A Descriptive Analysis of Severe Maternal Morbidities In Southern Arizona

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Honors Thesis

A DESCRIPTIVE ANALYSIS OF SEVERE MATERNAL MORBIDITIES IN
SOUTHERN ARIZONA

By
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Submitted to Brigham Young University in partial fulfillment
of graduation requirements for University Honors

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Brigham Young University
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ABSTRACT

A DESCRIPTIVE ANALYSIS OF SEVERE MATERNAL MORBIDITIES IN SOUTHERN ARIZONA

Joseph Paul Sherman

Cell Biology and Physiology Department
Bachelor of Science

Introduction

Maternal morbidities and maternal deaths are rising at an alarming rate throughout the United States, despite advances in medicine and technology (Centers for Disease Control and Prevention [CDC], 2020). In 2020, maternal deaths climbed to its highest peak in thirty years, at 23.8 deaths per 100,000 births (CDC 2020; CDC 2022b). Maternal morbidities have also increased by nearly 200% from 1993 to 2014 (CDC, 2021). The startling rise in both maternal morbidities and maternal deaths is likely exacerbated by limited access to healthcare and the pervasiveness of chronic diseases such as obesity, diabetes, and heart disease (Carroll, 2017; Geller et al., 2004; World Health Organization [WHO], 2019). Additional reasons for the increase in maternal deaths and maternal morbidities may also involve the increasing age of mothers and more accurate records of maternal death (Carroll, 2017; Joseph et al., 2021; National Vital Statistics Report [NVSR], 2015).
A maternal death refers to “the death of a woman as a result of pregnancy or its management during pregnancy or up to one year following pregnancy” (CDC, 2019). Severe maternal morbidity (SMM) broadly refers to “unintended outcomes of labor and delivery that result in significant short-term or long-term consequences to a mother’s health” (Kilpatrick & Ecker, 2016). While the American College of Obstetricians and Gynecologists (ACOG) as well as the Society for Maternal-Fetal Medicine (SMFM) have not currently endorsed a single definition of severe maternal morbidity, there are various definitions and proposed lists for what conditions constitute SMM. For example, the WHO classifies morbidities as “unanticipated complications of [pregnancy] management” (Pattinson et al., 2009). Researchers representing ACOG have also found that blood transfusion is the most common indicator of SMM and have proposed a list of conditions that can be implemented to further define SMM (Callaghan et al., 2012). The CDC identifies SMM using a list of many indicators such as acute myocardial infarction, eclampsia and sepsis (CDC, 2020).

While maternal health is frequently addressed at the national and state level, it is equally important to consider maternal health at the community level. Poor maternal health may be more heavily concentrated in particular communities than others and these differences may not be readily observed when only examined at a state or national level.

There is ample research that populations in rural regions generally experience poverty, less access to care, have decreased access to safe and affordable transportation, and frequently experience worse health outcomes. (Castañeda et al., 2015; Castañeda, 2017; Kozhimannil et al., 2019; Rural Health Information Hub [RHIH], 2020).
This study takes into account the challenges of rural populations while analyzing maternal morbidities in the Southern Arizona counties of Maricopa, Pima, Yuma, Santa Cruz, and Cochise. The U.S. Census classifies urban areas as regions of 50,000 or more people (U.S. Census Bureau, 2019) and further states that the term rural “encompasses all population, housing, and territory not included within an urban area” (U.S. Census Bureau, 2019). Based on this definition, only Santa Cruz county is considered rural (U.S. Census Bureau, 2021). However, the counties outside of Arizona’s most densely populated counties of Maricopa and Pima are sometimes referred to as rural since they are regions considered “remote from the state’s major population centers” (Berman, 2019). Due to large differences in population density referenced in Figure 3, the counties of Pima and Maricopa are considered urban and the counties of Yuma, Santa Cruz, and Cochise are generally considered rural.

This research specifically sought to answer whether there are associations between maternal morbidities and elements such as the mother’s geographical residence, race, marital status, age, access to care, and income level throughout Southern Arizona.

The maternal morbidities identified for this study are (1) hemorrhage; (2) infection; (3) eclampsia; (4) hypertension; and (5) drug use. Addressing maternal morbidities early and identifying potential risk factors is an important way to prevent maternal deaths from occurring.

**Methods**

This study is a descriptive analysis examining the diagnoses of maternal morbidity using 2018 discharge data from the Arizona State Inpatient Databases (SID)
developed as part of the Healthcare Cost and Utilization Project (Healthcare Cost and Utilization Project [HCUP], 2018). The percentage of each data element of interest (geographic residence, race, marital status, age, access to care, and median income) in each county was analyzed. A data element was analyzed by the percentage of a normal birth or a morbidity using a chi-squared test for independence. Data elements were then compared within an individual county and also compared to other counties in order to observe relevant trends.

