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An American Crisis: An Analysis of Maternal Mortality Across the U.S.

Emily Fernandes
Assumption College

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An American Crisis: An analysis of maternal mortality across the U.S

Emily Fernandes

Faculty Supervisor: Colleen Fahy, Ph.D.

Economics Department

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Introduction

Approximately 700 women die each year in the U.S from pregnancy related complications. According to the Centers for Disease Control and Prevention (CDC), over 60 percent of these deaths are preventable. In other words, 420 maternal deaths could be prevented each year.

The World Health Organization (WHO) classifies a maternal death, "as the death of a woman while pregnant or within forty-two days of the end of pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes" (MacDorman, Declercq & Thoma, 2017, pg. 2). The U.S. maternal mortality rate is high internationally and according to WHO, the United States leads developed nations in maternal mortality. Figure 1 displays how the U.S. is an outlier for maternal mortality when compared to other countries.

Figure 1

Source: https://www.washingtonpost.com/news/wonk/wp/2015/11/18/our-maternal-mortality-rate-is-a-national-embarrassment/?noredirect=on&utm_term=.8fe48b55e5fe

Not only is the U.S. high by international standards, maternal mortality has increased by 26.6 percent from 2000 to 2014 even though the U.S. spends more on healthcare than any other country in the world (MacDorman, et al, 2016). In 2017, the average American spent $10,224 on healthcare, the most per capita in the world. The comparable country averaged only $5,280 per person, meaning the U.S. spends 50 percent more on healthcare than the average comparable country (Cox & Sawyer, 2017). How can a country that spends the most money on healthcare have the highest maternal mortality rate in the industrialized world?

The CDC issued a report in May 2019 outlining the main causes of a pregnancy-related death and the time of occurrence. From 2011 to 2015, thirty-one percent of deaths happened during pregnancy. Over thirty-six percent of deaths happened at delivery or the week after and about 33 percent happened one week to one year postpartum (Pregnancy-Related Deaths Happen, 2019). More deaths are actually occurring outside of the delivery room, meaning women are dying from pregnancy-related complications in our communities. As shown in Figure 2, heart disease and cardiovascular conditions are the leading cause of deaths in pregnant women. Obstetric emergencies, such as, severe bleeding and amniotic fluid embolisms cause the most deaths at the time of delivery, whereas; severe bleeding, high blood pressure and infection are the most common causes of death the week after delivery. Cardiomyopathy, which is a weakened heart muscle is the leading cause of deaths one week to one year after delivery (Pregnancy-Related Deaths Happen, 2019). The majority of these deaths could have been prevented with proper surveillance and medical care throughout their entire pregnancy.

Figure 2

Causes of pregnancy-related death in the U.S: 2011-2016
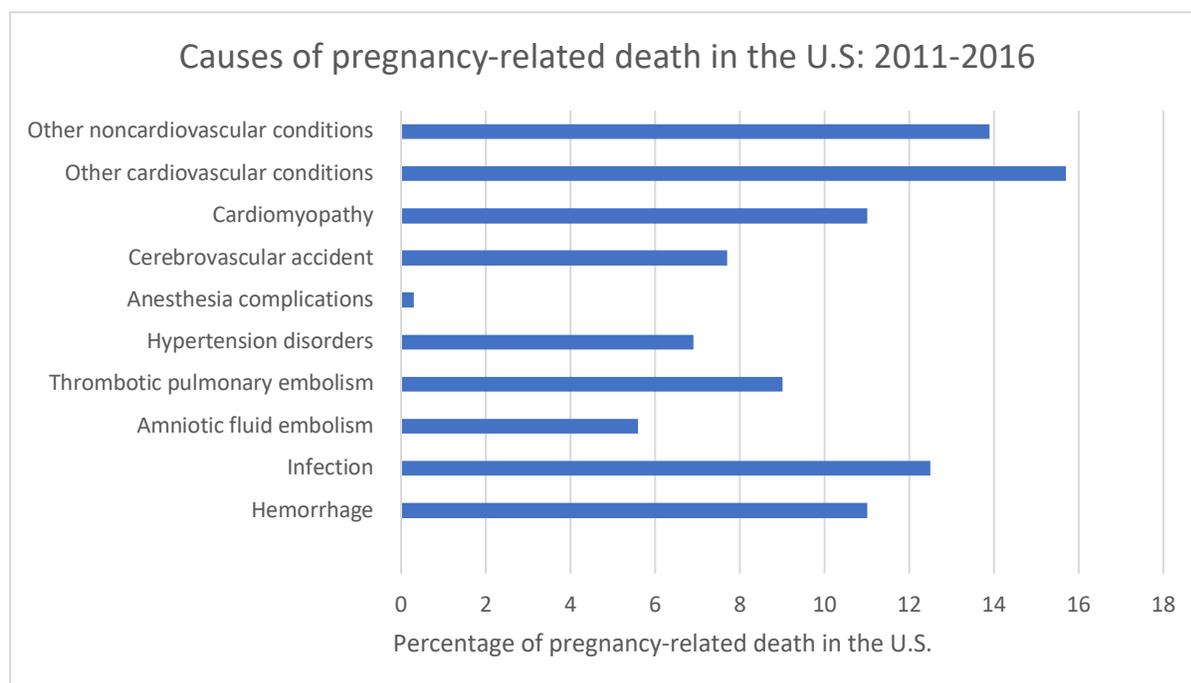
Source: Pregnancy Mortality Surveillance System, United States, 2011-2016,
https://www.cdc.gov/reproductivehealth/maternal-mortality/pregnancy-mortality-surveillance-system.htm

Maternal mortality rates vary considerably across U.S. states. For example, Georgia has the highest maternal mortality rate in the country with 39.3 deaths per 100,000 births. On the other hand, Massachusetts has a rate of 5.8 deaths per 100,000 births, the lowest in the country. New Jersey, Arkansas, Louisiana, Indiana, and Texas each have maternal mortality rates over 30, whereas, California, Nevada, and Maine are below 10 deaths per 100,000 births. State-level laws differ immensely, especially in insurance policy and hospital review boards.

