**Preeclampsia Problem Analysis in the United States**

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**Definition and Problem Description of Preeclampsia**
Preeclampsia (PE) is a hypertensive pregnancy condition that affects both mother and fetus and usually develops after the 20th week of pregnancy, or rarely soon after delivery, [1] [2] [3] in a previously normotensive woman. [4] Worldwide, PE affects between 5% to 7% of pregnancies and is one of the top six leading causes of maternal mortality in the United States. [3]

Diagnosis of PE is characterized as having a blood pressure of 140/90 mm Hg or higher [1] and is typically associated with the new onset of proteinuria (protein in the urine) but may also occur in its absence. PE may also be diagnosed in the presence of thrombocytopenia (low platelet count) and impaired liver function due to elevated liver enzymes found in the blood. [4] PE symptoms include unexplained severe and persistent epigastric pain that is unresponsive to treatment, renal insufficiency, pulmonary edema, unexplained new-onset cerebral symptoms that are unresponsive to medications, and visual changes. [4]

*Health Outcomes*
If left unmanaged, PE can bring about adverse short- and long-term maternal, fetal, and infant outcomes. Adverse maternal health outcomes include eclampsia, placental abruption, increased risk of cesarean delivery, chronic hypertension, pre-term birth, cerebrovascular disease, and death. [1] [3] Adverse fetal and infant outcomes include increased risk of stillbirth, neonatal death, low Apgar score, low birth weight, and intrauterine growth restriction. [1] [3] [6] [7] Additionally, maternal hypertension, low platelet counts, and having abnormally elevated blood pressure can affect the uterine blood flow rate to the placenta and fetus, which can lead to placental hypoxia and nutritional deficiencies. [2]

*Causes and Risk Factors,*
While the cause of PE is unknown, risk factors include nulliparity, use of assisted reproductive technologies, very young and advanced maternal age, history of hypertension or preeclampsia in a previous pregnancy, having a body mass index of 30 and higher, being of African American race, multiple gestations, and having chronic hypertension, chronic kidney disease, or diabetes mellitus prior to pregnancy. [3] [8]

*Prevention, Treatment, and Management*
If preeclampsia is left untreated, it may develop into eclampsia, which is the manifestation of hypertensive syndromes that result in the new onset of seizures in pregnant women. [4] There are currently no effective interventions to eliminate the risk of preeclampsia. [4]

Hofmeyr (2018) suggests that calcium supplementation may reduce preeclampsia risk in women living in settings where dietary calcium is inadequate, although further research is needed. [9] [10] Several studies indicate that high salt intake, defined by the World Health Organization (WHO) as greater than 6 grams per day, [11] increased the risk of pregnancy-induced gestational hypertension and preeclampsia. [10] [11] While the management of dietary salt intake to prevent preeclampsia lacks research providing significant results, there is strong supporting evidence that dietary salt intake

management helps prevent and reduce long-term cardiovascular risk. [11] [12] [13] Other PE expectant management strategies may include magnesium sulfate therapies to prevent seizures and antihypertensive medications. [12]

The removal of the placenta, or delivery, is the only effective cure for PE, which can result in the premature delivery of the infant. [1] [2] [4] Thus, managing PE symptoms through regular prenatal visits is vital to minimize maternal and fetal mortality and other health risks.

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**Epidemiology of Preeclampsia**

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### Extent of Preeclampsia

In the United States, preeclampsia is among the top six leading causes of maternal and fetal morbidity and mortality, [1] affecting 1 in 25 pregnancies, or approximately 4 percent. [14] [15] Recent data for PE is provided by the Healthcare Cost and Utilization Project (HCUP) Statistical Brief 2005-2014 report, [15] the 2020 Blue Cross Blue Shield (BCBS) report on trends in pregnancy and childbirth complications in the US, [16] and a 2019-2020 cross-sectional study using 2017 US birth certificate data of approximately 3.6 million women to evaluate variations at the state-level of hypertensive pregnancy disorders. [18]

In 2014, diagnoses of pregnancy-related hypertension accounted for 10.8% (*n= 409,495*) of all delivery hospitalizations (*n=3,796,496*) and the category type 'preeclampsia/eclampsia' was the most diagnosed, accounting for 4.7% (*n=176,925*) of deliveries with PE/eclampsia. [15] Among the 4.7% of delivery hospitalizations involving PE/eclampsia 46.9% (*n=82,910*) were diagnosed with mild or unspecified PE, followed by severe PE accounting for 37.2% *(n=65,880)*, and eclampsia accounting for 1.4% (*n=2510*). [15] About 14.5% *(n=25,625)* of deliveries with a PE/eclampsia diagnosis had preexisting hypertension. [15]

### Duration and Trends

The diagnosis of hypertensive disorders, including preeclampsia, has increased in the last three decades. [16] Between 2005 and 2014, PE/eclampsia rates increased by 21%, from a rate of 38.4 to 46.6 per 1000 deliveries. Between 2014 to 2018, BCBS found that pregnancy and childbirth complications increased by 16% and 14%, respectively. In women between the ages of 18 and 44 years, the prevalence of PE pregnancy complications rose from 54.2 to 64.5 per 1000 between 2014 and 2018, accounting for a 19.0% increase. [16] In the same period, the prevalence of childbirth complications due to eclampsia also increased from 1.1 to 1.7, accounting for a 57.9% increase. [16]

### *Variation of Selected Risk Factors*

**Maternal Age.** The rate of PE/eclampsia per 1000 deliveries is higher for pregnant women of very young (less than 20 years of age) or advanced ages (40 years and older). In 2014, the rate of PE/eclampsia for pregnant women younger than 20 years of age and women 40 years of age and older was 59.3 and 73.5 per 1000 deliveries, respectively. Compared to other age groups (excluding pregnant women over 40 years of age), the rate of PE/eclampsia for pregnant women younger than 20 years of age was higher by 6.8 to 13.1 per 1000 deliveries.