Results

Yuma demonstrated the lowest percentage of normal births and the highest percentages of hemorrhage, eclampsia and hypertension. Pima county demonstrated the highest percentages of infection and drug use, and the second lowest percentage of normal births. Overall, the lowest percentage of normal births occurred in Black and Native American populations. Married mothers had the highest percentage of normal births, followed by single mothers and then divorced mothers. The percentage of normal births decreased with age and hypertension increased with age. No uniform trends were observed by payment method and were instead unique to each county. The percentage of normal births increased as median income increased.

Conclusion

This study indicates there is a great need to target maternal health in Yuma and Pima counties. Clinicians and healthcare providers should be aware of the ethnic disparities in maternal health among Black and Native American mothers in Southern
Arizona. Effective strategies to improve surveillance and access to care include identifying and addressing maternal morbidities early in pregnancy, during delivery, and during the postpartum period. Longitudinal studies on severe maternal morbidities will help verify or confound trends discussed in this descriptive analysis.
I am immensely grateful to many. I would like to begin by acknowledging my namesake and great-great grandfather, Joseph F. Merrill. His legacy as the first native Utahn to earn a PhD and role as Commissioner of the Church Educational System inspired me to value higher education. He taught that a hallmark of true scholarship is humility.

I am also deeply grateful for another namesake, my great-grandfather Paul Buehner. Like Joseph F. Merrill, Paul Buehner loved Brigham Young University. As a contractor, Paul was renowned for the durability of his concrete products, and coined the term “quality work.” I have tried to honor that legacy in this research.

It is only fitting to also acknowledge my third namesake and grandfather, Clyde Sherman. Clyde lived in Southern Arizona throughout his life and loved his neighbors in this region of the world. I share his love for Arizona and am grateful to have been able to conduct research in Southern Arizona.

I am grateful for the love and encouragement of my mother and father who both graduated from Brigham Young University. They are my greatest mentors, and their love and support is constant.

This research is focused on mothers. When I saw the alarming trends of maternal morbidity and mortality in the United States, I immediately thought of my own mother. No one can fully measure the good that mothers do. When I consider this and the way my mother has influenced my life, I wanted to understand what could be done to prevent maternal morbidity and mortality. Their health and wellness is paramount.
Shortly after beginning my studies at Brigham Young University, Elder J. Devn Cornish of the seventy encouraged me to join the Honors Program. I will always be grateful for his counsel. He is a mentor to me in every way and I deeply admire him.

Of course, I want to thank my advisor Dr. Len Novilla. Dr. Novilla accepted the invitation to be my advisor without knowing me beforehand and has been so generous with her time. She has inspired me to see this research endeavor not as the finish line but the starting line. Dr. Novilla is an exceptional leader in public health research and has given me invaluable advice and insights as we have worked together.

I would also like to thank Dr. Dennis Eggett. The core of this research is statistical analyses, and was made possibly by Dr. Eggett’s remarkable abilities as a statistician. Dr. Eggett is also very generous with his time and patiently worked with me as we conducted statistical tests together.

One of the great privileges I have had as a student is to associate with Dr. Jonathon Hill. Dr. Hill is brilliant, and certainly challenged me as a student in his Cell Biology course. Dr. Hill also welcomed me into his research lab and frequently expressed his desire for me to succeed. He has been a constant support and incredible mentor to me.

Dr. Roy Silcox has been a remarkable influence on me as well, and I am thankful for his guidance, reassurance, and assistance as we have visited together.

I became aware of the challenges in maternal health while working as an intern to the former United States Surgeon General, Dr. Jerome Adams. I want to thank Dr. Adams, Dr. Erica Schwartz, Dr. Janet Wright, Rafael Campos, Catherine Bianchi, and all other staff members at the Office of the Surgeon General for their outstanding public health work, and for valuing me as a team member during my internship.
I am also grateful to the Agency for Health Research and Quality (AHRQ) and the HCUP data partners for providing research opportunities to students like me. I am grateful as well for Ricky Ricardo’s professional assistance in downloading the healthcare data for this project.

I would especially like to thank Teresa Gomez and Autumn Lee for their assistance in providing outstanding maps to help visualize the data in this research.

As I conclude this project, I also wish to thank Vika Filimoeatu for her constant guidance and support throughout my experience in the Honors Program. I would also like to thank the Honors Department as a whole for the exceptional experiences they have provided to me as a student. The Honors Program has helped me understand the personal responsibility I have to continue learning throughout my life.