Research conducted on the American healthcare system, pregnancy complications, maternal factors and postpartum care aims to help public health officials understand why the mortality rate is high by international standards and increasing over time. Mothers deserve the best possible medical care, regardless of age, socioeconomic status, race or background. Making

maternal health services a priority in hospitals and health systems is critical because complications pose a serious economic threat to patients and communities. The purpose of this thesis is to determine what factors have a significant effect on maternal mortality rates across the U.S and to devise policy recommendations to help reduce pregnancy-related deaths.

Literature Review

Data Classification

The National Vital Statistics System compiles maternal mortality data from state level death certificates (MacDorman, Declercq, &Thoma, 2017). The American College of Obstetricians and Gynecologists (2015) cited reports that found a 39 to 93 percent rate of under-reporting of maternal deaths in the U.S. largely because U.S. death certificate lacked standardized reporting of maternal deaths before 2003. Therefore, in 2003, the U.S. added a pregnancy-related question to the standard death certificate to provide better measurements for tracking maternal deaths (MacDorman, et al., 2016).[1] For reference, Figure 3 displays the pregnancy-related check box system on the revised standard certificate.

Figure 3
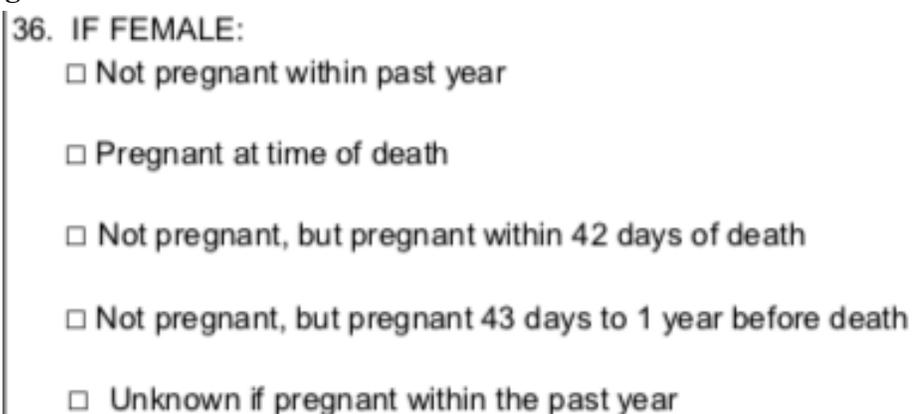
36. IF FEMALE:
   ☐ Not pregnant within past year

   ☐ Pregnant at time of death

   ☐ Not pregnant, but pregnant within 42 days of death

   ☐ Not pregnant, but pregnant 43 days to 1 year before death

   ☐ Unknown if pregnant within the past year

Source: Center for Disease Control and Prevention. U.S. Standard Certificate of Death.
https://www.cdc.gov/nchs/data/dvs/death11-03final-acc.pdf

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[1] However, Alabama and West Virginia have not implemented the changes leading to discrepancies and inconsistencies between states.

The U.S. vital statistics data depends entirely on the accuracy of the checkbox system. Using this system to report maternal deaths may not provide better data because it may lead to unintentional mistakes such as over-reporting. For instance, a person may inadvertently check-off the incorrect box on the death certificate, leading to false mortality data. Over the past decade, the large increase in maternal deaths across the U.S. has been attributed to over-reporting, perhaps by as much as eighty percent. However, even after allowing for over-reporting, medical research studies concluded that rates are significantly higher in the U.S. than other industrialized countries, as shown in Figure 4 (MacDorman, Declercq, Thoma, & 2017). A study compared the maternal mortality rate in the U.S. to Sweden, the United Kingdom and France, and found that despite over-reporting, the U.S. rate increased while the other countries decreased, making the U.S. still high by international standards (MacDorman, et al. 2016).

Figure 4

Source: https://www.npr.org/2017/05/12/528098789/u-s-has-the-worst-rate-of-maternal-deaths-in-the-developed-world
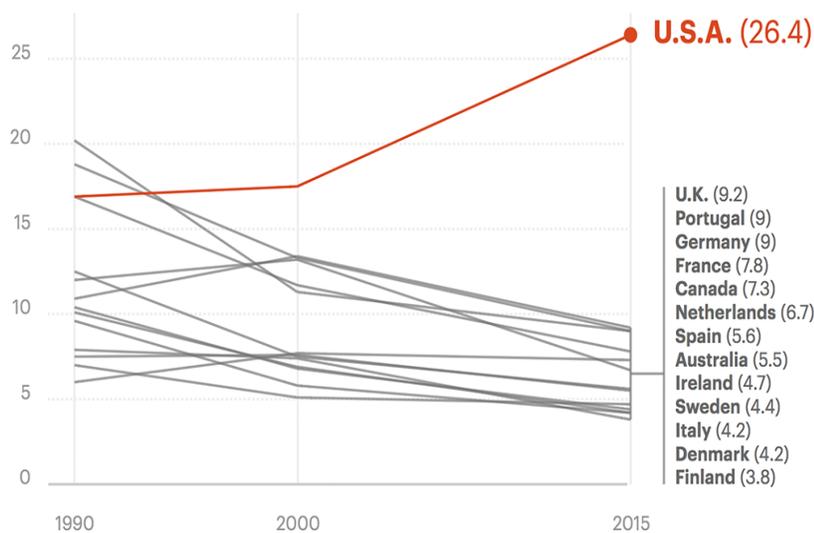
Though the problems associated with the data quality and classification system for maternal deaths continue to perplex researchers, they all agree that the U.S. has not improved

maternal mortality in decades. The overall goal of the research continues to be reducing maternal mortality. The U.S. has not officially published a federal maternal mortality rate in over a decade, meaning data is solely relied on the accuracy of state data management.

Maternal Factors

According to WHO, maternal mortality refers to the death of a woman while pregnant or within 42 days of pregnancy (Measure Evaluation, 2015). A late maternal death occurs within 43 days to one year after pregnancy. Maternal deaths can fall into two groups: direct and indirect obstetric deaths. A direct obstetric death result from pregnancy complications caused by interventions, omissions, or incorrect treatment. An indirect obstetric death results from preexisting disease that is not caused by pregnancy, but the condition was aggravated by the effects of pregnancy. Most maternal deaths occur post-partum, not in the delivery room, meaning the risk of dying from pregnancy increases after a woman gives birth. According to the CDC Foundation (2017), the leading cause of maternal deaths are hemorrhage, cardiovascular conditions, infection, preeclampsia and mental health conditions. I will review the literature on each of these causes in a later discussion of pregnancy complications. First though, two particular factors present dangerous consequences for women during pregnancy and may lead to the increase in maternal mortality in the U.S: prenatal care and age.