Pregnant women over 40 years of age had the highest rate of 73.5 per 1000 deliveries in 2014 but tied with the age group between 35 to 39 years for the most considerable percentage change between 2005 and 2014. Both groups reported a 36% increase in rates of PE/eclampsia. Data from a cross-sectional study conducted by Butwick et al. (2020) appears to be consistent with maternal age trends, specifically pregnant women over 40 years of age. [18] In the latter study, preeclampsia is grouped with other pregnancy-related hypertensive disorders. Among pregnant women over 40 years of age who experienced a live birth (*n=115,487*), 8.3% had a pregnancy-related hypertensive condition, making it between 1.6 to 2.3 percentage points higher than other age groups. 18

**Maternal Race and Ethnicity.** Preeclampsia trends by race and ethnicity reveal that African American and Black women experience at least 50% higher rates of PE/eclampsia than other racial and ethnic groups, with a total rate of 69.8 per 1000 deliveries. Hispanics and non-Hispanic white pregnant women have similar rates of 46.8 and 43.3 per 1000 deliveries, respectively. [15] Asians and Pacific Islanders have the lowest rate of PE/eclampsia, with a rate of 28.8 per 1000 deliveries. Within each race and ethnicity group and among the types of preeclampsia/eclampsia, African American and Black women were more likely to receive a severe diagnosis (38.5%), whereas non-Hispanic white, Hispanic, and Asian and Pacific Islanders were more likely to receive a mild or unspecified diagnosis of preeclampsia. [15]

**Geographic Region.** Prevalence data on pregnancy-related hypertensive disorders is limited. [18] Findings from the 2005 to 2014 HCUP statistical briefing reveal that PE/eclampsia was highest in the South, increasing from a rate of 43.1 to 51.6 per 1000 deliveries in that period, an increase of about 20 percent. [15] The Northeast experienced the most significant percentage change, increasing from 34.6 to 45.0 per 1000 deliveries for PE/eclampsia, about a 30% increase. [15]

## Justification for Taking Action

Pregnancy complications such as preeclampsia contribute to the steadily increasing rates of pregnancy-related deaths in the United States. Between 2000 and 2017, pregnancy-related deaths have increased from 14.5 to 17.3 per 100,000 live births. [19] Maternal and fetal morbidity and mortality are the most significant reasons to take action on managing and preventing preeclampsia in the United States. As the removal of the placenta or delivery is the only known effective cure, discovering more effective management and treatment options to prevent pre-term birth is necessary. Preeclampsia increases the risk of pre-term birth and has been found to lower the infant's gestational age by approximately 1.7 weeks. [20] Pre-term births can contribute to infant morbidity, including the onset of jaundice, respiratory distress syndrome or other chronic lung conditions, and neurodevelopmental disabilities. [21] Further, the rate of preeclampsia will continue to increase as other risk factors also increase (i.e., obesity, diabetes, pre-pregnancy hypertension, and delay in childbearing) [22]

## Examination of Determinants of Preeclampsia

### Social-Ecological Model

This problem analysis will apply McLeroy's Social-Ecological Model (SEM), a widely accepted public health model that utilizes a multi-level approach to understand health and health behaviors. [22] [24] Levels of analysis in the SEM include the individual, interpersonal, organizational, community, and

public policy. [24] Using the SEM allows health and public health practitioners, policymakers, government officials, and researchers to consider the community, social, policy, and environmental factors that contribute to a given health outcome or behavior. Figure 1 shows how each level of the SEM can contribute to a given health outcome.

### Individual Level

At the individual or intrapersonal level, factors such as beliefs, attitudes, behaviors, knowledge, skills, and developmental history are considered. [22] Concerning preeclampsia, individual-level factors would include primarily intrinsic factors such as genetic predisposition, nulliparity, age, and preexisting health conditions (i.e., BMI 30 and higher, history of chronic hypertension or kidney disease).

### Interpersonal Level

The interpersonal process includes formal and informal social networks and relationships such as family, church community, and work colleagues that provide social support and support. [22] [24] Social networks and relationships can influence how individuals acquire health-damaging and promoting behaviors, cope with stress, acquire new beliefs and attitudes, and gain access to resources. Indirect factors that would influence preeclampsia include the relationship with the healthcare provider.

### Organizational Level

The institutional or organizational level encompasses factors that constrain or promote behavior, [22] such as policies and regulations. The organizational level influences the diffusion and adoption of norms, behaviors, and knowledge as they have immediate access to large groups of people, whom of which may associate a given organization as part of their social identity. [22] Lack of trust in one's healthcare provider or perceived judgment during appointments may influence a pregnant woman's decision to attend regular prenatal visits or physical exams.

### Community Level

The community level considers the relationships among organizations or institutions and how they can act as mediating and power structures. [22] Cultural attitudes around health-seeking behaviors, such as regular prenatal visits and limited availability or access to quality and healthcare, may affect how many at-risk pregnant women engage in effective management or prevention of preeclampsia.

### Public Policy Level

The public policy level emphasizes how regulations, policies, and laws influence population or community health. Regarding preeclampsia, surveillance of specific maternal mortality and morbidity needs improvement at the state level to better inform policy and research.

