**UNITED STATES: THE ONLY DEVELOPED NATION WITH
INCREASING MATERNAL MORBIDITY AND MORTALITY**

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In the spring of 2018, while I was studying for my midterm examinations, I received a call from my mother informing me that my friend passed away. She had just given birth a month ago to a beautiful little girl and was at home spending time with her family. Her husband went out to buy dinner but when he returned, he noticed his wife was unconscious and called for the ambulance immediately. Unfortunately, she passed away shortly after, and the autopsy showed that it was most likely due to postpartum cardiomyopathy. During that time, I was merely a biology student who was studying for the MCAT and did not truly comprehend how such a young healthy person could have passed so abruptly. Fast forward a few years later, an obstetric anesthesiologist, Dr. Katherine Arendt was giving a lecture about her specialty, and she briefly mentioned an increase in maternal mortality in the United States, especially among people of color. This triggered my curiosity and thus I decided to research this topic for my Women's Health Scholar's project.

To start this paper, there are a few terms that I would like to define. The Centers for Disease Control and Prevention (CDC) has 3 classifications for pregnancy-associated death. It defines pregnancy-related death as "the death of a woman while pregnant or within 1 year of termination of pregnancy, from any cause related to or aggravated by her pregnancy or its management, but not from accidental or incidental causes." For example, the death of a woman from postpartum hemorrhage or amniotic fluid embolism. It defines pregnancy-associated but not pregnancy-related death as "the death of a woman while pregnant or within 1 year of termination of pregnancy due to a cause unrelated to pregnancy." For example, the death of a pregnant woman from an earthquake. Lastly, it defines pregnancy-associated but undetermined if pregnancy-related death as "the death of a woman while pregnant or within 1 year of termination of pregnancy from a cause that cannot be determined or conclusively categorized as either
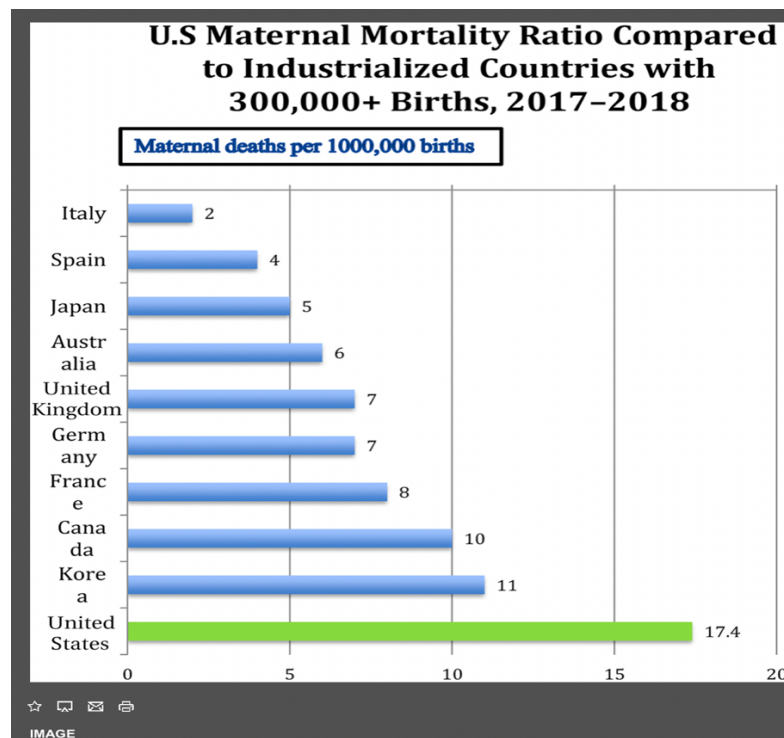
pregnancy-related or not pregnancy related." For example, a woman with an unknown mental health history dies at 6 months postpartum from a self-inflicted cause.[2]

