

# **SEVERE MATERNAL MORBIDITY IN ARIZONA 2016-2018**

**An Analysis of Singleton Delivery  
Hospitalizations Using Arizona  
Birth and Hospital Discharge Data**



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**Intended Audience:**

This is a technical report on the analysis of Severe Maternal Morbidity in Arizona, including the demographics and distribution of severe maternal morbidities among singleton delivery hospitalizations during 2016-2018. As such, the report is aimed primarily at those actively involved in care of and improvements to maternal health, including healthcare providers, community service providers, researchers, policymakers, and other stakeholders. While publically available, the intended audience of this report is not the general public, and extra care in the use or interpretation of this report should be taken by those with limited background or subject-matter expertise in the areas of maternal health and complications of labor and delivery.

**How to Use This Report:**

This report describes the incidence of severe maternal morbidities in Arizona, as well as a variety of risk factors contributing to these severe morbidities among women giving birth in Arizona. The key findings presented in this report should assist in the identification of future targets for intervention and guide effective and evidence-based efforts towards the reduction of adverse maternal health outcomes.

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**Suggested Citation:**

Lewandowski KS, Celaya MF, Quintana-Torres E, Coonrod D, Tarango P. *Severe Maternal Morbidity in Arizona 2016-2018: An Analysis of Singleton Delivery Hospitalizations Using Arizona Birth and Hospital Discharge Data*. Phoenix, AZ: Arizona Department of Health Services; 2020.

## EXECUTIVE SUMMARY

Severe maternal morbidity (SMM) includes unexpected outcomes of labor and delivery that lead to significant short- or long-term consequences to a woman's health and wellbeing.<sup>1</sup> Some of these unexpected pregnancy, delivery and postpartum complications include but are not limited to hemorrhage, organ failure and stroke.<sup>2,3</sup> Suffering from SMM may result in an extended hospital stay, major surgery, other medical interventions, and death.<sup>2,3</sup> SMM is often a sentinel measure used in understanding the causes and gaps leading to pregnancy-related maternal deaths.<sup>4</sup>

Over the past decade, SMM has increased nationally, along with maternal mortality and other adverse health outcomes.<sup>1</sup> In response, Arizona has launched a series of initiatives to improve maternal health in the state, including improved surveillance of maternal mortality and morbidity, as well as quality improvement efforts to implement maternal safety protocols during labor and delivery.

Beginning in 2019, the Arizona Department of Health Services conducted a study to identify and review cases of SMM utilizing the Hospital Discharge Database (HDD) and birth certificate data, based on an enhanced version of an algorithm developed by the American College of Gynecologists and Obstetrician's (ACOG) Alliance for Innovation in Maternal Health Initiative (AIM) and used by the New York City's Department of Health and Mental Hygiene.<sup>5,6</sup> This report focuses on the findings from the study of SMM among Arizona resident singleton births in hospitals from 2016 through 2018, presented in full as a table in **Appendix A**. See **Appendix B** for a complete list and definition of SMM indicators.

### Key Findings

- There were 218,433 qualifying singleton delivery hospitalizations of Arizona residents in 2016-2018.
- The overall rate of SMM among singleton births in Arizona for 2016-2018 was 117.1 cases per 10,000 delivery hospitalizations.
- The majority of SMM cases (84.5%) only had one SMM indicator, while 9.3% had two indicators, and 6.2% had three or more.
- The leading overall diagnosis indicators of SMM were adult respiratory distress (8.1%), sepsis (8.1%), and disseminated intravascular coagulation (7.9%). The leading overall procedure indicators were blood transfusion (64.6%) and hysterectomy (7.8%).
- Although all SMM cases had to have at least one qualifying condition for inclusion in this analysis, nearly three quarters (73%) had two or more qualifying conditions.
- The leading qualifying conditions were length of stay and a procedure indicator with 88.6% and 73.2% of SMM cases, respectively.