*Figure 1.* McLeroy's Social-Ecological Model (SEM)

**Public Policy**
National public policy, regulations, & laws

**Community**
Relationship, mediating, & power structures

**Organizational**
Constrain/promote behaviors; diffusion

**Interpersonal**
Family, friends,
& social networks

**Individual**
Beliefs, attitudes,
knowledge, &
behaviors
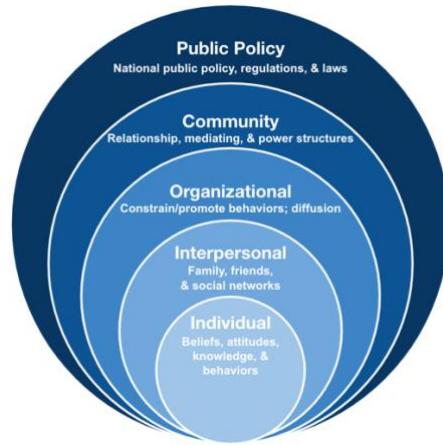
## Problem Analysis

*Figure 2*. Problem Diagram for Preeclampsia
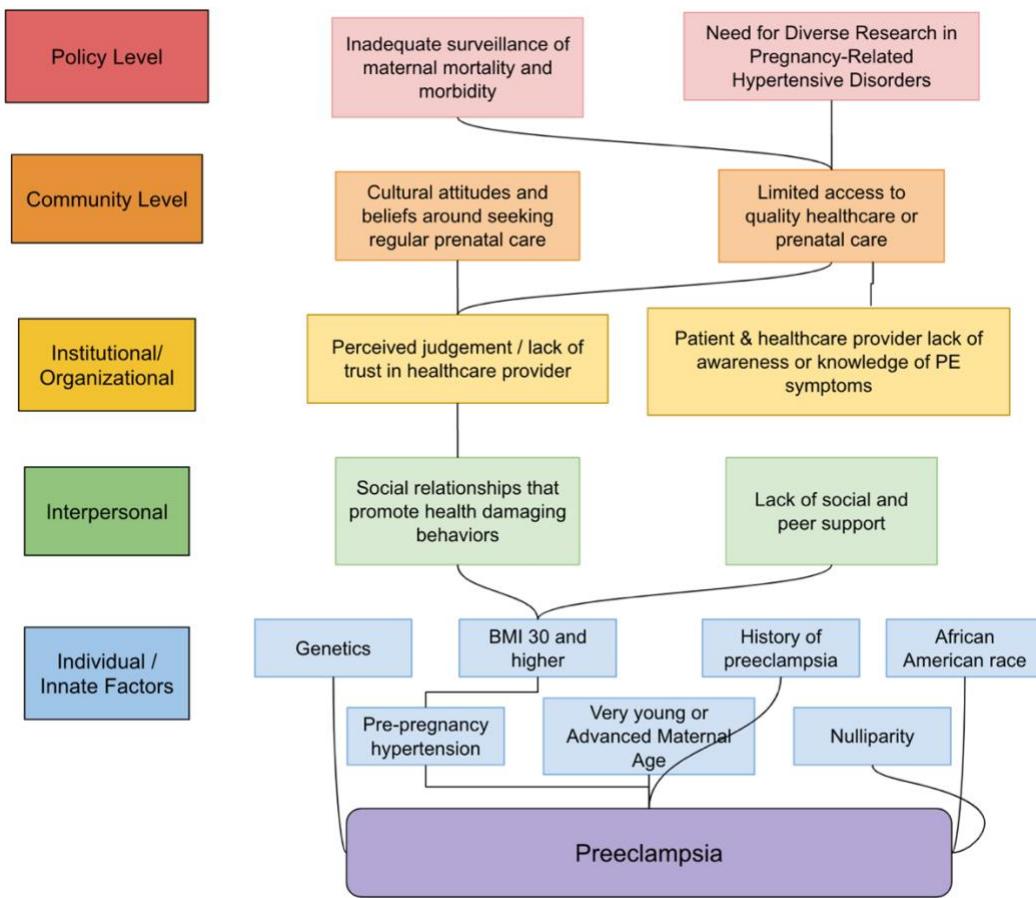


The use of the SEM in this problem analysis underscores that individual health outcomes are influenced by implicit and explicit factors outside of an individual's control. Figure 2 illustrates how various factors at different levels of the SEM can contribute as either proximal or distal influences.

### Policy Level Factors
#### *Inadequate Surveillance of Maternal Mortality and Morbidity*
The inadequate surveillance of maternal mortality and morbidity indicators, specifically regarding preeclampsia and pregnancy-related hypertensive disorders, was elucidated by several reports and articles [15-17] [25-28] that highlight inconsistencies found throughout literature in collecting and reporting maternal mortality and morbidity data. Accurate reporting and adequate maternal mortality surveillance are critical in assessing population health, improving maternal health outcomes, comparing state and local maternal health data, and identifying inequities according to sociodemographic characteristics [28].

The National Vital Statistics System (NVSS), the official source for maternal mortality data in the United States, was found to have significant issues with underreporting maternal deaths before 2000.

[25-28] To improve reporting of maternal or late maternal deaths, states were advised to adopt a series of checkboxes with pregnancy-related questions to add to their standard death certificate starting in 2003. [25][26] Over the next 14 years, states adopted these series of checkboxes in a staggered fashion [25], which posed problems with examining and comparing national, state, and regional level maternal mortality statistics. [25][26] The staggered implementation of the pregnancy checkboxes prevented the National Center for Health Statistics from reporting maternal mortality for ten years, between 2007 and 2017. [29]

Finally, the United States lacks a standardized definition and continuous population-based surveillance for maternal morbidity. [30] Such lack of standardization is significant given that severe maternal morbidity is strongly associated with maternal mortality [31].

### *Needs for Diverse Research in Pregnancy-Related Hypertensive Disorders*
Inadequate surveillance may be driven by the need for more diverse research concerning pregnancy-related hypertensive disorders. [32] While funding towards pregnancy-related hypertension disorders has increased over the years, with most awards going to the National Institute of Child Health and Human Development (NICHD) and the National Heart, Lung, and Blood Institute (NHLBI), there are still gaps in PE research and knowledge. [32]

Currently, delivery is the only known treatment option for PE. [1] [2] [4] However, this does not necessarily absolve any future morbidities or mortalities related to PE as both mother and child still face an increased risk of developing cardiovascular disease. [31] [32] [33] A 2018 analysis of the utilization of research funding [32] and 2020 NICHD and NHLBI health workshop for PE and pregnancy-related hypertensive disorders [34] revealed that more translational research is needed to discover and develop alternative treatments, diagnosis, models of care, and prevention strategies for PE, as well as more fundamental research aimed at learning more about the pathophysiology of PE. [32] [34] Finally, research aimed towards the development of new models of care may improve provider and patient awareness and knowledge of PE, as well as mitigating short, intermediate, and long-term outcomes related to PE. [34]