Prenatal care is essential for the overall health of the mother and the baby. Over one third of the women who die from pregnancy complications did not receive prenatal care (Creanga, 2018). According to the Eunice Kennedy Shriver National Institute of Child Health and Human Development (2018), prenatal care involves health visits with a health care provider such as, physical exams, ultrasounds and discussions of the mother's health. To reduce the risk of pregnancy complications, health care providers recommend women stay active, avoid exposure

to harmful substances, eat a healthy diet and consume supplements. Women who do not receive prenatal care are three to four times more likely to die from complications (Neggers, 2016). Women lacking prenatal care have a higher risk of dying from pregnancy-related causes.

Reports show how maternal mortality increases with age. Women aged twenty-five to twenty-nine are less than half as likely to die from pregnancy-related causes compared to women aged thirty-five to thirty-nine (Neggers, 2016). Women over forty have the highest rates of maternal mortality, with a risk factor five times greater than the younger population (MacDorman, Declercq, Thoma, & 2017). Advanced reproductive and medical technology allows women the opportunity to conceive later in life. (Highsmith, 2015). Advanced maternal age results in high-risk pregnancies because of the adverse pregnancy outcomes in older women. Older women are more likely to develop gestational diabetes, placenta previa, postpartum hemorrhaging, and require emergency C-sections, all of which have higher instances of maternal deaths. Over the last few decades social, educational and economic factors accounted for an increase in the number of delayed pregnancies. Maternal age is a determining factor in understanding why maternal mortality is increasing.

Pregnancy Complications

Cesarean-sections, obstetric hemorrhage and preeclampsia are among the leading causes of pregnancy complications, which have higher risks of maternal mortality. C-Sections have a higher risk for complications than vaginal births due to surgical and post-operative complications; including infections and amniotic fluid embolisms. The number of cesarean deliveries has grown by over 500 percent since the 1970s (Kaplan, 2019). A C-Section is a major surgery and patients are at risk for blood loss, requiring transfusions which can cause major infections. Furthermore, C-Sections pose a risk for adverse reactions to medications and

dangerous embolisms during and after surgery (March of Dimes). The World Health

Organization (Molina, 2015) recommends national rates for C-Sections not to exceed ten to

fifteen per one hundred live births. Over the past decade, the rate of C-Sections grew to more

than nineteen per one hundred births with studies suggesting a potential overuse of this

procedure. Overuse may be explained by advanced diagnostic technology, obstetrician lawsuits

and elective C-Sections (Clapp, 2014). The medical community considers C-Sections a life-

saving practice for high-risk pregnancies, but the U.S. conducts more C-Sections for

convenience and efficiency than for medical necessity. Obstetricians need to avoid the overuse of

this procedure in order to decrease maternal mortality.

The most preventable type of maternal mortality is obstetric hemorrhage (Creanga,

2018). Maternal mortality increases when women lose a significant amount of blood after

childbirth. Studies in hospitals conclude that medical staff need to quantify blood loss and

actively monitor women closely after they give birth to avoid dangerous outcomes. For example,

a USA Today study (Young, 2018, pg. 2) discovered "as many as 93% of women who bled to

death during childbirth could have been saved if hospital staff had been aware of how much

blood the woman lost." To reduce maternal mortality from preventable causes, the California

Maternal Quality Care Collaborative developed a tool kit for hemorrhage to decrease post-

partum deaths. Improving responses to obstetric hemorrhage is necessary in lowering maternal

mortality (Main, 2017).

Cardiovascular conditions in pregnant women also have a significant effect on maternal

mortality. Preeclampsia, or high blood pressure during pregnancy, is a common condition in

pregnant women. The number of deaths from hypertension has fallen over the past few years, but

women continue to die from missed signs and diagnoses (Ghulmiyyah, & Sibai, 2012). Severe

preeclampsia called hemolysis, elevated liver enzymes and low platelets (HELLP) syndrome increases the risk of maternal death. As many as 48,000 women will develop HELLP syndrome in the U.S. each year. Early detection and close monitoring are essential in treating hypertension disorders in pregnancy (Ghulmiyyah, & Sibai, 2012). However, women with diabetes, heart diseases and obesity are at an even greater risk for death if the conditions are left untreated (Neggers, 2016). Proper recognition and early diagnosis will help to reduce or eliminate the risk of maternal death from cardiovascular conditions.

Post-partum Care

More women die post-partum than in the delivery room. Post-partum care in the U.S. focuses more on the baby than on the pregnant woman. Over twenty hospitals in the U.S. created fetal care centers for babies with high risk medical conditions, but only one hospital developed a program for high-risk mothers. Kaplan (2019) found that maternal health advocates believe doctors and nurses are often unprepared for maternal complications and take hospital discharges in the maternity ward too lightly. During discharges, women are told how to breastfeed and what to watch for if their newborn gets sick; however, the mothers often miss key information on how to care for themselves after birth. To prevent post-partum complications, mothers need to monitor their blood pressure, blood loss, infection, chest pain and other side effects. Greater emphasis on the care of the mother, not just the baby, is essential to combatting maternal mortality.

Maternal mental health deserves a prominent place in the maternal mortality conversation. When a woman commits suicide during pregnancy or one year after pregnancy, the death is classified as a maternal death. A study last year found that in over seven percent of maternal deaths women reported cases of mental health conditions (Clasp, 2018). The stress of

becoming a new mother has a drastic impact on the mental well-being of the mother. Many women may develop postpartum depression, which is categorized as feelings of anxiety, sadness and hopelessness. But, because of the stigmas surrounding mental health care, they do not seek help and mental health conditions go undiagnosed. Pregnant women and mothers with mental health problems often have poor physical heath and a greater likelihood for high-risk behaviors such as, alcoholism (Clasp, 2018). Maternal mental health becomes a risk factor for pregnancy-related complications.