- The SMM rate amongst twins was 462.8 compared to 117.1 among singleton deliveries. As twins and other multiples make up a very small proportion of all delivery hospitalizations (1.7%) and are inherently higher risk pregnancies, singleton births were the focus of this study in order to identify other contributing factors of SMM.
- SMM disproportionately affected women of color, especially American Indian or Alaska Native women who had an SMM rate of 292.6 cases per 10,000 delivery hospitalizations. This was over 3.5 times the SMM rate of White women (82.1).
- Women 40 years or older (181.2) and 19 and younger (158.9) had the highest rates of SMM across maternal age groups.
- Women whose birth was paid for by IHS had the highest SMM rate (308.1), compared to AHCCCS (137.1), self-pay (109.5), and private insurance (86.4).
- Women who lived in primary care areas with 25-47% of the population living below the federal poverty level (FPL) had the highest SMM rate (148.9) compared to women living in primary care areas with between 4-10% of the population living below FPL (83.0).
- Increasing educational attainment had decreased SMM rates; some college or more (98.3) had a much lower SMM rate than women who did not complete high school or a GED (159.8).
- Overall, women living in rural counties had higher rates of SMM than women in urban counties (154.3 versus 112.5).
- Women with one previous live birth had a lower rate of SMM (88.5) than women without any previous births (136.2) and women with two previous births (97.9), three previous births (139.0), or four or more previous births (191.4).
- Among women with at least one previous live birth, interpregnancy intervals, or the time between a birth and the conception of a subsequent pregnancy, that were less than a year or greater than 5 years had the highest rates of SMM (125.5 for < 6 months, 121.8 for 6-11 months, and 131.4 for 5 years or more), especially compared to 18-23 months (77.9) and 24-35 months (81.4).
- SMM rates were higher for women with an underweight or obese pre-pregnancy BMI (130.7 and 128.5, respectively) compared to women with a normal pre-pregnancy BMI (106.6).
- Across all pre-pregnancy BMI groups, inadequate weight gain had the highest SMM rate at 132.1, followed by 117.3 for excess weight gain and 105.6 for recommended weight gain.
- In looking at the combined effect of pre-pregnancy BMI and weight gain during pregnancy, inadequate weight gain had the highest rate of SMM among underweight (148.4), normal weight (129.1), and overweight women (144.8) compared to recommended weight gain (103.3, 92.1, and 115.0, respectively), with no real difference for obese women. Excess weight gain had the most noticeable increase in SMM rate among underweight women (146.6) compared to recommended weight gain for

underweight women (103.3); excess weight gain had no effect on SMM for normal, overweight, or obese women.

