within the 30 minutes immediately before or the 15 minutes immediately after anesthesia end time	Labor & Delivery
MIPS Program	Proportion of Patients Sustaining a Bladder Injury at the Time of any Pelvic Organ Prolapse Repair	Outcome	Labor & Delivery
MIPS Program	Proportion of Patients Sustaining a Bowel Injury at the time of any Pelvic Organ Prolapse Repair	Outcome	Labor & Delivery
1523	Rate of Open Repair of Abdominal Aortic Aneurysms (AAA) Where	Percentage of asymptomatic patients undergoing open repair of abdominal aortic aneurysms (AAA)who are discharged alive. This measure is proposed for	Labor & Delivery

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
	Patients Are Discharged Alive	both hospitals and individual providers. At present, this measure is reported via the Vascular Quality Initiative (VQI) Registry.	
NQF 2902	Contraceptive Care – Postpartum Women Ages 15-44 (CCP-AD)	Among women ages 15 through 44 who had a live birth, the percentage that is provided: 1) A most effective (i.e., sterilization, implants, intrauterine devices or systems (IUD/IUS)) or moderately (i.e., injectables, oral pills, patch, ring, or diaphragm) effective method of contraception within three and 60 days of delivery. 2) A long-acting reversible method of contraception (LARC) within three and 60 days of delivery.	Postpartum
MIPS CQM	Maternity Care: Post-Partum Follow-up and Care Coordination	Percentage of patients, regardless of age, who gave birth during a 12-month period who were seen for post-partum care within eight weeks of giving birth who received a breast feeding evaluation and education, post-partum depression screening, post-partum glucose screening for gestational diabetes patients, and family and contraceptive planning	Postpartum
MIPS CQM, PCMH 2017	Maternal Depression Screening	The percentage of children who turned six months of age during the measurement year, who had a face-to-face visit between the clinician and the child during child's first six months, and who had a maternal depression screening for the mother at least once between zero and six months of life	Postpartum

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
Pregnancy Risk Assessment Monitoring System	Postpartum Depression	Percent of women who experience postpartum depressive symptoms following a recent live birth	Postpartum
0363	Retained Surgical Item or Unretrieved Device Fragment Count (PSI 05)	The number of hospital discharges with a retained surgical item or unretrieved device fragment (secondary diagnosis) among surgical and medical patients ages 18 years and older or obstetric patients. Excludes cases with principal diagnosis of retained surgical item or unretrieved device fragment and cases with a secondary diagnosis of retained surgical item or unretrieved device fragment present on admission.	Postpartum
0329	Risk-Adjusted 30-Day All-Cause Readmission Rate	The existing NQF-endorsed measure provides a means for determining the risk-adjusted readmission rate for a selected adult target population and can be applied for any desired timeframe. Readmission rate is defined as the percentage of acute inpatient discharges during the measurement period followed by an acute inpatient admission for any diagnosis to any hospital within 30 days We are proposing to change the measure and offer a risk factor approach. This method allows for calculation of a risk-adjusted readmission rate for use in two different ways: 1) retrospective analysis of hospital (or other study population) performance determination and 2) in a real-time Electronic Health Record (EHR) environment, analysis to determine the readmission risk	Postpartum

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		factor for each inpatient admission.	
1789	Risk-Standardized, All Condition Readmission	This measure estimates a hospital-level, risk-standardized readmission rate (RSRR) of unplanned, all-cause readmission within 30 days of discharge from an index admission with an eligible condition or procedure.	Postpartum
1768	Plan All-Cause Readmissions (PCR-AD)	For patients 18 years of age and older, the number of acute inpatient stays during the measurement year that were followed by an unplanned acute readmission for any diagnosis within 30 days and the predicted probability of an acute readmission.	Postpartum
MIPS Program	Maternity Care: Post-Partum Follow-Up and Care Coordination	Process	Postpartum
0711	Depression Remission at Six Months	Adult patients age 18 and older with major depression or dysthymia and an initial PHQ-9 score > 9 who demonstrate remission at six months defined as a PHQ-9 score less than 5. This measure applies to both patients with newly diagnosed and existing depression whose current PHQ-9 score indicates a need for treatment.	Postpartum
0710/0710e	Depression Remission at Twelve Months	Adult patients age 18 and older with major depression or dysthymia and an initial PHQ-9 score > 9 who demonstrate remission at twelve months defined as a PHQ-9 score less than 5. This measure applies to both patients with newly diagnosed and existing	Postpartum