Lastly, I am indebted for the privilege I have had to attend Brigham Young University. I truly love this institution and the principles it stands for. Much has been given and it is incumbent upon me to go forth and serve.
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I. BACKGROUND & SIGNIFICANCE

The United States is currently experiencing an alarming rise in maternal morbidity and mortality (CDC, 2020; CDC, 2022b). As seen below in Figure 1, it is concerning to note that maternal mortality has steadily increased to a maximum of 23.8 deaths per 100,000 births in 2020, compared to a minimum of 7.2 deaths per 100,000 births in 1987 (CDC, 2020; CDC, 2022b). This trend is a tragedy for families and for the U.S. society. Optimizing maternal health in the United States is critical for the well-being of current families and future generations.

The CDC defines a pregnancy-related death, maternal death or maternal mortality as “the death of a woman during pregnancy, or within one year of the end of pregnancy from a cause related to pregnancy or its management” (CDC, 2019). In comparison, severe maternal morbidity (SMM) refers to the “unintended outcomes of labor and delivery that result in significant short-term or long-term consequences to a woman’s health” (CDC, 2020). For this study, SMM will be equated with the term morbidity.

![Figure 1: Trends in Maternal Mortality in the United States 1987-2020](image)

The 2008 to 2017 trends in maternal mortality found that approximately 75% of maternal deaths were attributed to cardiovascular conditions, hemorrhage, infection, embolism, mental health conditions, and eclampsia (Davis et al., 2019). This same study also reported that two out of three maternal deaths were preventable (Davis et al., 2019).

Rates of maternal morbidities have also intensified, increasing from 49.5 morbidities per 10,000 deliveries in 1993 to 144.0 morbidities per 10,000 deliveries in 2014 (CDC, 2021). Many of the leading causes of morbidity reported include
hemorrhage, infection, eclampsia, hypertension, and drug use (CDC, 2021; WHO, 2019; Kimmel, 2020; Office of Disease Prevention and Health Promotion [ODPHP], 2014).

Despite these troubling findings, the precise reasons for the increase in maternal morbidity and mortality are not clearly defined. Contributing factors likely include challenges accessing quality healthcare, chronic health conditions such as obesity, diabetes, and heart disease, as well as the increasing age of mothers, substance abuse, and more accurate recordings of maternal deaths (WHO, 2019; NVSR, 2015; Caroll, 2017). As a result, current research is focused on analyzing the trends of maternal morbidity and mortality from the context of the social determinants of health. These include income level, educational attainment, environmental health, family structure, race, access to healthcare services, and health literacy (RHIH, 2020).

This study analyzed the 2018 Arizona State Inpatient Databases (SID) on maternal morbidities secondary to hypertension, eclampsia, hemorrhage, infection and drug use. Maternal drug use is included due to its association with poor mental health, and recent rise amidst the opioid epidemic (Metz et al., 2018). Trends in maternal morbidities have been shown to vary by geographic location, as seen in Figure 2. As such, addressing maternal health should be tailored to the needs of each population. Furthermore, poor maternal health may be more heavily concentrated in particular communities than others and these differences may not be readily observed when only examined at a state or national level. The present study examined severe maternal morbidities in the following Arizona counties: Maricopa, Yuma, Pima, Santa Cruz, and Cochise.

![Figure 2: Rate of Severe Maternal Morbidity by State, 2017](image)

The counties of Yuma, Pima, Santa Cruz, and Cochise are located on the United States border. Research has stated that residents in border communities experience
decreased access to care (Castañeda, 2017). As a result, this study will analyze maternal health in border counties and compare findings to maternal health in the non-border county of Maricopa to detect potential disparities.

![Arizona Counties by Population Density](image)

Figure 3: The map on the left displays specific counties that will be analyzed in this study. The map on the right displays population density for the counties included in this study. Darker shades on the map on the right indicate a higher population density. Source: United States Census Bureau (U.S. Census Bureau, 2021).

Maternal morbidities of each county will be compared and analyzed by race, marital status, age, access to healthcare services (indicated by payment method), and median income. The objective of this analysis is to observe relevant trends in maternal morbidities through these unique lenses that can contribute toward strategic thinking to further prevent maternal morbidity in Southern Arizona and beyond. Furthermore, this research will discuss priorities for future research and how to respond appropriately to the health of populations affected in these counties.
II. METHODS

Introduction

The dataset for this study was obtained through State Inpatient Databases. State Inpatient Databases (SID) are part of the Healthcare Cost and Utilization Project that is sponsored by the Agency for Healthcare Research and Quality (AHRQ). The SID are a set of hospital data from participating states, and contain approximately 97 percent of all U.S. hospital discharges (HCUP, 2021b). Information from the SID include the patient’s county code, race, marital status, age, income level, payment method, and diagnosis upon admission (HCUP, 2021b).