Healthcare System

Medical errors pose a dangerous threat to maternal health, as well as, the health of the baby. According to the CDC Foundation from Maternal Mortality Review Committees (2017), around 60% of maternal related deaths are preventable. In many maternal deaths, health care providers failed to recognize early signs in the patient's condition. Human error is inevitable in health care because health providers make mistakes due to many different factors. Outdated notions are a common practice in some obstetric offices. In some cases, for example, doctors believe delivering the baby will alleviate stress on the mother and cure her medical condition. (Martin, Montagne, 2017). Lack of crisis preparation and poor coordination of care can hinder maternal health services. The U.S. does not have a federal standardized policy or maternal review committee, leaving all efforts to the state-level. State-level practices are not uniform and vary across the fifty states due to lack of funding or differing opinions (Martin, & Montagne, 2017). Lastly, some studies have uncovered a "weekend effect" in the health sector, concluding that weekend care is associated with inferior outcomes compared to weekdays (Zapf, 2015). Pregnant women are unable to control these types of medical errors and decision-making, but these factors are immense threats to their well-being.

Accessibility to health insurance is an instrumental factor in providing beneficial

maternal health services. The main purpose of health insurance is to provide protection against

financial risk (Comfort, Peterson, & Hatt 2013). According to the Henry J. Kaiser Family

Foundation, over one in ten women in the U.S. lacked insurance in 2017 (2018). Women without

health insurance have inadequate access to medical care due to high costs. Such financial barriers

also play a role in maternal mortality because the uninsured population does not have easy access

to health services. For instance, women may not go to the hospital for a monthly appointment if

the costs are expensive, meaning doctors cannot treat preventable problems with pregnancy.

Pregnant women may be afraid of going the hospital if they have cramps or pain due to concerns

of high medical bills.   However, pain and discomfort during pregnancy can be signs of a

dangerous underlying medical issue that should not be ignored. According to The American

College of Obstetricians and Gynecologists, uninsured mothers receive fewer options for

prenatal care and are unaware of high-risk pregnancy factors (ACOG, 2015). Lack of insurance

and access to maternal health services lead to critical and problematic pregnancy outcomes.

Women living in rural areas may have inadequate access to healthcare and experience

poorer health outcomes than women living in urban areas. Rural areas have limited access to

women's health providers due to location. The American College of Obstetricians and

Gynecologists (2014) reported over 49% of the 3,143 U.S. counties did not have a practicing

obstetrician-gynecologist. Women living in rural communities travel substantially longer

distances to receive maternal health services, with over 87.6% of rural women travelling over

one hour (ACOG, 2014). Lack of care due to distance is a barrier for women to receive prenatal

and postpartum care, leading to higher risks in labor complications and other pregnancy-related

conditions. First trimester prenatal care for women in rural areas is significantly lower than for

women living in urban communities. After controlling for maternal variables, a medical study concluded woman residing in rural areas had higher rates for low birth weight and preterm births. Time is of the essence during pregnancy complications because a woman may not survive the hour-long car ride to receive care from an obstetrician. The health services accessibility disparity between rural and urban communities demonstrates the social risk of living in a certain area and how rural women are at a higher risk for maternal mortality than their urban counterparts.

Race Disparity

In New York City, black women are twelve times more likely to die due to a pregnancy-related complication than white women (Howell, 2016). Minority women deliver in lower-quality hospitals than their white counterparts, but why is this happening? Hospital data is complex, but some factors could be: distance to hospital, access to insurance, patient choice and physician referral (Howell, 2016). In one study, researchers discovered nearly 1,000 black women could avoid a "severe morbid event" if they delivered in the same hospitals as white women (Howell, 2016). A great deal of the race disparity in the healthcare system relates to socioeconomic factors; however, a significant portion may be directly related to race and biases.

Overall, black women are three to four times more likely to die from pregnancy complications than white women because physicians are susceptible to implicit biases. (Creanga, 2018). Racial disparities are still a prevalent issue in the healthcare system today due to unconscious or implicit biases towards certain individuals. An implicit bias is defined as, "an unconscious and involuntary attitudes which lie below the surface of consciousness, but can influence and affect, behavior and cognitive processes" (Maina, Belton, Ginzberg, & Johnson, 2018). An unconscious bias occurs when a cultural stereotype influences how an individual

processes information, leading to unintended biases (Chapman, Kaatz, & Carnes, 2013). The Implicit Association Test (IAT) measures implicit biases by asking participants to pair social groups with positive and negative attributes. After accounting for economic and educational differences, studies concluded that doctors perceive black patients in more negative terms than white patients. Additionally, in hypothetical medical recommendations, black patients' medical course of action differed from their white counterparts, despite the exact same symptoms (Zestcott, Blair, & Stone, 2017). Many times, despite the intention to provide equal treatment, health care providers make decisions and medical recommendations with unconscious biases towards certain races or general appearances. Black mothers are especially vulnerable, with a higher risk of mortality due to the vast racial disparities in the healthcare system.

Methodology

Description of Data

The purpose of this research is to determine which risk factors, racial barriers and pregnancy complications have a significant effect on the number of maternal deaths each year across U.S. states. To do so, I will develop a statistical model for maternal mortality and use state-level data to try and identify important factors. Results are estimated using STATA, a statistical package software, to analyze data and run regression analysis.

Ten variables are included in this model; one dependent variable and nine independent variables. In this model there are forty-eight observations taken from 2016 state-level data.[2] The objective of this study is to determine if certain factors have an impact on the maternal mortality rate; therefore, the dependent variable of the model is the maternal mortality rate by state. The CDC defines the maternal mortality rate as a measure of the number of deaths from any cause

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[2] Alaska and Vermont do not publish maternal death and therefore, were dropped from the model.

related to pregnancy or its management during pregnancy and childbirth or within 42 days of

termination, per 100,000 births (American Health Rankings, 2016).

The variable on maternal age is measuring births per 1,000 women by age of mother,

where the mother is over 35 years old at the time of birth (CDC, 2016). I predict the coefficient

on the percentage of births of women over 35 years old to be positive. Medical research has

found higher instances of maternal deaths when the mother is considered to be of advanced

maternal age. I expect that when the population of women conceiving over age thirty increases,

the number of women who die while giving birth will rise.