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		depression whose current PHQ-9 score indicates a need for treatment.	
Hospital Compare	Alcohol & Other Drug Use Disorder Treatment Provided or Offered at Discharge and Alcohol & Other Drug Use Disorder Treatment at Discharge	Process	Postpartum
1664 (No Longer Endorsed)	(SUB)-3 Alcohol & Other Drug Use Disorder Treatment Provided or Offered at Discharge and SUB-3a Alcohol & Other Drug Use Disorder Treatment at Discharge	The measure is reported as an overall rate which includes all hospitalized patients 18 years of age and older to whom alcohol or drug use disorder treatment was provided, or offered and refused, at the time of hospital discharge, and a second rate, a subset of the first, which includes only those patients who received alcohol or drug use disorder treatment at discharge.	Postpartum
0567	APPROPRIATE WORK UP PRIOR TO ENDOMETRIAL ABLATION PROCEDURE	To ensure that all women have endometrial sampling performed before undergoing an endometrial ablation.	Postpartum
2483	Gains in Patient Activation (PAM) Scores at 12 Months	The Patient Activation Measure® (PAM®) is a 10 or 13 item questionnaire that assesses an individual´s knowledge, skill, and confidence for managing their health and health care. The measure assesses individuals on a zero to 100 scale. There are 4 levels of activation, from low (1) to high (4). The measure is not disease specific but has been successfully used with a wide variety of chronic conditions, as well as with people with no conditions. The performance score would be the change in score from the baseline measurement to follow-up	Postpartum

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		measurement, or the change in activation score over time for the eligible patients associated with the accountable unit. The outcome of interest is the patient's ability to self-manage. High quality care should result in gains in ability to self-manage for most chronic disease patients. The outcome measured is a change in activation over time. The change score would indicate a change in the patient´s knowledge, skills, and confidence for self-management. A positive change would mean the patient is gaining in their ability to manage their health. A "passing" score for eligible patients would be to show an average net 3-point PAM score increase in a six to 12-month period. An "excellent" score for eligible patients would be to show an average net 6-point PAM score increase in a six to 12-month period.	
2677	Preoperative evaluation for stress urinary incontinence prior to hysterectomy for pelvic organ prolapse.	Percentage of women undergoing hysterectomy for pelvic organ prolapse who have preoperative evaluation for stress urinary incontinence.	Postpartum
0166	Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS)	HCAHPS is a 29-item survey instrument that produces 10 publicly reported measures: Six multi-item measures (communication with doctors, communication with nurses, responsiveness of hospital staff, communication about medicines, discharge information and care transition);	Postpartum

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		and four single-item measures (cleanliness of the hospital environment, quietness of the hospital environment, overall rating of the hospital, and recommendation of hospital).	
1517 (No Longer Endorsed)	Prenatal & Postpartum Care (PPC)	The percentage of deliveries of live births between November 6 of the year prior to the measurement year and November 5 of the measurement year. For these women, the measure assesses the following facets of prenatal and postpartum care: Rate 1: Timeliness of Prenatal Care. The percentage of deliveries that received a prenatal care visit as a member of the organization in the first trimester or within 42 days of enrollment in the organization. Rate 2: Postpartum Care. The percentage of deliveries that had a postpartum visit on or between 21 and 56 days after delivery.	Prenatal; Postpartum
0517	CAHPS Home Health Care Survey (experience with care)	Survey instrument and data collection methodology for measuring home health patients 'perspectives on their home health care in Medicare-certified home health care agencies.	Preconception; Prenatal; Labor & Delivery; Postpartum
1824	L1A: Screening for preferred spoken language for health care	This measure is used to assess the percent of patient visits and admissions where preferred spoken language for health care is screened and recorded. Hospitals cannot provide adequate and appropriate language services to their patients if they do not create mechanisms to screen for	Preconception; Prenatal; Labor & Delivery; Postpartum

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		limited English-proficient patients and record patients´ preferred spoken language for health care. Standard practices of collecting preferred spoken language for health care would assist hospitals in planning for demand. Access to and availability of patient language preference is critical for providers in planning care. This measure provides information on the extent to which patients are asked about the language they prefer to receive care in and the extent to which this information is recorded.	
0531	CMS Patient Safety and Adverse Events Composite	Weighted average of the reliability-adjusted, indirectly standardized, observed-to-expected ratios for the following component indicators: PSI 03 Pressure Ulcer Rate, PSI 06 Iatrogenic Pneumothorax Rate, PSI 08 In-Hospital Fall with Hip Fracture Rate, PSI 09 Perioperative Hemorrhage or Hematoma Rate, PSI 10 Post-Operative Acute Kidney Injury Requiring Dialysis Rate, PSI 11 Postoperative Respiratory Failure Rate, PSI 12 Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate, PSI 13 Postoperative Sepsis Rate, PSI 14 Postoperative Wound Dehiscence Rate, and PSI 15 Unrecognized Accidental Puncture or Laceration Rate	Labor & Delivery; Postpartum
1821	L2: Patients receiving language services supported by qualified language services providers	This measure is used to assess the percentage of limited English-proficient (LEP) patients receiving both initial assessment and discharge instructions supported by assessed and	Preconception; Prenatal; Labor & Delivery; Postpartum