A written research proposal for this study was approved by the Brigham Young University Honors Program and subsequently by the AHRQ. Following the AHRQ approval, selected Arizona SID were purchased to study variables potentially associated with maternal morbidity.

Sample Subjects

To isolate the maternal cohort, mothers with normal births and selected morbidities of hypertension, eclampsia, infection, hemorrhage and drug use were isolated using the following codes listed in Table 1. All other patients were excluded from the 2018 SID.

Table 1: Diagnosis Codes to Isolate Maternal Cohort of Interest

<table>
<thead>
<tr>
<th>Condition or Morbidity</th>
<th>Diagnosis Code(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Birth</td>
<td>O80</td>
</tr>
<tr>
<td>Hypertension</td>
<td>O134, O133, O114, O1092, O1002, O113, O163, O164, O10013, O139</td>
</tr>
<tr>
<td>Eclampsia</td>
<td>O1414, O1494, O1404, O1493, O1413, O1403, O1415, O1495</td>
</tr>
<tr>
<td>Infection</td>
<td>O99824, O99820, O2302, O9832, O860, O98813, O2343, O98812, O9882, O753, O98313, O2301, O98811, O2342</td>
</tr>
<tr>
<td>Hemorrhage</td>
<td>O4693, O4692, O722, O721, O679, O209</td>
</tr>
<tr>
<td>Drug Use</td>
<td>O99324, O99334, O99323, O99322, O99333, O99321</td>
</tr>
</tbody>
</table>

*Table 1: The following codes were used to isolate maternal patients with the above conditions. All other patients were excluded from the 2018 Arizona SID. Diagnosis codes were identified under the Data Element I10_DX_Admittance (HCUP, 2020). The description for each code was then identified using a description provided by the Centers for Medicare and Medicaid Services (CMS). For a more comprehensive description of each individual code, please refer to the references (CMS, 2021).*
The maternal cohort was further categorized by isolating mothers with the county codes of interest. Codes utilized in this step are summarized in Table 2.

Table 2: Patient County Code

<table>
<thead>
<tr>
<th>County</th>
<th>Patient County Code:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maricopa</td>
<td>04013</td>
</tr>
<tr>
<td>Pima</td>
<td>04019</td>
</tr>
<tr>
<td>Yuma</td>
<td>04027</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>04023</td>
</tr>
<tr>
<td>Cochise</td>
<td>04003</td>
</tr>
</tbody>
</table>

*Table 2: Patient County Code was identified using the Data Element PSTCO2 on the SID (HCUP, 2020), which refers to the county from which the maternal patient is from.*

Analysis and Interpretation

The cohort was further analyzed by the data elements specified in Table 3. Initially, this study sought to establish a prediction model of maternal morbidities by the data elements listed in Table 3. However, this model of study was abandoned since the best prediction rate found using a discriminate analysis of these data elements at the state level had a 70% error rate. Therefore, the percentage of each data element in each county was then analyzed by maternal condition using a chi-squared test for independence. Data elements were then compared within an individual county and also compared to other counties to observe relevant trends. A \( p \) value of .05 was also established as a standard to ensure differences were not due to random chance. When \( p < .05 \), the data is identified as statistically significant with an asterisk (*\( p \)). Specific sample sizes are not reported. Instead, a percentage is shown as the HCUP Data Use Agreement prohibits the reporting of fewer than 11 observations in order to protect patient confidentiality (HCUP, 2021a).

Table 3: Variables by Which Maternal Cohort is Analyzed:

<table>
<thead>
<tr>
<th>Data Element</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td>RACE</td>
<td>Indicates the patient’s race</td>
</tr>
<tr>
<td>Marital Status</td>
<td>MARITALSTATUSUB04</td>
<td>Indicates the patient’s marital status</td>
</tr>
<tr>
<td>Age</td>
<td>AGE</td>
<td>Age is calculated from the patient’s recorded date of birth</td>
</tr>
<tr>
<td>Payment Method</td>
<td>PAY 1</td>
<td>Indicates the patient’s method of payment</td>
</tr>
<tr>
<td>Median Income</td>
<td>MEDINCSTQ</td>
<td>Quartile of median household income of patient</td>
</tr>
</tbody>
</table>

*Table 3: Variables by Which Maternal Cohort Is Analyzed. For a more comprehensive description of these variables please refer to the SID Data Element description (HCUP, 2020).*
III. RESULTS

Geography

In terms of geography, Yuma and Pima counties demonstrated the lowest percentages of normal births. Furthermore, Yuma demonstrated the highest percentages of hemorrhage, eclampsia, and hypertension among mothers. However, Pima demonstrated the highest percentages of both infection and drug use. These trends are further demonstrated in Figure 4 and Figure 5.