### Community Level Factors
### *Cultural Attitudes and Beliefs Around Seeking Prenatal Care*
Promoting maternal health is critical for fetal development and infant health. Maternal behaviors such as inadequate nutrition, alcohol consumption, tobacco exposure, exposure to toxins or radiation, and unhealthy weight gain [35] can impact fetal and infant development and the mother's health. [35] [36] Specific fetal and infant impacts include pre-term birth, low-birth weight, infant mortality, birth defects, effects on early childhood development, and cognitive and physical delays. [35] [36] Positive health-seeking behaviors and expectations towards prenatal care are protective factors that can ultimately minimize the incidence of fetal and infant impacts and pregnancy complications. [36]

At the community level, cultural attitudes and beliefs towards prenatal care in the United States are driven by sociocultural factors such as perceived availability of social support, [36] quality of maternal health care, [36] [37] unintended pregnancy [37], social stigma, lack of understanding, and fear. [35]

Among Hispanic women, early initiation of prenatal care is often delayed. [38] [39] Inability of healthcare providers and clinic personnel to speak Spanish presented barriers for Hispanic women to communicate health concerns without a translator easily. [38] Additionally, Hispanic women have expressed that having access to a Spanish-speaking healthcare provider has significance as the provider is more likely to understand cultural nuances, expectations, and norms, ultimately influencing their decision to access prenatal care. [38] [39]

American Indian and Alaskan Native (AI/AN) women also experience delayed or inadequate prenatal care. Communicational, institutional, and structural barriers also contributed to cultural attitudes and beliefs about seeking prenatal care. [40] [41] Additionally, AI/AN women have reported that they were uncomfortable or embarrassed with receiving maternal care from a male physician as they felt that their female health concerns were inappropriate to be sharing with a male physician. [41]

### Limited Access to Quality Healthcare or Prenatal Care

Limited access to quality healthcare creates barriers to early detection, management, and treatment strategies for PE, leading to increased maternal and fetal/infant morbidity and mortality from PE. Access to quality health care before pregnancy and pre-and post-natal care during pregnancy, especially in rural communities, can improve maternal and fetal/infant outcomes. [34] Services such as routine check-ups, support services (i.e., mental health screening, substance use treatment, social services), identification of high-risk conditions, prenatal classes, and enrollment into programs aimed at reducing healthcare disparities [25] will help to ensure both mother and baby have access to vital support services that improve and maintain their overall health and well-being.

### Organizational Level Factors
### Perceived Judgment from or Lack of Trust in Healthcare Provider

Perceived judgment from a healthcare provider may create a sense of distrust between the patient and provider relationship. Further or not being taken seriously [37] could cause patients to feel devalued and create stigma or feelings of discrimination around seeking treatment and self-efficacy. [**Error! Reference source not found.**] Feelings of fear – of preeclampsia [42], being judged, medical procedures (i.e., blood draws and vaginal examinations), or losing custody due to illicit drug use [43] – have also been shown to affect women's health-seeking behavior. [42]

Lack of trust in one's healthcare provider is attributed to provider and patient dissimilar communication styles. For instance, among AI/AN women, providers being too busy to answer questions or spending too little time with their patients has created a lack of trust in modern institutions and healthcare practices. [40] Further, past negative experiences with healthcare providers during prenatal care, pregnancy, or delivery resulted in distrust towards healthcare institutions and providers. [41]

### Patient and Healthcare Provider Lack of Awareness or Knowledge of PE Risk & Symptoms

Communication barriers between the healthcare provider and patient also present issues with facilitating knowledge sharing around prenatal care. Providers talking too fast, using complex medical terminology, not demonstrating good listening skills, disregarding or belittling patient health care concerns about PE, or providing confusing and conflicting advice or information about PE

contributed to women's lack of understanding and knowledge about PE. [42] Several studies in the US have found that women were not aware of the link between hypertensive disorders of pregnancy and subsequent risk for cardiovascular disease. [44] [45] [46] In these studies, women felt that their knowledge and individual risk about PE were insufficient. [44] A 2018 cross-sectional survey found that women who reported high awareness about PE and subsequent increased risk for cardiovascular disease and hypertension were more likely to have self-acquired this knowledge (approximately 60% of women). [47] Only 25%, 13%, and 6% of women gained knowledge about PE and their risks from their obstetricians, general practitioners, and midwives, respectively. [44] [47]

Opportunities exist to improve healthcare providers' knowledge and consistent treatment of PE. Several studies reveal that the majority of internists and obstetricians provide routine counseling for reducing the risk of cardiovascular disease, about 95% and 70%, respectively. [44] [48] However, approximately half of obstetricians and one-quarter to one-third of internists were unaware of the relationship between PE and ischemic heart disease, stroke, and shorter life expectancy. [44] [48] Regarding management and treatment of hypertension among women with severe PE, one study found that antihypertensive medications were not administered in compliance according to guidelines provided by the American College of Obstetricians and Gynecologists. [49]

### Interpersonal Level Factors
*Lack of Social and Peer Support*
The World Health Organization (WHO) report on the social determinants of health finds that social support can affect one's health and contribute to inequalities in health. [51] Social support can allow individuals to be part of social networks that influence health behaviors, provide social capital, access resources and information, and impact coping styles or behaviors. [51] One pilot study conducted in 2015 assessed the effects of psychosocial factors and preeclampsia. [52] The study found that higher levels of optimism and perceived social support among African American women are negatively associated with psychological distress, whereas poor coping strategies (i.e., avoidance or negative interpretation of events) were positively associated with psychological distress. [52]

*Social Relationships that Promote Health Damaging Behaviors*
The self-initiated lifestyle behaviors of pregnant women can impact pregnancy outcomes. Such behaviors include health responsibility, interpersonal relationships, nutrition, physical activity, self-actualization, and stress management [53]. Psychosocial factors, such as depression and stress, affect the self-initiated lifestyle behaviors of women.