NQF ID or Measure Source	Measure Title	Measure Description	Sub-Domain
		trained interpreters or from bilingual providers and bilingual workers/employees assessed for language proficiency. Interpreter services are frequently provided by untrained individuals, or individuals who have not been assessed for their language proficiency, including family members, friends, and other employees. Research has demonstrated that the likely results of using untrained interpreters or friends, family, and associates are an increase in medical errors, poorer patient-provider communication, and poorer follow-up and adherence to clinical instructions. The measure provides information on the extent to which language services are provided by trained and assessed interpreters or assessed bilingual providers and bilingual workers/employees during critical times in a patient's health care experience.	

Table 2: Maternal Morbidity Measure Concepts

Measure Source	Measure Description	Sub-Domain
Center for Medicaid and CHIP Services	Percentage of female clients ages 15 to 44 who are at risk of unintended pregnancy, that adopt or continue use of FDA-approved methods of contraception that are MOST effective or MODERATELY effective	Preconception
Center for Medicaid and CHIP Services	Percentage of female clients ages 15 to 44 who are at risk of unintended pregnancy, that adopt or continue use of FDA-approved methods of contraception that are long-acting reversible contraception	Preconception

Measure Source	Measure Description	Sub-Domain
	Proportion of women who receive antenatal assessments by 13 weeks of pregnancy	Prenatal
	Proportion of women with eclampsia treated with magnesium sulphate	Prenatal
	Proportion of women with severe pre-eclampsia who were treated with magnesium sulphate	Prenatal
	Proportion of women with singleton pregnancies and threatened preterm labor who receive corticosteroids	Prenatal
	Proportion of women with threatened preterm labor treated with magnesium sulphate	Prenatal
	Proportion of women who are treated with calcium channel blockers for inhibiting preterm labor	Prenatal
	Proportion of women with preterm rupture of membranes (PRM) who receive antibiotic treatment	Labor & Delivery
	Proportion of women who are administered uterotonics in the third stage of labor	Labor & Delivery
	Proportion of women with term pregnancies and a breech presentation in which external cephalic version is performed or offered	Labor & Delivery
	Proportion of women induced with an indication of post-dates who are at less than 41 weeks' gestation at delivery	Labor & Delivery
	Proportion of women with labor induction who give birth after 41 weeks of gestation	Labor & Delivery
	Proportion of women whose second-degree perineal tear or episiotomy is repaired with continuous suture	Labor & Delivery
	Proportion of pregnant women having a planned cesarean section who have the procedure carried out at or after 39 weeks zero days	Labor & Delivery
	Rate of repeat cesarean section in low-risk women prior to 39 weeks' gestation	Labor & Delivery
	Proportion of women whose peritoneum is sutured at cesarean delivery	Labor & Delivery
	Proportion of women who are given an enema during labor	Labor & Delivery

Measure Source	Measure Description	Sub-Domain
	Rate of uterine rupture	Labor & Delivery
	Proportion of women with prolonged labor	Labor & Delivery
	Births without obstetric intervention	Labor & Delivery
	Instrumental vaginal delivery rate	Labor & Delivery
	Cesarean section before labor	Labor & Delivery
	Cesarean section during labor	Labor & Delivery
	Incidence of tear of the perineum	Labor & Delivery
	Maternal Intensive Care Unit (ICU) transfer and/or admission	Labor & Delivery
	Proportion of women with severe systemic infection or sepsis in postnatal period, including readmissions	Postpartum
	Blood transfusion during and/or after delivery	Multi-Domain
	Incidence of severe maternal morbidity	Multi-Domain
	Intra hospital women with life-threatening conditions (WLTC) ratio	Multi-Domain
	Severe maternal outcome ratio	Multi-Domain
	Maternal near miss incidence ratio	Multi-Domain
	Met need for EmOC	Multi-Domain