The uninsured variable is defined as the percentage of women ages 18 to 44 who are not

covered by private or public health insurance (American Health Rankings, 2016). The coefficient

on the percentage of uninsured women is predicted to have a positive effect on the maternal

mortality rate. The greater the number of uninsured women, the greater the number of maternal

deaths due to lack of access to affordable care. People without health insurance have inadequate

access to medical care due to cost. Additionally, pregnant women may be afraid of going to the

hospital if they have cramps or pain out of fear of such high medical bills.

The variable on the cesarean delivery rate measures the percentage of all live births that

were C-Sections (CDC, 2016). The coefficient of the cesarean delivery rate for women should

have a positive effect on maternal mortality. C-Sections have a higher risk of mortality than

vaginal births due to surgical complications and infections. I believe the number of C-Sections

will have a significant impact on maternal deaths since the U.S. is conducting more C-Sections

than medically necessary.

To measure the race disparity in maternal health services, I will look at the percentage of

births by black women (Kids Count, 2016). I believe the coefficient on this variable will be

positive due to the implicit biases health care providers have towards black women. Past studies indicated black women are at a higher risk of maternal death due to racial disparities and lack of access to quality hospitals.

The variable on prenatal care measures the percentage of women who began prenatal care in their first trimester (CDC, 2016). I believe the coefficient on this variable will be negative because prenatal care can help prevent complications and helps to ensure a healthy pregnancy.

To account for medical care access in rural areas, I will include a variable looking at hospitals per square mile. I predict the coefficient on hospitals per square mile to be negative. The greater the distance between hospitals means women may have a harder time with access to medical care in an emergency.

Lastly, I will include two dummy variables in my regression analysis. A dummy variable is set to equal 0 or 1 because it measures the absence or presence of a variable. For example, I want to include states that have not adopted the checkbox system on the death certificate as an independent variable. In my model, I would use a 0 for states without the checkbox system and a 1 for states with the checkbox system. I believe states without the checkbox system will have a negative effect on maternal mortality because they have a higher chance of underreporting maternal deaths. In addition, including a dummy variable on states with a maternal review board will be important to my analysis. States with a maternal review board have better protocols and systems in place for maternal deaths and pregnancy complications. Therefore, I believe the coefficient on states with a review board will have a negative effect on the maternal mortality rate.

Table 1: Summary Statistics

Number of Observations= 48	Mean	Median	St. Dev.	Minimum	Maximum
Maternal Mortality *(deaths per 100,000 births)*	19.68	18.30	8.28	5.80	39.30
C-Section *(Percentage of live births that were C-Sections)*	30.77	31.05	3.75	22.30	38.20
Uninsured Women *(Percentage of women ages 18-44 not covered by private or public insurance)*	15.57	15.55	5.28	3.60	28.30
Obesity *(Percentage of women ages 18-44 with a BMI over 30)*	26.66	26.20	4.11	18.50	36.60
Race *(Percentage of live births by black women)*	13.48	12.00	10.39	1.00	42.00
Maternal Age *(Births per 1,000 women over 35 years old)*	15.41	14.47	4.18	9.20	25.87
Prenatal Care *(Percentage of women who began prenatal care in 1st trimester)*	77.58	77.60	4.51	67.00	85.60
Hospitals per square mile *(Percentage of hospitals per square mile)*	0.002	0.002	0.003	0.000	0.011
Data Classification *(States with the check-box system)*	0.96	1.00	0.20	0.00	1.00
Maternal Review Board *(States with a maternal review board)*	0.63	1.00	0.49	0.00	1.00

Table 1 displays the summary statistics of the variables included in the model. Throughout the data, Massachusetts consistently led the country in health statistics. For example, the state had the lowest maternal mortality rate, uninsured women, and obesity rate. Massachusetts' maternal mortality rate for 2016 was 5.8 deaths for every 100,000 births in the state. On the other hand, Georgia had the highest rate in the country with 39.3 deaths for every 100,000 births. Texas leads the country in lack of insurance with 28.3 percent of women without insurance in the state. In addition, Mississippi has the highest C-Section rate, obesity rate and percentage of black women giving birth in the country.

After testing for outliers and missing variables, I had to test for multicollinearity and heteroskedasticity. To test for multicollinearity, I found the simple correlation coefficients for the independent variables.

Figure 5: Correlation between independent variables

```
. corr csection uninsuredwomen obesity race maternalage prenatalcare hospitalspe
> rsquaremile hospitalspersquaremile dataclassificationchange maternalreviewboar
> d2016
(obs=48)

             |  csection uninsu~n  obesity     race matern~e prenat~e hospit~e
-------------+------------------------------------------------------------------
    csection |   1.0000
  uninsuredw~n|   0.2422   1.0000
     obesity |   0.3830   0.4112   1.0000
        race |   0.6263   0.2816   0.4781   1.0000
  maternalage|   0.0654  -0.4585  -0.7601  -0.0895   1.0000
 prenatalcare|  -0.1758  -0.6093  -0.4669  -0.3228   0.4124   1.0000
  hospitalsp~e|   0.4222  -0.3558  -0.2354   0.2160   0.6299   0.2118   1.0000
  hospitalsp~e|   0.4222  -0.3558  -0.2354   0.2160   0.6299   0.2118   1.0000
  dataclassi~e|  -0.2177  -0.0113  -0.3203  -0.0714   0.2831   0.0973   0.0526
  materna~2016|   0.2615   0.0247   0.0202   0.2997   0.1911  -0.1586   0.1083

             |  hospit~e datacl~e mat~2016
-------------+---------------------------
  hospitalsp~e|   1.0000
  dataclassi~e|   0.0526   1.0000
  materna~2016|   0.1083   0.0538   1.0000
```

In Figure 5, the number of variables that are highly correlated showcase that there is multicollinearity throughout the model. For example, obesity is highly negatively correlated with maternal age because it has a correlation coefficient of -0.76. The multicollinearity associated with this model is irresolvable, meaning if one variable is left out, there will be omitted variable bias, which is a violation of the Best Linear Estimate (BLUE) principle. The further implications of this multicollinearity will be discussed later.

In addition, to test for heteroskedasticity, I ran the Breusch-Pagan and Modified White's tests in Stata. Heteroskedasticity refers to a non-constant variation in the error term. As shown by Figure 6, both tests had p-values greater than 10 percent, meaning that we conclude an absence of heteroskedasticity in the model.