Regarding interpersonal relationships, one population-based study in Norway, a high-income country, found that high levels of marital satisfaction and relationship quality among married and cohabiting couples were significantly and negatively associated with pregnant women's odds of experiencing or self-reporting an infection (i.e., influenza, common cold, pneumonia or bronchitis, throat infection, ear infection, diarrhea, vaginal thrush or catarrh, and urinary bladder infection). [54] Among pregnant women who reported low marital satisfaction and relationship quality were twice as likely to report experiencing or self-reporting an infection. [54] Though further research is needed to assess clinical biomarkers, these findings are significant as emotional distress during

pregnancy and after birth can adversely impact the well-being of mothers, infants, and their families. [55]

### Individual and Innate Level Factors
#### *Genetics and History of Preeclampsia*
Genetic predisposition to preeclampsia is complex as it has been found to follow patterns of disease inheritance, recurs in individuals and families, [56] and occur as variants that appear on different loci of a gene. [57] Susceptibility to preeclampsia can be determined by maternal and fetal genotype. [57] [58] Environmental and intrinsic factors (i.e., nutrition, age, and weight) also play a role in the expression and function of preeclampsia-related genes. [57] [58] However, there is still a need for genome-wide association studies to understand the heritability and expression of preeclampsia fully. [57] [58]

#### *Nulliparity*
Nulliparous women, or women who have not given birth, are found to have already increased risk of experiencing adverse pregnancy outcomes. [59] Concerning preeclampsia, nulliparity has the largest population attributable risk factor, [60] although this does not necessarily mean that this factor has significant importance over other risk factors. [59] Immunological mechanisms partially explain the onset of preeclampsia as maternal immune recognition is necessary for implantation and placental growth. [60] [61] Partial maternal immune tolerance to fetal blood antigens, or alloantigens, and poor placentation may induce inflammatory and oxidative stress responses that affect the placenta's ability to transfer nutrients and oxygen between mother and fetus. [61] Maternal immune memory is likely to adopt more efficiently in subsequent pregnancies due to T-cell memory. [61] Additionally, recent studies have revealed that assisted reproductive technologies may introduce foreign antigens that would induce similar maternal immune responses. [60]

#### *Body Mass Index of 30 or Higher*
Like nulliparity, obesity (having a body mass index of 30 or higher) is among the most considerable population attributable risk for preeclampsia. [60] A 2012 report found that obesity is present in 30% of preeclampsia cases and is the leading attributable risk factor in the US. [62] Having a body mass index of 30 or higher changes the inflammatory and metabolic profiles (i.e., insulin resistance), all of which are associated with preeclampsia. [60] [62]

#### *Pre-pregnancy Hypertension*
Women who have hypertension before pregnancy, or pre-pregnancy hypertension, are at an increased risk of preeclampsia and adverse pregnancy outcomes, including placental abruption and fetal growth restriction. [63] [64] Women with mild and severe hypertension increase their risk for preeclampsia by 20% and 50%, respectively. [63]

#### *Very Young or Advanced Maternal Age*
Preeclampsia is higher among extreme maternal ages. Among very young pregnant women, inadequate prenatal care, sociodemographic factors, overlapping maternal growth, and quality of familial and partner relationships influence the risk of preeclampsia. [65] Among women of advanced maternal age, factors such as assisted reproductive technologies [60], having a body mass index

greater than 25, [66] and higher incidence of chronic hypertension [63] [66] increase the risk of preeclampsia and pregnancy complications. [66]

### African American Race

Preeclampsia rates are about 50% higher among African American women. [15] Structural, institutional, and internalized racism have impacts on individual health outcomes. [68] For instance, inequities in housing, education, access to transportation, employment opportunities, socioeconomic status, and inequitable access to healthcare services increase one's risk for obesity, hypertension, and diabetes. [68] Such conditions increase one's risk for cardiovascular disease, both a risk factor and an outcome for preeclampsia. [68]

## Evidence-Based Interventions

Four interventions and programs have been identified to address modifiable precursors at each of the levels of McLeroy's Social-Ecological Model. Logic models for each of the following interventions can be referenced in Appendix A.

### Maternal Mortality Prevention Program (MMPP)

The Maternal Mortality Prevention Program [69] addresses precursors at the policy level, specifically "inadequate surveillance of maternal mortality and morbidity" and "lack of investment in research for pregnancy-related hypertensive disorders." The program's overarching goal was to eliminate preventable maternal deaths in Colorado by establishing a Maternal Mortality Review Committee (MMRC). The state of Colorado recognizes that health inequities exist within their healthcare systems and that such inequities are preventable. In 2019, Colorado Governor Jared Polis signed a bipartisan act that would fund the establishment of the MMRC and also allowed Colorado to apply for CDC grants (i.e., ERASE Maternal Mortality grant program) that would go towards the development of public health programs, community-led solutions, and improve clinical quality of maternal healthcare. Ultimately, funds would allow for the state of Colorado to improve its review process and subsequently improve its collection, analysis, and ability to take immediate action on maternal mortality and morbidity data.

Prior to 2019, a review of maternal deaths was delayed by approximately three to four years. Since the signing of the bipartisan act, the MMRC has reduced the delay in review time of maternal deaths, allowing for the state of Colorado to secure additional CDC grant funding.

There are three primary components of the program. The first core component is "community-led solutions." Project activities include locally-based perinatal providers and local Maternal and Child Health Community Advisory Boards partnering with communities with high maternal mortality to identify and implement strategies that would improve maternal health outcomes.

The second core component is 'clinical quality improvement.' Project activities include improving maternal patient safety and reducing pregnancy complications by partnering with organizations specializing in quality improvement.