![Percentage of Maternal Morbidities by County](image)

*Figure 4: The percentage of maternal morbidities by county is represented. *p < 0.0001 for the data provided.*
A Geographic Perspective of Maternal Health in Southern Arizona

Drug Use  Eclampsia  Hemorrhage

Figure 5: A Geographic Perspective of Maternal Health in Southern Arizona. Darker tones represent higher percentages of drug use, eclampsia, hemorrhage, hypertension, infection, or normal birth. Yuma demonstrates the highest percentages of eclampsia, hypertension and hemorrhage. Pima demonstrates the highest percentages of infection and drug use. As seen in the bottom right, normal birth rates are highest among patients in Santa Cruz and lowest among patients in Yuma. *p < 0.0001 for the data provided.
Race

It is important to consider that due to large $p$ values, the differences in morbidities by race are not reliable in certain counties, and may be due to random chance. For all counties where $p < .05$, normal births are lowest among Black and Native American mothers. This trend is demonstrated in Figure 6 below.

Figure 6: Maternal morbidities by race are represented. When the sample size of a particular race is extremely limited in a county, the racial category is not included.
As observed in Figure 7 below, White and Hispanic mothers constitute the majority of maternal patients in this study, while Native Americans, Blacks and Asian or Pacific Islanders constitute the minority of maternal patients. Significantly, Native Americans and Blacks demonstrated the lowest percentages of normal births (see Figure 6) while also constituting the minority of maternal patients in this study.

Figure 7: The percentage of maternal race by county is represented. *p < 0.0001 for the data provided.
Marital Status

The results of maternal morbidity by marital status show that mothers that are divorced have the lowest percentages of normal births in every county. However, $p > .05$ for the counties of Cochise, Santa Cruz, and Yuma, indicating that these differences may be due to random chance and are not reliable. Thus, the most reliable trends for marital status are in Maricopa and Pima. Maricopa and Pima demonstrate a consistent trend: married mothers have the highest percentage of normal births, followed by single and then divorced mothers. This trend is observed in Figure 8.

*Figure 8: Maternal morbidities by marital status are represented.*
A further analysis observing marital status by county demonstrates that the percentage of mothers that are divorced is exceptionally low compared to mothers that are married or single.

Additionally, there is a higher percentage of single mothers than married mothers in each county, with the exception of Maricopa. This indicates that for all counties outside of Maricopa, the majority of pregnancies occur out of wedlock. This pattern is observed in Figure 9.

![Percentage of Marital Status by County](image)

*Figure 9: Percentage of marital status by county is represented (referring to maternal patients only). *p* < 0.0001 for the data provided.*
Age

In Yuma, \( p > .05 \), indicating that trends in Yuma are not reliable. However, \( p < .05 \) for all other counties. Thus, the following analysis excludes Yuma. Examining age and morbidities shows that without exception, the percentage of normal births decreases with age. Furthermore, the percentage of maternal patients with hypertension increases with age. Eclampsia increased with age in Maricopa, Pima, and Santa Cruz, but not Cochise. No consistent trends were observed for drug use and age. However, since drug use is reported to be exceptionally high in Pima county compared to all other counties, it is of interest to note that the percentage of maternal patients with drug use increased with age in Pima county.

### Percentage of Maternal Morbidities by Age

![Percentage of Maternal Morbidities by Age](image)

**Figure 10:** The percentage of maternal morbidities by age is represented.

No consistent trends were observed with hemorrhage and age. The percentage of maternal patients with infection decreased with age in each county with the exception of patients from Maricopa county. These trends are demonstrated in **Figure 10** above.
Figure 11 contextualizes the data in Figure 10 by indicating the ages for the mothers included in this study. An expected trend of increased births in the mid-twenties followed by an overall decline in the thirties is observed.

*Figure 11: The percentage of maternal age by county is represented. *p < 0.0001 for the data provided.*
Payment Method

The results in Figure 12 do not demonstrate overall trends, and data for Yuma county is not reliable since \( p > .05 \). It is noted that drug use is generally higher among maternal patients under Medicaid, but no maternal patients are shown to have drug use in Santa Cruz.

![Percentage of Maternal Morbidities by Payment Method](image)

*Figure 12: The percentage of maternal morbidities by payment method is represented.*

It is especially interesting to consider that normal births are relatively high among mothers utilizing self-pay. In another perspective, Figure 13 shows that the majority of maternal patients utilize Medicaid in all counties. These data further show that private insurance is particularly low in border counties like Santa Cruz and Yuma. Self-pay is low in comparison to Medicaid and private insurance, but remains highest in Santa Cruz and Yuma.
Figure 13: The percentage of payment method by county is represented. * $p < 0.0001$ for the data provided. The category “Other” includes healthcare payments provided by worker’s compensation, the Civilian Health and Medical Program of the Uniformed Services (CHAMPUS), the Civilian Health and Medical Program of the Department of Veterans Affairs (CHAMPVA), Title V, and other government programs (HCUP, 2020).
Median Income

In Figure 14, $p > .05$ for the data in Cochise, Santa Cruz, and Yuma, and should not be considered reliable. When only analyzing Maricopa and Pima, the percentage of normal births show a linear increase as the quartile of median income increases, demonstrating that increased income is associated with a higher percentage of normal births. This trend is shown in Figure 14.