Figure 6: Testing for Heteroskedasticity

```
. hettest csection uninsuredwomen obesity race maternalage hospitalspersquaremil
> e dataclassificationchange maternalreviewboard2016, fstat

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
        Ho: Constant variance
        Variables: csection uninsuredwomen obesity race maternalage
                   hospitalspersquaremile dataclassificationchange
                   maternalreviewboard2016

        F(8 , 39)     =      0.75
        Prob > F      =    0.6439

. estat imtest, white

White's test for Ho: homoskedasticity
        against Ha: unrestricted heteroskedasticity

        chi2(45)      =     43.66
        Prob > chi2   =    0.5289

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	43.66	45	0.5289
Skewness	2.91	9	0.9678
Kurtosis	0.47	1	0.4927
Total	47.04	55	0.7688

Results

  The model had an adjusted R^2 of 50.8 percent; therefore, 50.8 percent of the variation in maternal mortality is explained by the variation of the independent variables. The overall significance of the model is significant because Significant F= 0.000017, meaning at least one variable is significantly affecting maternal mortality. As shown in Table 2, two of the variables are statistically significant at a confidence interval of 1 percent, one variable is statistically significant at 5 percent, and two variables are significant at 10 percent.

Table 2: Ordinary Least Squared Estimates

Dependent Variable: Maternal Mortality		
Independent Variable	*Coefficient*	*P-value*
Intercept	42.21	0.150
C-Section	0.02	0.952
Uninsured Women	0.45[c]	0.067
Obesity	0.03	0.952
Race	0.01	0.957
Maternal Age	-1.08[b]	0.044
Prenatal care	-0.44[c]	0.096
Hospitals per square mile	1739.33[a]	0.003
Data Classification	14.51[a]	0.004
Maternal Review Board	2.85	0.152

a. Significant at 1%
b. Significant at 5%
c. Significant at 10%

The variable on the C-Section rate, obesity rate, and race variables were not statistically significant in this model, with P-values equal to 0.95. As previously shown in Figure 5, the C-Section rate was highly correlated with the race and hospitals per state variables. The race variable had high correlation with prenatal care, maternal age and obesity. In addition, the obesity variable was highly correlated with race, maternal age and prenatal care. The correlation between these variables is considered irresolvable multicollinearity because the independent variables cannot be redefined. Therefore, the multicollinearity in this model had a direct effect on the significance of these three variables.

There can be important inferences made from the correlation between C-Sections and race; despite the insignificance of the variables. For instance, the variables had a correlation coefficient of 0.63, which is surprisingly high. This could imply black women are seeing

unnecessarily high rates of C-Sections in the U.S. The results of this correlation could

demonstrate some of the biases towards black women in the healthcare system. Further

information and analysis are needed to fully conclude that there is an association between C-

Sections and race.

Additionally, the variable measuring whether states have a Maternal Review Board is not

statistically significant at the 10 percent confidence interval. One of the reasons the variable is

insignificant is because Maternal Review Boards fluctuate across states. Some states have strict

protocols and meet to discuss after each maternal death in the states, whereas, other boards only

meet a few times a year. Also, the implementation date of the Maternal Review Board could

have an impact on the results. If the Board is less than a year old, they may have not made

progress in the maternal health services yet. Therefore, frequency, policy, and implementation

could have biased this variable and should be included to fully look at the impact of a Maternal

Review Board.

The variable on uninsured women is statistically significant at 10 percent. In addition, my

prediction of a positive coefficient for uninsured women is correct. Therefore, as the percentage

of women who are uninsured increases by 1 percentage point, the predicted number of maternal

deaths increased by 0.45 deaths per 100,000 births, holding all other independent variables

constant.

Maternal age is statistically significant at 5 percent. However, my prediction of a positive

coefficient for maternal age is incorrect. As the percentage of women over thirty-five years old

give birth increases by 1 percentage point, the predicted number of maternal deaths decreases by

1.1 deaths per 100,000 births, holding all other independent variables constant. Although my

theory on maternal age is incorrect for this model, I can speculate to why the coefficient came

out as negative. When a woman reaches advanced maternal age, the pregnancy is considered high-risk. When this happens, doctors place increased cautions and take preventative actions immediately. Therefore, higher maternal age can actually indicate increased scrutinization and lower the risk of maternal mortality.

The variable on prenatal care is statistically significant at 10 percent. In addition, my prediction on a negative coefficient for prenatal care is correct. As the percentage of women who began prenatal care in the first trimester increases by 1 percentage point, the predicted number of maternal deaths decreases by 0.44 per 100,000 births, holding all other independent variables constant. Prenatal care is an integral part of ensuring a safe and healthy pregnancy. Not only does it entail taking vitamins and eating certain foods, but it also encompasses maternal health care such as, ultrasounds and physicals. Therefore, prenatal care continues to be a significant part of the maternal health care system.

Hospitals per square mile in the U.S. is statistically significant at 1 percent. However, my prediction on a negative coefficient is incorrect. The model predicted a positive coefficient meaning, as hospitals per 100 square mile increases by 1 hospital, the predicted number of maternal deaths increases by 1.74 deaths per 100,000 births, holding all other independent variables constant. I was surprised by the results of a positive coefficient because previous literature suggested women living in rural areas lived hours away from hospitals, meaning they lacked accessibility to medical care. The model indicates maternal deaths increase despite proximity to hospitals and as a result, I can only hypothesize on why this could be true. For instance, just because a woman is a close distance to a hospital does not mean the hospital is adequately prepared to care for pregnancy complications. Obstetrics and gynecology units vary across the country and many of the successful doctors chose to work in nationally ranked

hospitals, leaving a disparity in poorly achieving hospitals. According to Carol Sakala, director of maternity quality group Childbirth Connection, "the door you walk in will have a big impact on what happens during and after childbirth" (Bebinger, 2015). In Massachusetts alone, C-Section rates and early elective delivery rates vary drastically across hospitals. Many times, women do not have a choice in the hospital they end up in nor are they aware of quality of care varying by hospitals. Therefore, the quality of care by hospital has a substantial effect on the maternal mortality rate.

The variable capturing the data classification change for maternal mortality rates is statistically significant at 1 percent and corresponds with the coefficient previously predicted. Maternal mortality is significantly higher for states with a check-box system than states without a check-box system. The results on a positive maternal mortality rate for states with a check-box system corresponds to my predicted hypothesis and previous literature. States without a check-box system on the standard death certificate are at an increased risk for underreporting maternal deaths, meaning their maternal mortality rates look considerably better than those with a check-box system. For example, Alabama has not implemented the check-box system and has a maternal mortality rate of 9.8 deaths per 100,000 births, despite the fact that they have exceptionally high C-Section rates, uninsured population and obesity rates. Most of the country has switched over to a check-box system to improve data collection and analysis on mortality rates.