The third core component is 'public health programs.' Project activities include direct use of funding secured by the MMPP and CDC to build and implement systems, provide outreach and education for maternal health and mental health, and address structural determinants of health that impact maternal health.

The effectiveness of this program has not yet been evaluated, but its acceptance by the CDC, Title V maternal and child health partners, community partners, and community stakeholders signifies success. Short-term outcomes of the program include ensuring a timely review of each maternal death up to one year, regardless of cause, and improving the maternal mortality review process. Intermediate outcomes include implementing recommendations for clinical quality improvement and identifying the social and structural determinants of health affecting communities. Long-term outcomes include reducing maternal mortality in the state of Colorado.

### Healthy Babies Are Worth The Wait (HBWW)

Healthy Babies are Worth the Wait® [70] [71] is a community program initially run as a pilot in Kentucky between 2007 and 2009. The main partners of the study were March of Dimes, the Kentucky Department for Public Health, and Johnson & Johnson. The program was initially designed to address the steadily rising pre-term births in the two decades prior to 2006. Kentucky was chosen as the pilot site for this program as its pre-term birth rate was above the national average. The program's main goal was to decrease preterm birth rates in the three selected Kentucky sites by 15% using evidence-based interventions that targeted patients, perinatal providers, and the community.

The HBWW program targets the community, organizational, and individual levels of McLeroy's. Further, the intervention addresses all precursors at the community level – "cultural attitudes and beliefs around seeking regular prenatal care" and "limited access to quality healthcare or prenatal care."

Project activities were designed and implemented for each key population, specifically pregnant women, perinatal providers, communities, and hospitals. For pregnant women, home visitation programs allowed perinatal nurses to provide patient education about preterm births, prenatal care, and substance use treatment and provide opportunities to practice healthy habits and access to resources.

For perinatal providers, activities included continuing medical education, improving knowledge and changing attitudes and behaviors towards current research and guidelines regarding preterm birth prevention, and access to patient education materials.

Project activities for communities primarily focused on increasing awareness about the significance of preterm birth prevention through providing educational materials at clinics and hospitals and media campaigns.

Finally, project activities for hospitals included ensuring adherence to institutional guidelines on prevention and intervention of preterm births and data reporting practices.

Outcomes from the pilot program were promising. Short-term outcomes included changes in knowledge and attitudes towards preterm birth among pregnant women, perinatal providers, and communities. Perinatal providers also increased their knowledge and self-efficacy using referral systems for high-risk pregnant women. Intermediate outcomes for pregnant women, perinatal providers, and communities included adopting behaviors that reduced preterm births. Hospitals made changes in policies and practices centered around patient safety and promoting good health outcomes among women of childbearing age. Long-term outcomes included a reduction of preterm births by almost 7%.

### The Cuff Kit Program

The Cuff Kit Program [72] is a nationwide program that aims to improve timely diagnosis and treatment of pregnancy-related hypertensive disorders. The program began in June 2020 and came about due to the COVID-19 pandemic adversely affecting prenatal and postpartum care access. The move to telehealth visits required a solution that allowed for patient engagement in at-home blood pressuring monitoring. The Cuff Kit program provides eligible patients with an easy-to-use blood pressure measuring device, educational materials about hypertension, instructions, and a rubber brace for postpartum women indicating they are still "at risk." Participating providers receive information about how to engage and teach their patients about measuring their blood pressure at home. Providers are also required to provide data about patient use.

The program targets the community and institutional levels of McLeroy's SEM. Modifiable precursors at the community level include "limited access to quality healthcare or prenatal care." Modifiable precursors at the institutional level include "patient and healthcare provider lack of awareness and knowledge of preeclampsia symptoms."

The target population was any participating providers who had patients with identifiable risk factors for developing preeclampsia. Participating providers include OB/GYNs, hospitals and clinics, community health centers, federally qualified health centers, and nurse home-visiting programs.

The Cuff Kit Program pursues five primary project activities. The first project activity for providers to determine a need for Cuff Kits and identify how many cuffs will be required between a 6-to-12-month span. The next step would be to apply for the kits and then distribute kits to their patients who are high-risk pregnant women. These project activities fulfill the assessment, procurement, and distribution components of the program.

The second project activity requires that providers are trained to demonstrate the use of cuff kits to their patients. The third project activity is for patients to receive Cuff Kits' demonstration and educational materials from their providers. The fourth project activity is the quarterly collection of data from patients by providers to the Preeclampsia foundation. The fifth project activity is for patients and providers to engage in monthly online discussions on the Cuff Kits community web platform, although this activity is optional. These project activities fulfill the staff training, patient education, reporting, and communications component of the program.

Although this program is still in progress, short-term and intermediate outcomes have been realized. Short-term outcomes include rapid use of telehealth for pregnant women who are determined to be at-risk or high-risk for preeclampsia. Other short-term outcomes include patient and provider engagement in patient health through blood pressuring monitoring and educational materials about preeclampsia. Although the program is still ongoing and more research is needed, long-term outcomes include reducing maternal and fetal morbidity and mortality disparities.

### MoMMA's Voices Champions Training Center

The Maternal Mortality and Morbidity Advocates (MoMMA's) [73] Voices Champions Training Center is a national patient advocacy established in 2018 and comprises organizations and individuals who want to share their experience and advocate to reduce maternal morbidity and mortality. The program's goal is to equip Patient Family Partners – volunteers, providers, family members, friends, and community members – with the knowledge and resources to work alongside organizations and healthcare providers to impact maternal mortality and morbidity.

The program targets the policy, community, and interpersonal levels of McLeroy's SEM. Specific modifiable precursors include "inadequate surveillance of maternal mortality and morbidity," "limited access to quality healthcare or prenatal care," and "lack of social and peer support."