**Percentage of Maternal Morbidities by Median Income**

Figure 14: The percentage of maternal morbidities by median income is represented. A quartile of median income category is excluded when the sample size for the quartile level is extremely limited. Median income increases as the quartile of median income on the x-axis increases.
It is important to note that the fourth quartile of income, representative of the wealthiest populations in Arizona, were not included in the counties of Cochise, Santa Cruz or Yuma, due to a small sample size. The third quartile of income was also excluded from Santa Cruz and Yuma for the same reason.

The data in Figure 15 indicate that the majority of mothers in the counties included in this study are among the first quartile of median income, with the fewest among the fourth quartile. The exception to this trend is an overall level trend in Maricopa county. However, the downward trend for all other border counties shows that most mothers sampled in border counties have a low income level.

*Figure 15: Percentage of median income by county is represented. *p < 0.0001 for the data provided.*
IV. DISCUSSION

The goal of this study has been to investigate trends in maternal morbidity throughout Southern Arizona and consider future strategies to prevent maternal morbidity and mortality in Southern Arizona and beyond. Key insights gained in analyzing maternal morbidities by variables of interest, their implications, and opportunities for future research are now discussed.

Geography

Viewing maternal morbidity through a geographic lens has shed light on the severe morbidities that are especially present in Yuma. There are large percentages of morbidities such as hypertension, eclampsia, and hemorrhage in Yuma (see Figures 4, 5). One of the reasons these disparities may be particularly high in Yuma is due to the limited availability of hospitals (see Figure 16).

Figure 16: Hospitals by county and by number of beds is represented. This figure demonstrates the challenge Yuma, Santa Cruz and Cochise face in providing high quality maternal care due to the relatively small amount of hospitals available compared to Maricopa and Pima counties. Data source: Homeland Infrastructure Foundation Level Data (HIFLD, 2022).
The sheer distance to major hospitals for patients in Yuma, in regions of Pima and even in certain regions of Maricopa indicate that individuals in these geographic locations face extraordinary challenges accessing care, even if Medicaid or insurance is provided. As cited earlier, the CDC has stated that two out of three maternal deaths are preventable and occur from conditions such as eclampsia and infection that are largely treatable (Davis et al., 2019). When maternal morbidities and maternal deaths are preventable but still occur, it is likely that mothers are not meeting with a healthcare provider frequently enough, both prior to the delivery and postpartum. As a result, strategies should be implemented that increase the frequency of maternal care throughout a pregnancy and during the postpartum period. A practical method to address this challenge may be studying whether telemedicine is an effective strategy in preventing maternal morbidity in rural regions. In any case, programs that aim to increase the frequency of contact between mothers and their healthcare provider are strongly encouraged, especially for at-risk mothers that demonstrate chronic conditions such as obesity, diabetes, and heart disease.

When considering maternal health in Southern Arizona, it is important to mention the relevance of immigration. As demonstrated below in Figure 17, the United States experienced its highest influx of immigration ever in 2019. These trends indicate that addressing immigration as a social determinant of health is becoming increasingly important (Castañeda et al., 2015). Immigrants in Southern Arizona generally face extreme healthcare challenges and may lack culturally-appropriate care, such as assistance via their native language. These individuals do not have access to insurance and likely demonstrate healthcare avoidance behaviors that exacerbate devastating morbidities. Future studies that address maternal morbidities by immigration status would be a valuable way to identify the distribution of maternal morbidities among immigrants and citizens.

![Immigration Into the United States (1850-2019)](image)

*Figure 17: Immigration Into the United States (1850-2019). Source: (Migration Policy Institute, 2019).*
Race

This study observed that maternal morbidities are highest among Black and Native American populations. As shown in Figure 18, these trends in Southern Arizona are consistent with national trends. In addition, Figure 19, shows that Black and Native Americans (American Indian or Alaska Native) mothers also experience the highest rates of maternal mortality.

Consequently, it is important for future studies to further investigate the specific reasons as to why these ethnicities are particularly vulnerable, and for clinicians to develop a heightened awareness and sensitivity to the health risks of Black and Native American mothers. Studies should perhaps further investigate genetic predispositions to chronic diseases and their association with maternal morbidities. Other factors such as the frequency of visits and quality of care provided to mothers by race during pregnancy and the postpartum period is also an important study to consider.