Problems

There are some problems that I encountered during my analysis of maternal mortality in the U.S. The literature examines different risk factors and complications related to pregnancy, however; certain factors are not measured on a state-level or are even tracked at all. For instance,

according to the CDC, one of the major causes for maternal mortality is hemorrhaging

(Pregnancy-Related Deaths Happen, 2019). Most hospitals do not quantify blood loss after

childbirth, making this variable impossible to measure. Hypertension and preeclampsia rates

have an essential impact on the maternal mortality rate but, could not be included in the model

due to lack of state-level data on these rates. The number of women struggling with post-partum

depression has increased over the past decade. However, the rates of depression are vastly

underreported and often times go undiagnosed due to stigmas surrounding mental health (Clasp,

2018). As a result, a variable on post-partum depression should be included in analysis of

maternal mortality rates. Lastly, there is not an accessible way to measure implicit biases or

clinician errors. Therefore, there seem to be missing variables in my model that would have an

important effect on the maternal mortality rate.

Furthermore, the Health Insurance Portability and Accountability (HIPAA) Privacy Rule

protects patients' medical records and health information (HIPAA Privacy Rule, 2015). The

general public does not have access to full medical records or maternal deaths due to these

patient confidentiality laws. Obtaining medical data proved to be difficult due to the strict patient

confidentiality laws and lack of publication of health data in the U.S.

Policy Recommendations

There is a maternal healthcare crisis in the U.S. but, many Americans are unaware of the

dangers of giving birth inside the country. Two women die and about 137 suffer severe

complications of life-threatening injuries every day in America (Young, 2019). The way the U.S.

investigates and identifies maternal deaths is flawed. Even more so, the U.S. has not officially

published a federal maternal mortality rate in over a decade, which is a reflection of the lack of

priority of maternal health care in the country. The United Kingdom is described as having "the

gold standard of maternal health data" (Fields and Sexton, 2017). Healthcare practitioners in the U.K. review every maternal death and use medical records to determine why they happened and if they could have been prevented. Over four million women in the U.S. give birth each year, which is roughly six times greater than the U.K, however; the U.S. does not have a national review of maternal deaths (Fields and Sexton, 2017). The U.S. should implement a national review of maternal deaths and a national maternal mortality rate to begin solving the crisis.

For more than a century, the U.S. has relied on death certificates as the single source of information to measure maternal deaths and causes. The death certificates are filled out with information from doctors, collected by state and local vital statistics offices and then analyzed by the CDC. Epidemiologists determine whether the death was related to pregnancy of childbirth by using standardized codes for causes of death. Death certificates are prone to error and miss critical information, such as the underlying cause of the death. Even more so, an obstetrician or gynecologist may not be the ones filling out the death certificate, leading to greater instances of error (Fields and Sexton, 2017). The U.S. should institute a training procedure for those who fill out death certificate in order to fully value the public health implications. The U.S. should look at information collected by state maternal mortality review committees to validate data.

State-level maternal mortality review committees are essential to solving the maternal death crisis in the U.S. Maternal Mortality Review Committees identify, review, and analyze maternal deaths, while using the results to conclude comprehensive recommendations. For instance, California decreased their maternal mortality rate by 55 percent after the implementation of the California Maternal Quality Care Collaborative in 2006 (Montage, 2018). The board was able to access records on how every mother had died in the past five years and analyze why the deaths happened. There they discovered high instances of cardiac arrest in

maternal deaths and implemented a basic standardized approach for emergency maternal cardiac care in hospitals (Montage 2018). According to Review to Action (2019), committees are comprised of a vast array of professionals engaged with women during and after pregnancy to construct a comprehensive approach towards maternal deaths. Each state should implement a Maternal Mortality Review Committee to analyze data and develop recommendations for how to prevent future mothers' deaths. However, there should be a standardized method in how committee procedures and organization to alleviate differences by state. The U.S. should establish a national Maternal Mortality Review Board that has authority over each state. The National Maternal Mortality Review Board should create a national data center for maternal health, which could collect birth data, discharge records and other medical information. The system could be used for hospitals and states to compare performances against one another and pinpoint problems. By doing this, the national board could allow state-level boards to collaborate with one another and share results and offer recommendations.

On December 21, 2018, President Trump signed the Preventing Maternal Deaths Act of 2018, a bipartisan bill designed to support states in their work with maternal healthcare services (Beutler, 2018). This bill is the first step Congress has taken to address the country's maternal mortality crisis. The Preventing Maternal Deaths Act of 2018 helps states improve how they track and investigate maternal deaths. The bill authorizes twelve million dollars a year for five years to create state-level Maternal Review Committees. Many state-level committees rely on volunteers and lack the funding necessary to be successful. While this bill is an important first step in the maternal mortality crisis, there is still a substantial amount of work needed in maternal healthcare, therefore; the U.S. needs to continue to pass legislation supporting mothers.

Medicaid policy has a substantial effect on the maternal mortality rate in the U.S. because insurance plays a key part in quality of healthcare. Under the Affordable Care Act, Medicaid offers women comprehensive health coverage to women who lack access to needed care. Medicaid finances over half of the births in the nation but, more than half of pregnant women experience a lapse with their public health insurance coverage in the year after giving birth (Kozhimannil, 2019). Disruptions in health coverage are associated with adverse health consequences. Many women encounter disruptions in their insurance after giving birth, which is a critical time for preventing maternal mortality. As stated before, 33 percent of maternal deaths happened one week to one-year post-partum (Pregnancy-Related Deaths Happen, 2019). Medicaid offers a post-partum period of only sixty days, which forces women to abandon medication and ongoing treatment due to high costs. In addition, women lack Medicaid coverage in the early stages of pregnancy, which is the most significant period for initiating prenatal care. A 2019 study found a link between implementation of Medicaid expansion and reflected 1.6 fewer maternal deaths per 100,000 births (Searing & Ross, 2019). Expanding access to health coverage is an essential and prominent strategy to address the growing number of maternal deaths.