The maternal mortality ratio (MMR) is used as the major metric to quantify and monitor maternal mortality globally. The World Health Organization (WHO) defines the maternal mortality ratio as "the number of maternal deaths per 100,000 live births, [where] maternal death is the death of a woman while pregnant or within 42 days of termination of pregnancy" for a specific period.[3] This, however, does not include deaths resulting from accidental or incidental causes. A late maternal death is defined as the death of a woman from direct or indirect obstetric causes, more than 42 days but less than one year after the termination of pregnancy.[3]
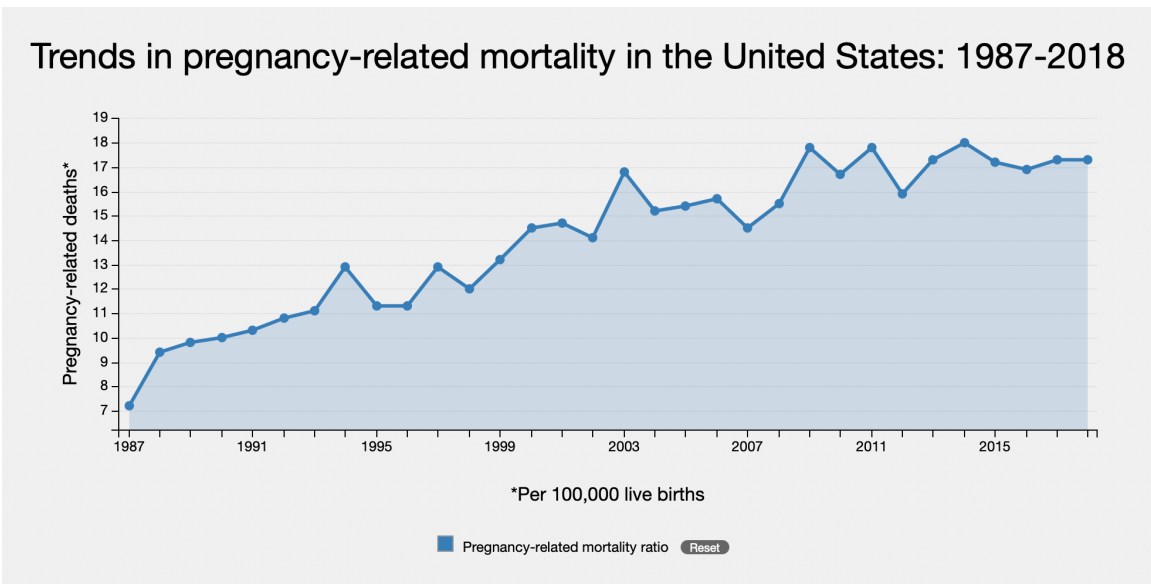
As one can imagine with the advances in technology and healthcare, various aspects of maternal health have improved in the past several centuries and decades. Back in the early 1900s, childbirth occurred naturally at home with the aid of midwives without the use of anesthesia. It wasn't until 1914 that the first maternity hospital was established, and doctors became more prominent in obstetrics. During this time, "Twilight Sleep" became a popular childbirth method that involved putting mothers to sleep using morphine and scopolamine, however, this placed mothers and newborns at higher risk of death. In the 1920s, doctors began to think childbirth was a pathological process and would routinely forcibly dilate the cervix, administer ether, cut an episiotomy, and delivered the baby using forceps. During this period, maternal and infant mortality rose significantly. In 1933, a report published by the White House Conference on Child Health Protection, Fetal, Newborn, and Maternal Mortality and Morbidity prompted major changes and implementation in policies and practice guidelines hoping to improve maternal mortality: during pregnancy, childbirth, and postpartum.[1] Slowly, as more research and understanding about childbirth came to light, major changes in the obstetrics world

prompted safer deliveries and better health outcomes. With the advancement in aseptic techniques, the use of antibiotics, oxytocin, safer anesthetics, improved blood transfusion techniques, and better management of pregnancy complications, maternal mortality drastically decreased by 71% from 1939 to 1948.[1]

Since advancements and changes were made, the MMR has declined drastically in the United States and worldwide, especially among developed nations. However, recent data has shown that the United States is the **only** developed nation with an increasing MMR. The following bar graph shows the MMR of the US compared to other developed nations in 2017-2018.[4] It is more than double the ratio of the United Kingdom which will be discussed a bit later in the paper. With the US having such advanced technology and a complex healthcare system, this prompts further investigation, and some reasons for this increased MMR will be explored in this paper.