Addressing the health of Black and Native American mothers is of particular concern in Arizona, as it is the state housing the third largest Native American population in the United States and is a state that is becoming increasingly diverse, increasing its diversity index from 57.4% in 2010 to 61.5% in 2020 (CDC, 2017; Bureau, 2021).

![Severe Maternal Morbidity (SMM) Rate by Race, 2017](Figure 18: Severe Maternal Morbidity (SMM) Rate by Race/Ethnicity, 2017. Source: (OSG, 2020).)
In terms of marital status, significant $p$ values were only observed in Maricopa and Pima counties (see Figure 12). These counties demonstrated that the highest percentage of normal births occurred among married mothers. The percentage of normal births decreased in single mothers and was lowest among divorced mothers. These findings indicate that there is an association between marriage and positive maternal health.

These findings are consistent with previous research indicating that the presence of a male partner is associated with improved maternal health outcomes (Yargawa & Leonardi-Bee, 2015). Since this finding is confirmed, it is especially concerning to observe that the majority of pregnancies are occurring out of wedlock in border counties (see Figure 13).

When the presence of a marital partner is associated with a higher percentage of positive health outcomes for mothers, it is also concerning that the marriage rates in the United States have steadily decreased and have reached an all-time low as of 2020 (see Figure 20).
As a result of these trends, fewer mothers are able to receive the support of a marital partner during pregnancy. There is also a dramatic increase in out-of-wedlock child-bearing in the United States as a whole. In 2010, 40.8 percent of all children born in the U.S. were born out of wedlock (Rector, 2012). Furthermore, ample evidence demonstrates that chronic life stress that occurs during events such as pregnancy can alter sympathetic, neuro-endocrine and immune responsiveness (Pike et al., 1997). The lack of support from a marital partner during pregnancy may further increase stress and exacerbate the morbidities mothers can experience.

Interestingly, studies have also indicated that marriage has the potential to reduce poverty. According to the U.S. Census, the poverty rate for single parents with children in the United States in 2009 was 37.1 percent, whereas the rate for married couples with children was 6.8 percent (Rector, 2012). This demonstrates that being raised in a married family reduced a child’s probability of living in poverty by about 82 percent (Rector, 2012). This suggests that morbidities intensified by poverty can perhaps be curtailed by the support of a marital partner. Longitudinal research should continue to observe whether the presence of a marital partner is associated with positive maternal health outcomes and increased economic security.

Age

An analysis of age found that normal births declined with age and hypertension increased with age. Importantly, only counties with significant \( p \) values were considered in this analysis. This is rather consistent with data at the national level, which indicates that risks for morbidities increase past age 35 for mothers, as seen in Figure 21. However, this study did not highlight that morbidities are also risky for younger mothers,
particularly for mothers between the ages of 12 to 19 as demonstrated in *Figure 21*. Taken together, this research demonstrates that ideal ages for pregnancy range in the twenties, and risk of morbidities increases rather dramatically at age 35. In order to optimize maternal health, mothers should be aware of the increased risk of maternal morbidities and age. Researchers should continue to observe the rate of morbidity and age over time, particularly as new therapeutics and medicines become increasingly available.

![Severe Maternal Morbidity (SMM) Rate by Age, 2017](image)

*Figure 21: Severe Maternal Morbidity (SMM) Rate by Age, 2017. Source: Office of the Surgeon General (OSG, 2020).*

It is significant to note that one of the drivers of maternal morbidity may be attributed to a larger societal trend in which mothers increasingly delay childbirth, as demonstrated in *Figure 22* below. Data from the U.S. Census show that the average age at which women in the United States have their first child is increasing, from approximately age 23 in 1980 to approximately age 26 in 2013 (National Vital Statistics Report [NVSR], 2015). Future studies should continue to monitor this trend. Assuming the trend of delayed childbirth continues, it is possible that maternal morbidity and mortality will continue to rise in the United States.
Overall, no uniform trends were observed in all counties by payment method in this study. However, this finding may be confounded in longitudinal studies. As cited earlier, the CDC has stated that two out of three maternal deaths are preventable, which strongly suggests the presence of morbidities and maternal deaths are likely due, in part, to decreased contact with healthcare providers. It was expected that mothers without insurance would demonstrate greater morbidities, but this trend was not observed. However, this perspective does not tell how frequently a mother is interacting with a clinician during a pregnancy or throughout the post-partum period. Therefore, future studies should analyze maternal morbidities by the frequency of care provided by a clinician. It is expected that maternal morbidities are likely reduced by more frequent check-ups with a clinician.