The training program has three components on which project activities are based: training, support, and outreach. The first component, training, is addressed by the project's development and provision of training courses for Patient and Family Partners. Training courses comprise at least 5 hours of self-paced, online training and are broken down into four modules: advocate readiness, storytelling, navigating media, and understanding quality improvement. During this training, Patient Family Partners will have the opportunity to communicate and participate with others who have experienced adverse maternal health outcomes and learn how to use their story for advocacy. Finally, Patient Family Partners who complete the program will be awarded a completion certificate.

The second core component, support, is addressed by participation in the Facebook Community Group. Here, Patient Family Partners can share their stories, learn and encourage one another, and build community. The third core component, outreach, is addressed with project activities involving Patient Family Partner engagement. External organizations and stakeholders such as the Preeclampsia Foundation and Black Women's Health Imperative will also participate in the online community and offer training, perspective, and opportunities for Patient Family Partners to impact maternal morbidity and mortality through policy change and patient advocacy.

Short-term outcomes of the program included improved self-efficacy among Patient Family Partners in advocating for improved maternity care and providing a space for healing. The online platform allows for immediate and active engagement while providing a sense of community. Intermediate outcomes include Patient Family Partners' increased self-awareness about their experience, learning from other's experiences, and ultimately understanding their collective experiences. Long-term outcomes include better patient-provider communication, positive change in maternity care and treatment, and reducing maternal morbidity and mortality.

## Recommendations

### Increase Use of Telehealth Strategies and Smart Technologies for High-Risk Pregnancies

The Cuff Kit Program and MoMMA's Voices Champions Training Center provide evidence that there is a growing need for telehealth solutions. Due to the COVID-19 pandemic, telehealth strategies and solutions have been in high demand to ensure that patients, especially high-risk patients, are getting their healthcare needs met. Among high-risk pregnant women, it is essential to minimize further exposure to other risks, including COVID-19. The Cuff Kit Program provides an excellent example of how high-risk pregnancies can be more closely managed at home, not only for symptoms related to high blood pressure and preeclampsia but also other conditions such as pregestational or gestational diabetes. Other health services that may be provided for high-risk pregnancies are genetic counseling, mental health services, and information about prenatal care and postpartum care.

Provision of increased telehealth solutions for high-risk pregnancies can also help patients overcome the fear of being judged or of medical procedures, improve limited access to quality prenatal, encourage early initiation of prenatal care, and positively impact cultural attitudes towards prenatal care.

### Establish Online Learning and Advocacy Communities for Patients and Providers

The establishment of online communities for MoMMA's Voices and the Cuff Kit also allow patients to ask questions without fear of discrimination or judgment. Additionally, online communities can help patients learn about the experiences of others, learn how to advocate for themselves, receive and provide social and emotional support to others, and potentially start social relationships that encourage health-promoting behaviors. Online communities for patients can play an essential role in providing healthy social relationships and outlets to receive peer and social support.

From the provider's perspective, providers can be part of a community where they can learn from the community in which they serve, learn how to be advocates for their community, and effect change in practices and policies at their hospital or clinic to meet the needs of the community. Providers will also have the opportunity to educate and provide resources to community members. Additionally, providers will also have the opportunity to network with other healthcare providers to learn about best practices, referral services and systems, and patient advocacy concerns.

Community members stand to significantly benefit from patient-provider community forums as they will have access to stakeholders, resources, and knowledge readily available at their disposal. Thus, expanding the use of online communities for high-risk pregnancies is strongly recommended to increase knowledge and awareness about preeclampsia, improve patient-provider relationships, build community, and increase access to peer support relationships.

### Standardize and Establish Maternal Mortality Review Committees in Every State

Currently, the United States lacks a standardized mortality review process. Adopting practices that would help gather data about maternal mortality (i.e., pregnancy checkboxes on certificates) occurs in a staggard and inconsistent fashion. Improving surveillance of maternal mortality and morbidity is

needed to understand better various factors (i.e., innate, interpersonal, institutional, community, and policy factors) that contribute to preeclampsia and other high-risk pregnancy conditions.

Colorado's implementation of a Maternal Mortality Review Committee sought to maximize the use of grant funding from the CDC and Title V maternal and child health partners to reduce the amount of time it took for the state of Colorado to review the causes of maternal deaths. Having only been implemented in 2019, Colorado has since been able to act on emerging data and secure further grant funding for public health interventions and programs to reduce health inequities in maternal healthcare, morbidity, and mortality. Expanding and making available grant funding to establish maternal mortality review committees should be incentivized at the federal level to increase uptake of such grants to develop review committees.

Further, emerging maternal mortality and morbidity data can likely inform or guide research for interventions, management, and treatment for pregnancy-related hypertensive disorders.

### Improve Existing Prenatal Programs and Increase Program Referrals Among Providers

The Healthy Babies are Worth the Wait program revealed that there is an opportunity for providers to improve cultural competency, knowledge about risk, practices, and guidelines surrounding prenatal and postpartum care, and self-efficacy around accessing and using referral systems. Improving existing prenatal programs and increasing program referrals, where appropriate, would improve many factors at different level of the social-ecological model, primarily cultural attitudes and beliefs around seeking regular prenatal care, improving access and quality of prenatal care, minimizing fears of being judged by healthcare providers, and improving the patient-provider relationship. The benefit of improving existing resources and positively changing attitudes, behaviors, and knowledge of providers is that community resources are being utilized and community members – patients and providers – are involved in the healthy changes in their community. The latter is significant as the program is likely to be sustainable beyond the duration of the intervention.