U.S Maternal Mortality Ratio Compared to Industrialized Countries with 300,000+ Births, 2017–2018

Maternal deaths per 1000,000 births

Country	Value
Italy	2
Spain	4
Japan	5
Australia	6
United Kingdom	7
Germany	7
France	8
Canada	10
Korea	11
United States	17.4

IMAGE

Data from WHO showed that maternal mortality declined by 38% worldwide and by 53% in Europe from 2000-2017.[7] Maternal mortality is influenced by many factors such as advanced maternal age, higher cesarean delivery, better data collection, etc. To better understand the US trend in maternal mortality, it is pertinent to consider historical events that could have impacted MMR. Within the past few decades, data collection has become more computerized and reporting causes of death has also been more streamlined. This in turn results in improved detection and analysis. In 2003, the death certificate added a check box to report the pregnancy status of the deceased. As seen in the chart below, this could explain the tick in a significantly increased MMR during 2003.[5] This new death certificate could have potentially overestimated the number of pregnancy-related deaths by including pregnancy-associated but not pregnancy-related death or pregnancy-associated but undetermined if pregnancy-related death. However, this policy was not fully implemented in all states until 2016 so other factors could also contribute to the reason for the higher MMR. MacDorman et al. analyzed this policy factor and calculated an adjusted average MMR across the 48 states. The MMR was still estimated to have risen by 27% from 18.8 to 23.8 per 100,000 live births from 2000 to 2014.[6] In 2014, it was reported that complications during pregnancy, childbirth, and the postpartum period ranked as the 6th greatest cause of death among women aged 20-34 in the US. Thus, I believe this is a worthwhile issue that deserves our time and resources to address ways to decrease maternal mortality.

Trends in pregnancy-related mortality in the United States: 1987-2018

*Per 100,000 live births

■ Pregnancy-related mortality ratio   Reset

State-based maternal mortality review committees (MMRCs) are the gold standard in identifying and reviewing pregnancy-associated and pregnancy-related deaths. The MMRCs review prenatal records, hospital records, and autopsy reports. Two major national data sources, the National Center for Health Statistics (NCHS) and the Pregnancy Mortality Surveillance System (PMSS) are then used to collect data on maternal mortality.[5] The chart below is shown to compare the two databases as this is where most researchers have gathered their data from.[8]

TABLE.
Sources of Maternal Mortality Information in the United States

	NATIONAL CENTER FOR HEALTH STATISTICS (NCHS)	PREGNANCY MORTALITY SURVEILLANCE SYSTEM (PMSS)
Data source	Death certificates	Death certificates linked to fetal death and birth certificates
Time frame	During pregnancy to 42 days postpartum	During pregnancy to 365 days postpartum
Source of classification	ICD-10 codes	Medical epidemiologists assign PMSS codes
Terms	Maternal death	Pregnancy-associated death
		Pregnancy-related death
		Associated but not pregnancy-related death
Measure	Maternal Mortality Rate	Pregnancy-Related Mortality Ratio
	= # of maternal deaths per 100,000 live births	= # of pregnancy-related deaths per 100,000 live births
Purpose(s)	Show national trends and provide basis for international comparison	Analyze clinical factors associated with deaths, publish information that may lead to prevention strategies
Strengths	Best source of historical data (back to 1900)	Most clinically relevant national measure of the burden of maternal deaths
	Reliable basis for international comparison	
	Based on readily available data (death certificates)	
Challenges	Constrained by ICD-10 codes	Constrained by information available on death and birth certificates
	Lacks sufficient detail to inform prevention strategies	Lacks detailed information on contributors to death

ICD-10=International Classification of Diseases, 10th Revision.

In 2018, a report from 9 state MMRCs showed approximately 50% of all pregnancy-related deaths were caused by cardiomyopathy and other cardiovascular conditions, hemorrhage, infection, or chronic medical conditions.[5] I have attached a bar graph below that shows the leading causes of pregnancy-related death and sorted by the timing of death.[9] As one can see, the most common causes of death during the day of delivery are hemorrhage and amniotic fluid embolism. Meanwhile, cardiovascular events tend to occur more than 43 days after delivery. This is notable because the MMR includes death related to pregnancy or within 42 days of termination of pregnancy, thus often, does not include cardiovascular events.