Senator Cory Booker and Representative Ayanna Pressley have reintroduced the Maximizing Outcomes for Moms Through Medicaid Improvement and Enhancement of Services Act, or the MOMMIES Act, which establishes six Medicaid-related strategies to maximize health outcomes. One of the main components is expanding Medicaid coverage for pregnant women by increasing coverage from 60 to 365 days following childbirth and offer a full range of health services, rather than just pregnancy-related services (MOMMIES Act). The MOMMIES Act provides the uninsured population increased access to maternity care, which will in turn, lead

to better outcomes. Every woman in the U.S. deserves adequate and accessible healthcare services throughout the duration of their pregnancy.

To combat pregnancy complications, hospitals have implemented toolkits to tackle emergency complications. The toolkits include everything from checklists, written procedures, equipment and medications. The California Maternal Review Committee created a toolkit for obstetric hemorrhage, which is similar to a cardiac arrest cart. The hemorrhage cart is on wheels so it can move to various locations quickly. Inside of the cart includes equipment necessary in any emergency such as, an IV line, oxygen masks, sutures, a task light, a special speculum and a Bakri balloon (Montagne, 2018). The toolkit provides doctors and nurses with easy access to the tools needed in an emergency all in one easy location. Measuring blood loss during pregnancy is extremely important to avoid a maternal death by hemorrhage. Traditionally, hospitals estimate the amount of blood loss by sight, which can lead to clinician error and poor outcomes. Some hospitals have created a procedure to measure blood accurately, by weighing the sponges and pads on a scale. The U.S. should implement a standardized policy requiring all hospitals with these toolkits to combat emergency complications.

Education and training are fundamental parts of dismantling the maternal health crisis in the U.S. Many people are unaware of the complications and dangerous consequences associated with childbirth. Healthcare professionals should be trained in emergency complications because muscle memory can save lives. Having a standardized procedure for the steps to follow for emergency complications allows doctors and nurses to be on the same page. Establishing manuals for hospitals to follow could be a beneficial program for nurses and doctors.

Women and their families and health providers lack training on the early warning signs of emergencies during pregnancy and the post-partum period. Often times, women are

discharged early and once home, these women are unaware of the signs of serious complications. Women usually are so focused on taking care of the baby that they forget about monitoring their own health and often times, brush off their symptoms as lack of sleep. Post-partum care is crucial to preventing maternal mortality. Women need to monitor their blood pressure, temperature, and blood loss. Healthcare provides should be educating parents about the symptoms of pregnancy complications. In addition, maternal mental health checks should be a component of follow-up care. Post-partum depression is a serious and common condition in women. Women feel embarrassed to share their emotions of sadness during this period, meaning diagnosis is often undiagnosed. Maternal mental health should be incorporated into conversations with the whole family and healthcare providers throughout the entire pregnancy and post-partum period. There should be a greater emphasis on follow-up care throughout the post-partum period to reduce maternal mortality.

All healthcare providers should be required to take implicit bias training once a year. Black women are 3 to 4 times more likely than white women to die during childbirth, even when all other maternal factors are held constant (Creanga, 2018). Race should not impact the quality of care a woman receives. Hospitals need to develop training programs to address unconscious biases and encourage integrated health services that respect other races' cultures. Senator Kamala Harris has introduced the Maternal Care Access and Reducing Emergencies Act, or the Maternal CARE Act, which is designed to award grants to health professional training programs that addresses implicit biases in obstetrics and gynecology (Harris, 2018). The law has not been passed yet, but it serves as an example for what the U.S. could be doing to decimate the structural racism in hospitals.

During childbirth, health care providers focus more on the health of the baby than the mother. Maternity wards should have a designated nurse who focuses solely on the health of the mother. In most cases, the same nurse watches the baby and mother, meaning the symptoms for the mother go unnoticed. Having a designated nurse for the mother will allow for better outcomes. For instance, the nurse can monitor blood pressure and quantify blood loss, without worrying about having to take care of the newborn. One of the misconceptions is that childbirth is considered easy because over four million women in the U.S. give birth each year (CDC, 2018). However, childbirth should be taken seriously because many women suffer severe complications and die each year. Furthermore, a designated nurse could improve pregnancy-related outcomes.

According to American Health Rankings (2019), the prevalence of obesity in women aged twenty or older increased from 25.5 percent in 1988 to 40.7 percent in 2016. Adults who are obese are at an increased rate for hypertension, stroke, diabetes and other serious conditions. Even more so, obesity has an adverse impact on pregnancy complications (CDC, 2018). Lowering obesity rates among adults proves as challenging. The most important part is to educate women on the adverse outcomes associated with obesity. Also, Americans needs affordable access to healthy food and fitness facilities. By teaching children at a young age how to eat healthy and exercise, they can grow up understanding the importance of a healthy lifestyle.

Lastly, the U.S needs to decrease the number of C-Sections performed on women. The rates of C-Sections have increased at an alarming rate over the past decade. WHO recommends countries to stay between 10 to 15 percent of births as C-Sections The U.S. is conducting more C-Sections than medically necessary, which could be caused by a growing trend of elective surgeries. In many private clinics, women chose to have a C-Section, which increases their risk

for infection and other complications (Doucleff, 2018). Virginia Hospital Center discovered their C-Section rate was 33 percent, a substantially higher rate than what is medically necessary. To lower their rate, they designed an evidence-based approach to analyze every single C-Section performed in the hospital. If they find that any doctors have performed C-Sections that could have been avoided, they provide a report with of six months of births performed and write what could have been done better (Washington Post, 2019). This program holds doctors accountable for their actions and improves patient outcomes.

On what is supposed to be the happiest time of your life, many families are left grieving with a loss of the mother. Over 700 women die each year from pregnancy-related complications and over 60 percent of these deaths could have been prevented (CDC, 2017). Not one maternal death should be acceptable in a highly developed nation like the U.S. Maternal mortality is a serious and important issue in today's society. After analyzing maternal mortality in the U.S., the results display the important variables to focus on. Furthermore, the U.S. needs to develop a systematic approach to decreasing maternal mortality and developing maternal health services so that, no more families have to deal with a maternal death.

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