It is likely that there is also decreased visits due to an inability to pay medical fees or due to the challenge of accessing transportation in rural areas. Data in Figure 15 found that the majority of mothers sampled in border counties are in the first and second quartiles of median income, and Figure 16 affirms that hospitals are very distant for residents in certain areas of Pima, Maricopa and Yuma, in particular.

Another valuable study could also include how long insurance or Medicaid covers maternal health and compare these timetables to the timing in which morbidities and mortalities occur. Maternal morbidities and mortalities have the potential of occurring
several months postpartum, and extending maternal coverage for longer periods of time following delivery may have the potential of preventing maternal morbidity and mortality.

**Median Income Levels**

As mentioned in the previous section, the majority of mothers sampled in border counties are grouped within the first and second quartiles of median income, which are the two lowest quartiles of income for this study. These findings confirm previous research stating that poverty is generally more common in rural regions (RHIH, 2020).

In Maricopa and Pima counties where $p$ is significant, this study observed that the overall percentage of normal births increased as the quartile of median income increased. However, it is important to consider that this increase in normal births was not extreme.

One of the challenges that poor income mothers face is an inability to pay medical fees, which may decrease the frequency of their visits. Recent surveys have found that many adults in the United States avoid healthcare because of costs (Osborn et al., 2016). Mothers are extremely vulnerable during pregnancy, and as previously mentioned, an increasing number of mothers are experiencing pregnancy without the support of a marital partner. Studies have highlighted that extreme poverty is a “key hindrance to women’s wellbeing, especially during pregnancy, resulting in malnutrition, anemia, low birth babies or fetal loss” (Tanya, 2008). Clinicians, healthcare workers, and community members at large should help mothers become aware of opportunities to receive support through Medicaid, other government programs, private institutions or through volunteer organizations that can provide support. Policymakers may also consider ways to make quality maternal care more accessible for impoverished populations.

**Limitations**

As a descriptive analysis of maternal morbidities, this study cannot establish cause or effect relationships between the variables of geography, race, marital status, age, access to care, income level and maternal morbidity. Additionally, these variables cannot be used as models to predict the prevalence of maternal morbidity using data from the current research. This is a subject of further research endeavors. These data only establish the prevalence of maternal morbidities by various variables and can be used to identify trends and correlations. However, these trends are only found for the year 2018 and longitudinal studies should be implemented to confirm or confound these findings.

Additionally, $p$ values have been shown in the data. For much of the data in border counties, $p > .05$ and in such circumstances, the data was identified as unreliable since differences may be a result of random chance rather than the presence of a data element. Furthermore, the data from this study is strictly obtained from major hospitals connected to the Arizona SID.
V. CONCLUSION

This study has established that there is a significant correlation between maternal morbidity and the factors of geographical residence, race, marital status, age, and income in Southern Arizona.

There are additional variables that need to be identified and studied to complete the picture of what is impacting maternal health. Maternal morbidity is not only an independent challenge but connected to larger societal trends such as the disconcerting increase of drug use (Jalal et al., 2018) and prevalence of chronic diseases such as obesity (Liu et al., 2021), heart disease, and diabetes (Mc Namara et al., 2019; American Diabetes Association, 2022) as well as societal trends of decreasing marriage rates, and delayed child birth (Brown & Sheffield, 2015; CDC, 2022a; NVSR, 2015). Taken together, maternal morbidity is not showing signs of decline.

Within the counties of Southern Arizona, there is a great need to target maternal health in Yuma and Pima counties. Relevant strategies and policies to improve maternal health include increasing the frequency of care throughout pregnancy, during delivery and throughout the postpartum period. Implementing telemedicine may be a promising strategy to help address maternal morbidity in rural regions, and studies can report whether intervention via telemedicine is associated with a decrease in maternal morbidities. While less discussed in this research, clinicians should also consider the impact of certain procedures on mothers. For example, future studies should investigate the impact of C-section rates on morbidities and discuss ways to ensure the mother’s long-term health and well-being.

To reiterate, two out of three maternal deaths are preventable (Davis et al., 2019). These findings strongly indicate that there is a great need to improve both the quality and frequency of care for mothers. Clinicians are increasingly aware of the challenges mothers face today and should have a heightened awareness of morbidities, particularly for Black and Native American mothers. Healthcare leaders should also implement protocols and training for clinicians to identify morbidities upstream and begin preventative treatment early. Healthcare leaders, researchers, and clinicians should continue to identify risk factors associated with maternal morbidity. As discussed in this study, geographical residence, race, marital status, age, and income are each significant factors to consider.

Lastly, this study invites policymakers, clinicians, healthcare leaders, private businesses, researchers, families, and community members at large to raise awareness of the current challenges mothers face during and after pregnancy. Maternal health is a hallmark of the well-being of society, and merits the nation’s best efforts and continued attention.
References