Even more importantly, the report found that more than 60% of pregnancy-related deaths were preventable. Common contributors were patient/family factors such as the lack of knowledge about early warning signs to seeking care, provider factors such as misdiagnosis or ineffective treatment plans, and factors related to the healthcare system such as the lack of coordination between providers.[5] Ways to address these factors will be discussed later in the paper but first, I wanted to delve a bit more into each pregnancy complication causing mortality.


Leading causes of pregnancy-related death, by timing of death
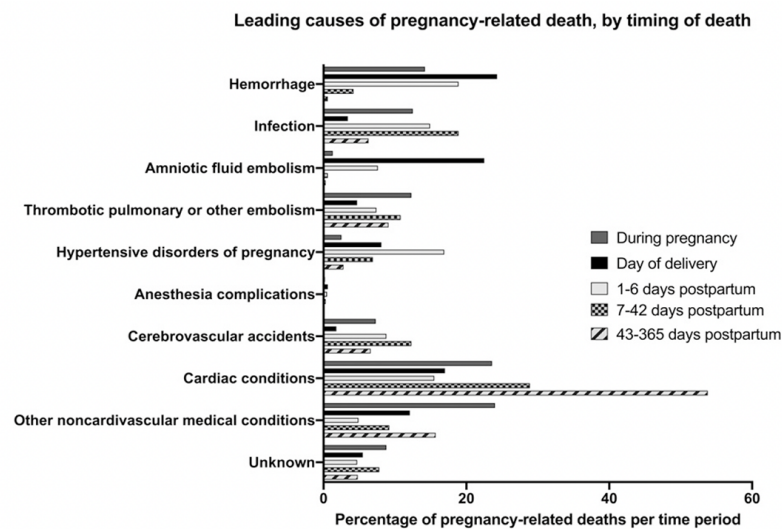
Leading causes of pregnancy-related death, by timing of death. Adapted from Petersen EE, Davis NL, Goodman D,etal. Vital signs: pregnancy-related deaths, United States, 2011–2015, and strategies for prevention, 13 states, 2013–2017. *MMWR Morb Mortal Wkly Rep*. 2019;68:423–429. Note: Cardiac conditions include both cardiomyopathy and other cardiovascular disease.

Cardiovascular complications are one of the most common causes of maternal mortality. From 2003 to 2012, there was a 25% increase in women who entered pregnancy with preexisting heart disease, thus making the pregnancy more high-risk.[5] The prevalence of cardiomyopathy and pulmonary hypertension also causes high mortality. Peripartum cardiomyopathy is defined as cardiomyopathy in which unexplained left ventricular systolic dysfunction and heart failure develop during pregnancy or postpartum in women without a history of heart disease. Some risk factors associated with increased risk for cardiovascular disease are increasing maternal age, obesity, and hypertensive disorders. Interestingly, the incidence is higher in African Americans in the US and high among women in African countries and Haiti.[4,10]

Another common cause of mortality is obstetric hemorrhage. This was the cause of 11.5% of pregnancy-related deaths from 2011-2014 and is usually preventable. Some of this could be attributed to increasing cesarean deliveries. The US average annual cesarean delivery rate rose from 23% in 1996 to 33% in 2011, without a corresponding reduction in maternal and neonatal morbidity or mortality.[5] This prompted the American College of Obstetricians and Gynecologists (ACOG) to implement guidelines for the safe prevention of primary cesarean to reduce the number of unnecessary cesarean deliveries. California has been at the forefront of such campaigns. Successful implementation of state-wide bundles across 99 diverse hospitals in California has demonstrated reductions in severe morbidity rates from hemorrhage by 20.8%.[11]