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## Appendix A
## Logic Models

### MATERNAL MORTALITY PREVENTION PROGRAM - LOGIC MODEL

| Process | | | Outcomes | | |
| --- | --- | --- | --- | --- | --- |
| Inputs | Activities | Participants | Short-Term | Intermediate | Long-Term |
| • Funding from CDC and state of Colorado<br>• Maternal Health Manager<br>• Maternal Health Clinical Consultant<br>• Secondary Case Abstractor<br>• Maternal Mortality Data Analyst<br>• Perinatal Behavioral Specialist<br>• Program Assistant<br>• Special Projects Coordinator<br>• Maternal and infant Wellness Section Manager | Establishment of the Colorado Maternal Mortality Review Committee<br><br>Build partnerships and learn from communities experiencing high maternal mortality<br><br>Improve maternal patient safety<br><br>Development of community-led solutions<br><br>Adhere to Colorado's Mortality Prevention Program Framework | • Maternal Mortality Review Committee<br>• Maternal and Child health Community Advisory Board<br>• Community-based perinatal and birth providers<br>• State-level Title V maternal and child health partners and community partners | Timely review of each maternal death, regardless of cause, in the state of Colorado<br><br>Improvement of maternal mortality review process | Implementation of recommendations for clinical quality improvement<br><br>Identification of specific social determinants of health in communities | • Reduction of maternal mortality<br>• Improved maternal health and well-being<br>• Reduction in various disparities |

### HEALTHY BABIES ARE WORTH THE WAIT - LOGIC MODEL

| Process | | | Outcomes | | |
| --- | --- | --- | --- | --- | --- |
| Inputs | Activities | Participants | Short-Term | Intermediate | Long-Term |
| Steering Committee<br><br>Advisory Board<br><br>Executive Leadership Team<br><br>Ad-Hoc Workshops<br><br>Program Site Implementation Team<br><br>Electronic Communication Website<br><br>Shared Virtual Workspace<br><br>Evidence-based practice guidelines | Prenatal care clinical services<br><br>Referral and social support services<br><br>Home-visitation services (Nurse-Family Partnership)<br><br>Cultural competence training<br><br>**Media Campaign.** Development and dissemination of educational materials about preterm birth and associated risk factors | • Women of childbearing age living in Kentucky<br>• Family members and friends affected by the event of preterm birth<br><br>**Partners**<br>• Kentucky Department for Public Health<br>• March of Dimes<br>• Johnson & Johnson | • Improves knowledge and perceived behavioral control around preterm birth among pregnant women<br>• Improves knowledge and changes attitudes in the community around family planning and prevention of preterm birth<br>• Improves provider knowledge of referral services | • Adoption of behaviors among pregnant women and community members that prevent pre-term births | • Reduce preterm birth<br>• Reduce neonatal morbidity |

## CUFF KIT PROGRAM LOGIC MODEL

| Process | | | Outcomes | | |
|---------|---------|--------------|------------|--------------|-----------|
| **Inputs** | **Activities** | **Participants** | **Short-Term** | **Intermediate** | **Long-Term** |
| **Cuff Kit**<br>• Validated automatic blood pressure measuring device<br>• Patient education materials available in print, video, & web<br>• Blood pressure tracking logs<br>• "Still at risk" bracelet<br>• Staff education materials<br><br>**Staff & Other Materials**<br>• Statistician / Data Analyst<br>• Project manager<br>• Healthcare providers / Nurse educator<br>• Accounts payable department<br>• Tracking/distribution system for Cuff Kits<br>• Cuff Kit Connection online platform | **1.** Practice or provider determines need for Cuff Kits, completes order form, and distributes kits to high-risk pregnant women.<br><br>**2.** Provide instructions and trainings to providers on how to demonstrate use of cuff kits to patient.<br><br>**3.** Patients receives demonstration and educational materials on how to use Cuff Kit.<br><br>**4.** Optional monthly online discussions via Cuff Kit connection | **Participating Providers**<br>• OB/GYNs<br>• Hospitals and clinics<br>• Community health centers<br>• Federally Qualified Health Centers<br>• Public health clinics<br>• Nurse home-visiting programs<br><br>**Patients**<br>• Pregnant women with identifiable risk factors for developing preeclampsia | • Rapidly uses Telehealth for pregnant women who are either high-risk or at-risk for preeclampsia.<br><br>• Provides tools and educational materials for patients to monitor blood pressure at home.<br><br>• Engages both patient and provider in education about preeclampsia | • Improves patient-provider communication and relationship<br><br>• Improves patient knowledge and self-efficacy of monitoring blood pressure<br><br>• Utilization of data to inform treatment and improve program | • Increased patient engagement in managing healthcare<br><br>• Increased uptake of BP monitoring will allow for timely diagnosis and treatment of preeclampsia<br><br>• Reducing disparities in maternal and fetal health outcomes |

## MOMMA'S VOICES CHAMPIONS TRAINING CENTER - LOGIC MODEL

| Process | | | Outcomes | | |
|---------|---------|--------------|------------|--------------|-----------|
| **Inputs** | **Activities** | **Participants** | **Short-Term** | **Intermediate** | **Long-Term** |
| **Training and Support**<br>• Facebook community group<br>• Third-party online platform<br>• Training modules available online via Word, PowerPoint, and video formats.<br>• Community partnerships<br><br>**Staff**<br>• Coalition manager<br>• Project manager<br>• Graphic designer & Video editor<br>• Content contributors | Patient Family Partners (PFPs) undergo 4 training modules<br><br>Provision of supplementary training modules<br><br>Outreach to potential PFP stakeholders and patient advocacy organizations | **Patient Family Partners (PFPs)**<br>• Volunteers<br>• Providers<br>• Family members<br>• Friends<br>• Community members<br><br>**Patient Advocacy Organizations**<br>• Preeclampsia Foundation<br>• 2020 Mom<br>• Every Mother Counts<br>• Black Women's Health imperative<br>• Shades of Blue Project<br>• National Accreta Foundation<br>• AFE Foundation | • Promotes patient advocacy engagement in a virtual setting<br><br>• Promotes PFP self-efficacy in patient advocacy for improved maternity care<br><br>• Provides a space for healing and community belonging<br><br>• Certification of completion | • Improves understanding and emotional awareness of one's experience.<br><br>• Ability for PFPs to share their experience to effect change | • Impact and change how providers deliver maternity care and treatment<br><br>• Better communication and relationship between provider and patients receiving maternity care<br><br>• Reducing maternal morbidity and mortality |