Appendix C: Maternal Mortality Measure Array

Table 3: Maternal Mortality Measures

Measure Source	Measure Title	Measure Description	Sub-Domain
National Vital Statistics System	Maternal Mortality Rate	Maternal mortality rate per 100,000 live births	Delivery-related
CDC Pregnancy Mortality Surveillance System	Pregnancy-Related Mortality Ratio	The number of pregnancy-related deaths for every 100,000 live births, defined as the death of a woman while pregnant or within one year of the end of a pregnancy from any cause relate to or aggravated by the pregnancy or its management.	Delivery-related

Table 4: Maternal Mortality Measure Concepts

Measure Source	Measure Description	Sub-Domain
	Maternal near miss: mortality ratio	Delivery-related
	Case fatality rate	Delivery-related
	Case fatality rate – all complications	Delivery-related
	Institutional maternal mortality ratio (per 100,000 deliveries)	Delivery-related
	Intra hospital mortality index	Delivery-related

Appendix D: Measure Initiatives Array

Table 5. Federal Programs and Measurement Initiatives Addressing Maternal Morbidity and Mortality

Federal Partner Agency	Program Name	Supported Entity	Focus on Maternal or Infant	Public Accountability /Data Collection?	Brief Description of Program
HRSA	Title V Maternal and Child Health Block Grants	States & Jurisdictions	Both	Yes	Supports improved health care for mothers and children, especially those with low-income.
HRSA	Maternal, Infant, and Early Childhood Home Visiting (MIECHV) Program	States, territories, tribal entities	Both	Yes	Supports evidence-based home visits for at-risk pregnant women and pregnant women with young children.
HRSA	Healthy Start	Currently 34 states (+DC & Puerto Rico)	Both	No	Supports state and local jurisdictions in improving health care access, reducing infant mortality, and improving maternal access to prenatal care.
HRSA	Alliance for Innovation on Maternal Health and Safety (AIM)	Funds state-based teams	Maternal	Yes	Led to AIM community care initiative (pregnancy-related deaths outside of hospital)
HRSA	AIM Community Care Initiative	Awarded to one organization serving one region	Maternal		Supports the development and implementation of non-hospital focused maternal safety bundles within community-based organizations and outpatient clinical settings
HRSA	State Maternal Health Innovation Program (State MHI Program)	Funds 9 state entities annually	Maternal	No	States are addressing critical gaps in maternity care service delivery

Federal Partner Agency	Program Name	Supported Entity	Focus on Maternal or Infant	Public Accountability /Data Collection?	Brief Description of Program
HRSA	Supporting Maternal Health Innovation Program (Supporting MHI)	Supports the 9 State MHI recipients	Maternal	No	Program serves as a national resource center and provides capacity building assistance to HRSA's maternal health grantees and other stakeholders
HRSA	Rural Maternity and Obstetrics Management Strategies (RMOMS)	2019 Pilot program awarded to recipients in 3 states: Missouri, New Mexico, and Texas	Maternal		Program to demonstrate the impact on access to and continuity of maternal and obstetrics care in rural communities through testing models.
CDC	Pregnancy Mortality Surveillance System	States + NYC and DC	Maternal	Yes	States report pregnancy-related mortality info
CDC	Maternal Mortality Review Committees	States and Cities	Maternal	Yes	Review all pregnancy-related mortality
CDC	Enhancing Reviews and Surveillance to Eliminate Maternal Mortality (ERASE MM)	25 States	Maternal	Yes	Identify and characterize maternal death and ID prevention opportunities
CDC	Perinatal Quality Collaboratives (PQCs)	States or multi-state networks – 13 states currently funded	Both	Yes	Improvements in health care and outcomes for mothers and babies

Federal Partner Agency	Program Name	Supported Entity	Focus on Maternal or Infant	Public Accountability /Data Collection?	Brief Description of Program
CDC	Levels of Care Assessment Tool (LOCATe)	Birth facilities in participating states	Both	No	Tool to help standardize definitions and assessments of levels of maternal and neonatal care.
CDC + March of Dimes	National Network of Perinatal Quality Collaboratives	States or multi-state networks	Both	No	Support state PQCs in making measurable improvements in maternal and infant health outcomes.
CDC	Pregnancy Risk Assessment Monitoring System (PRAMS)	47 states, NYC, DC, Puerto Rico, and Great Plains Tribal Chairman's Health Board	Both	Yes	Surveillance project between CDC and state health departments
CDC	Maternal and Child Health Epidemiology Program (MCHEP)	State and regional public health agencies and organizations	Both	No	Mission to promote and improve the health and well-being of women, children, and families by building capacity at state, local, and tribal levels and to use and apply sound epidemiologic research and scientific information to maternal and child health programs and policies.