The bar graph below is data from 9 MMRCs in 2018, showing the proportion of pregnancy-associated death determined to be pregnancy-related death based on race and ethnicity.[5] In the United States, non-Hispanic black women have a 3-4 times higher rate of pregnancy-related death compared to non-Hispanic white women regardless of socioeconomic status and comorbidities. This finding was surprising and prompted me to investigate further to

see if some underlying causes could be attributed to this racial disparity. As mentioned earlier, African Americans tend to have a higher incidence of cardiovascular complications. Studies show that the most common underlying causes of death in non-Hispanic black women are pre-eclampsia, eclampsia, and embolism. The most common cause of death in non-Hispanic white women is mental health conditions.
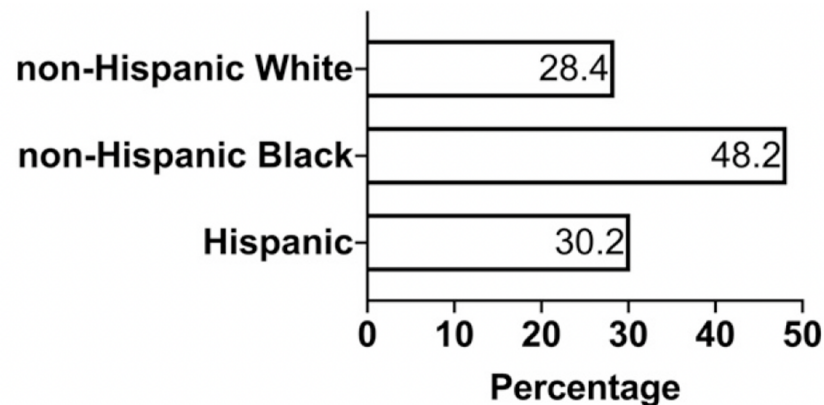
Proportion of pregnancy-associated deaths determined to be pregnancy-related based on race and ethnicity. Adapted from Building U.S. Capacity to Review and Prevent Maternal Deaths. (2018). Report from 9 maternal mortality review committees. http://reviewtoaction.org/Report_from_Nine_MMRCs. (22)

The map and graph below were pulled from the CDC's report on state strategies for preventing pregnancy-related deaths and data analyzed from 2014-2016.[23] As one can see, MMR varies in each region in the US with the highest MMR in region 4 and the lowest MMR in region 1. Based on the map of the regions, it seems that MMR is correlated to the population diversity in the regions. Moaddab et al completed a study that showed that there was significant variability in MMR from state to state and that these differences tended to correlate with the percentage of non-Hispanic black women in that state.[12] For example, Massachusetts (MA) had the lowest MMR at 5.6 maternal deaths per 100,000 live births compared to the District of Columbia's (DC) MMR at 38.8 maternal deaths per 100,000 live births. MA is ranked 25th in the states for the percentage of non-Hispanic black births while DC is ranked 1st. Surprisingly, DC has the

lowest MMR for non-Hispanic white births. Analysis showed that these disparities in maternal outcomes are not correlated to poverty, immigration, or rural status. In addition, this study showed that differences in hypertensive disease, diabetes, tobacco use, and obesity were not found to be significantly correlated with mortality ratios. This study showed that variations in MMR were more closely associated with factors such as unintended pregnancy, unmarried status, and being identified as non-Hispanic black.[12]
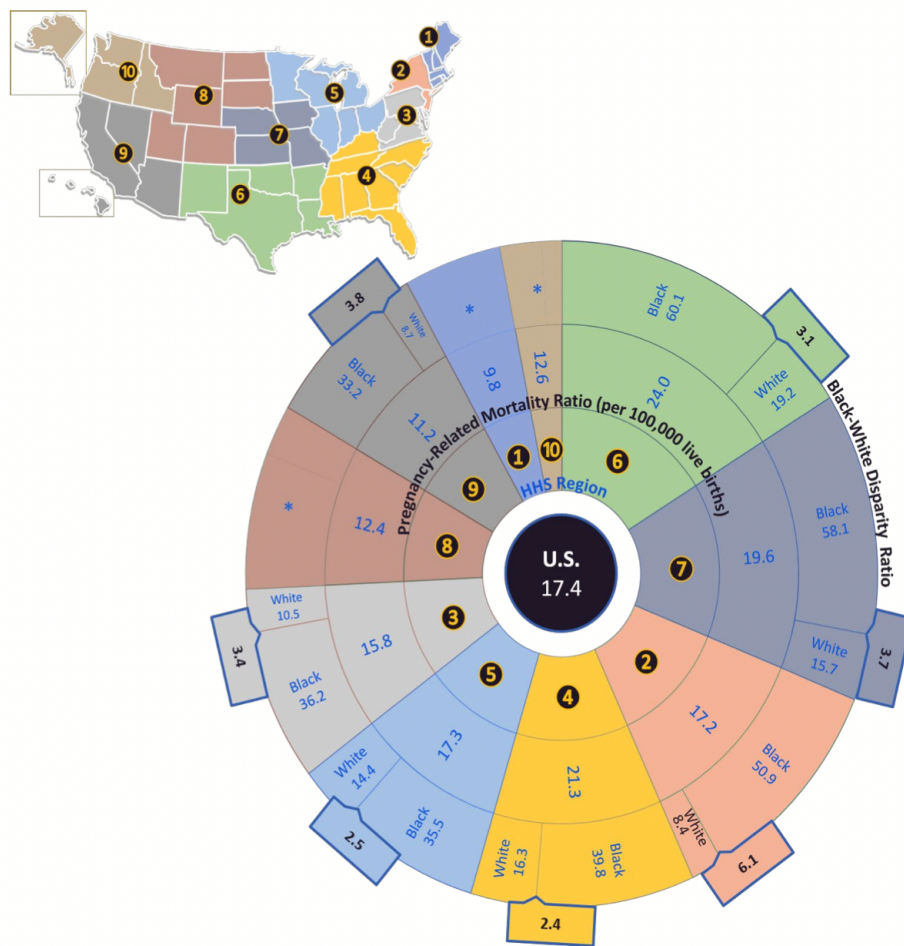
Note: *Race specific ratios and disparity ratio suppressed because at least one numerator count was <8.

Figure 6. Pregnancy-Related Mortality Ratio by U.S. Dept of Health & Human Services Region. Black-White Disparity Ratio, CDC Pregnancy Mortality Surveillance System 2014-2016.

In addition, Admon, et al found that severe maternal morbidity (SMM) during delivery hospitalization was higher among all racial and ethnic women compared to non-Hispanic white

women. Despite controlling for patient-level factors and the hospital of delivery to rule out confounding, racial and ethnic disparities in SMM persisted.[14] The incidence of SMM was highest for women with multiple chronic conditions.[13] It was found that blacks, Hispanics, and Asians had lower labor induction odds than whites. An episiotomy is a surgical cut that is made at the opening of the vagina during childbirth to help with a difficult delivery and was thought to prevent the rupture of tissues. However, this procedure has fallen out of favor amongst obstetricians because research has shown that it contributes to worse tearing.[15] Despite this, the odds of receiving an episiotomy were increased in Asians but decreased in blacks and Hispanics compared to whites.[14] This leads one to wonder if there might be some biases related to care delivery whether conscious or unconscious. Thus, implicit bias training is critical amongst healthcare workers to sensitize individuals to the role that it may play in their interaction and care for patients.

The CDC recently published a report on morbidity and mortality and found that more black women are dying in the postpartum period compared with other racial groups. As demonstrated by the graph prior showing the causes and timing of death, one could see that cardiomyopathy and cardiac conditions usually cause death months after delivery and incidence is higher in black women. This could partly explain CDC's findings, but the loss of affordable health insurance or access to care after the 6-week postpartum visit could also be contributory.

Collier, et al analyzed that the root cause of inequities in maternal health seems to be rooted in structural racism. They noted that one important driver of inequities is the historical and contemporary discrimination leading to distrust in the healthcare system. This results in the under-utilization of prenatal care and adherence to treatment plans. Furthermore, it results in a more severe presentation if there are complications associated with the pregnancy. Another

driver is the variation in hospital quality of care during childbirth. Women of color tend to go to hospitals with higher risk-adjusted morbidity compared with the hospitals that white women frequent.[5]

As mentioned before and in the chart below[5], we see that more than 60% of all maternal deaths are preventable. Seeing this maternal morbidity and mortality trend has prompted the government and professional organizations to take proper actions to reverse this trend. To address the variation in hospital quality of care, Collier, et al proposed three different mechanisms that are important to focus on: team communication and team training, implementation of evidence-based safety bundles or toolkits to manage complications most likely to cause maternal morbidity and mortality, and data-driven MMRCs that can provide specific recommendations for systems and quality improvement.[5] In addition, having multidisciplinary care for women with high-risk comorbidities during preconception care, pregnancy, postpartum, and beyond and addressing structural racism and social determinants of health could be ways to improve maternal health outcomes. Patient communication and education about early warning signs for medical complications of pregnancy could be helpful. The POST-BIRTH warning sign toolkit was created to improve the recognition of symptoms and medical evaluation especially postpartum.[16]
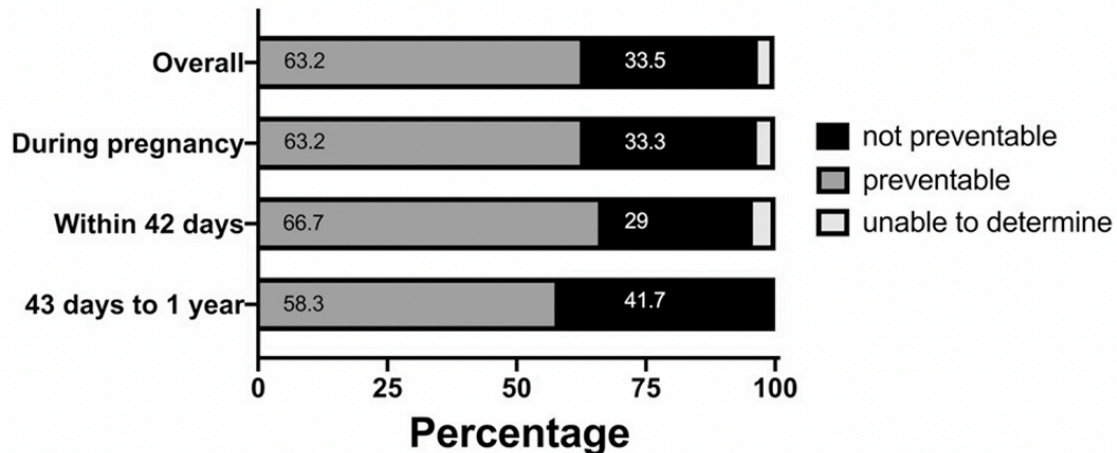
Preventability of pregnancy-related deaths by time of death in analysis of 9 state maternalmortality review committees. Adapted from Building U.S. Capacity to Review and Prevent Maternal Deaths. (2018). Report from 9 maternalmortality review committees. http://reviewtoaction.org/Report_from_Nine_MMRCs. (22)

Looking at another country's system might be helpful to craft ideas that the United States could use to help our worsening problem in maternal outcomes. The United Kingdom (UK) is a developed nation with an MMR of about half of that in the United States. The UK has used a national system called the Confidential Enquiries into Maternal Deaths to review maternal deaths for the past 60 years.[17] This system has helped further decrease maternal mortality and has been credited with narrowing the gap related to pregnancy outcomes and racial disparities. For example, the Enquiries have identified issues with communication and language barriers that can prevent women from ethnic minority backgrounds from receiving appropriate care and have recommended healthcare providers receive cultural competency training to improve communication and understanding of these women's needs. They incorporated such training into medical students, nursing students, and other healthcare trainees' curricula early on. They have also conducted evaluations of such programs to assess their effectiveness.[17]

One might say that the US also has a reporting system in place such as the state MMRCs and PMSS so what makes it unique in the UK? An analysis of the Confidential Enquiries conducted in 2018 showed that the actions and engagement of individuals and organizations at

all levels of both healthcare and political systems are needed to make an impact. The Royal College of Obstetricians and Gynaecologists and the Obstetric Anaesthetists Association run postgraduate course sessions regarding the works of the Enquiries early in the training of obstetricians, midwives, and anesthetists. Questions about appropriate recommendations and healthcare disparities are included in postgraduate examinations. Regional and national training packages are also developed to address these issues and disseminated across hospitals. Government involvement is also of utmost importance as the UK government created a "halve it" campaign to reduce its already low maternal deaths by 50% by 2030. In addition, voluntary organizations involved in maternal health help spread the messages in colloquial settings to ensure women are empowered to improve their care.[17] These methods have produced significant results in lowered MMR in the UK.

Focusing back on the US, we'll investigate what measures have been put in place. On December 21st, 2018, the government signed the Preventing Maternal Deaths Act (HR 1318) into law. This act allocates federal funding to support states in establishing and sustaining MMRCs. In addition, in 2021, the Maternal Care Access and Reducing Emergencies (CARE) Act was introduced to the senate to address maternal mortality and morbidity in the US. The bill proposed multiple measures including expanding Medicaid coverage for pregnant and postpartum women from 60 days to a full year after delivery. This bill also would provide funding for training and support for maternal care providers and the development of maternal health infrastructure in underserved communities. The bill would establish a grant program to support initiatives aimed at addressing social determinants of health such as housing and food insecurities. The bill also would establish a national standard for collecting and reporting maternal mortality and morbidity data and support programs and services that will address maternal mental health issues.[18] This

bill has broad bipartisan support and is critical towards improving maternal health outcomes in the US but so far, no further action has been taken. Currently, the onus on maternal health outcomes is on individual states.

California and Florida are two states that have been at the forefront of researching the issue of maternal morbidity and mortality. In 2020, a group of researchers published a study analyzing three public health program expenditures for all Florida counties from 2001 through 2014 to examine the effect of expenditures on MMRs using data from the Florida Department of Health.[19] One program is the Maternal Health and Improved Pregnancy Outcomes program which provided pregnancy testing, nurse home visits, depression screening, vitamin supplements, and educational material in English, Spanish, and Creole. Another program called Healthy Start helps women, infants, and children up to 3 years old with nutritional advice, psychosocial counseling, smoking cessation counseling, breastfeeding training, inter-conception education, and home visits. The third program is the Women, Infants, and Children which provides healthy foods, nutrition education, counseling, etc. To eliminate confounding, they accounted for the demographic characteristics, unemployment rate, personal income per capita, percentage of births covered by Medicaid, and the number of physicians and hospital beds per 100,000 people. Researchers found that the overall public health spending for these 3 programs did not yield any statistically significant effects on MMRs. However, they found a 10% increase in pregnancy-related public health spending led to a 13.5% decline in MMR among black mothers and a 20% reduction in the black-white maternal mortality gap.[19]

The California Maternal Quality Care Collaborative (CMQCC) was established in 2006 and is an organization that brings together healthcare providers, public health experts, and patient advocates to improve maternal outcomes. Since its establishment, it has managed to reduce the

state's MMR by 57% and by 50% for African Americans. They have accomplished this amazing feat by implementing several policies including improving access to maternal mental health care, establishing the California birth equity collaborative which aims to reduce health disparities and address social determinants of health, and adding paid family leave policies that allow new mothers to take up to 12 paid weeks off work.[20]

I was interested to see what Pennsylvania has done to address maternal health outcomes. It seems that in 2016, PA established an MMRC and quality improvement collaboratives that bring together experts to address this issue. Although it takes time to see significant changes in MMR, according to PA's Department of Health, the state MMR decreased from 15.6 deaths per 100,000 births in 2017 to 11.4 deaths per 100,000 births in 2018.[21] In 2019, PA launched a pilot program to increase access to doula services for Medicaid-eligible pregnant women. The aim was to provide support from a trained doula who can improve birth outcomes and reduce the need for medical interventions during childbirth. Mehta, et al reported that in Philadelphia, about half of maternal deaths were due to nonmedical causes such as unintentional injury from an overdose, motor vehicle accidents, homicides, and suicides.[22] Thus, I believe continual care throughout the pregnancy and even before conception is important.

The WHO has presented the objective of reducing global MMR from 2015 to 2030. I believe with the right tools and initiatives, the US will be able to significantly reduce its MMR. However, each state is unique and must tailor its public health programs according to its needs. Learning from the UK which has made a significant impact, there must have people and organizations who are invested in this issue to raise awareness and committed to improving maternal health outcomes, involved healthcare providers and hospital systems, continued

monitoring, evaluation, and refinement of initiatives to ensure effectiveness, involvement from

the government regarding policies, and engagement from the public.

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