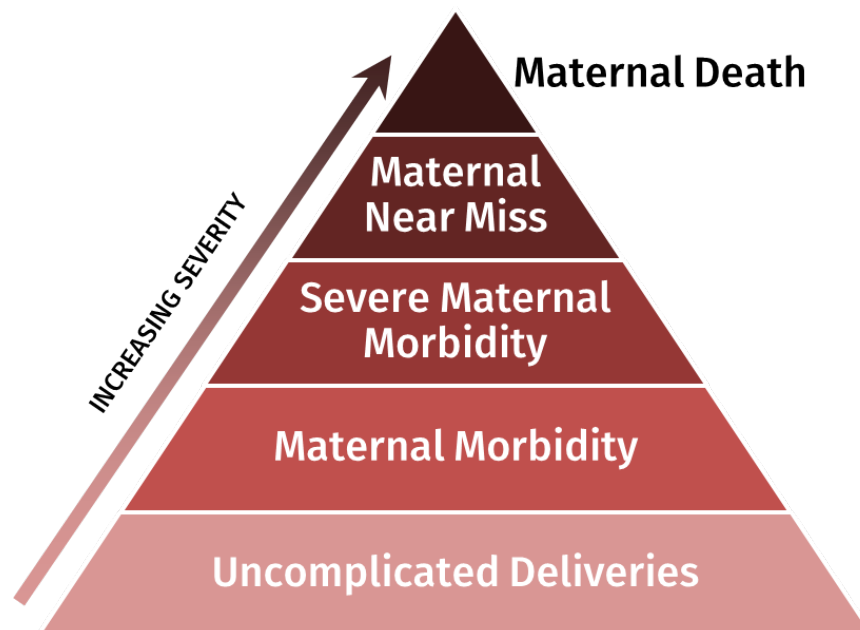
- Women with chronic conditions (pre-existing diabetes or chronic hypertension) had much higher SMM rates (between 2.3 to 2.6 times) than women without these chronic conditions. Women who developed a hypertensive disorder of pregnancy had over 3x the rate of SMM than women who did not develop a hypertensive disorder of pregnancy. Gestational diabetes also resulted in an increase in SMM than without gestational diabetes, however it was more subtle than hypertensive disorders of pregnancy (147.3 with gestational diabetes versus 114.6 without).
- There was no difference in SMM rate by smoking tobacco, regardless of whether a woman smoked prior to or during pregnancy; women who smoked had an SMM rate of 122.8, while non-smokers had an SMM rate of 116.4.
- Women with no prenatal care had remarkably higher SMM rates than women who began care in the first trimester or received adequate prenatal care (over 3x the SMM rate). Additionally, women without prenatal care even had an SMM rate of over 2x the rate of women who began prenatal care in the third trimester or received inadequate prenatal care.
- Method of delivery had a notable effect on the rate of SMM, with primary cesareans (296.9) and repeat cesareans (180.3) higher than both vaginal births after cesareans (VBAC, 119.7) and other vaginal deliveries (69.6). This could correspond to higher risk pregnancies or medical indications for cesarean delivery, as well as complications of the procedure.
- Among early term deliveries at 37-38 weeks gestation, those with a cesarean section or induction of labor without a medical indication for these interventions had much higher rates of SMM than spontaneous vaginal deliveries: 165.1 for early non-medically indicated cesarean and 109.7 for early non-medically indicated induction compared to 53.2 for spontaneous vaginal deliveries.
- Deliveries occurring in a level II facility, as certified by the Arizona Perinatal Trust (APT), had the lowest rates of SMM (78.9) compared to other certified levels of care. Non-APT certified hospitals had the highest rate of SMM (156.5), which includes deliveries at non-birthing facilities.
- Women who had a preterm delivery (before 37 weeks gestation) had much higher rates of SMM than deliveries at or after 37 weeks. Similarly, women who had a postterm delivery (42 weeks gestation or later) also had higher rates of SMM compared to term (37-41 weeks).
- Women who had an SMM during delivery were also more likely to have an infant with adverse health outcomes: 20.6% of SMM cases had very low or low birth weight infants compared to 5.9% of all deliveries, 8.5% low 5 minute Apgar scores compared to 1.7%, and 24.9% NICU admissions compared to 6.2% among all deliveries.

## BACKGROUND AND SIGNIFICANCE

**Maternal Morbidity** is part of the continuum from uncomplicated deliveries to life-threatening events, or even death, that can occur prior to, during, or after childbirth. This can range from minor complications to near-miss events that without timely identification and treatment could lead to death.<sup>7</sup> **Figure 1** depicts the spectrum of maternal morbidity with uncomplicated deliveries progressing to a maternal death as the level of severity increases during delivery.

Within this continuum, severe maternal morbidities (SMM) are the unexpected conditions or outcomes of pregnancy, delivery, or postpartum that aggravate or lead to significant negative effects on a woman's health and wellbeing.<sup>7-9</sup> This can include both physical or psychological conditions, and can have impacts in either the short- or long-term.<sup>2,7,8</sup> It has been shown that SMM has a persistent effect on the functioning of women even up to 5 years later.<sup>10</sup> Severe maternal morbidity may also affect the fetuses/neonates with adverse outcomes such as premature birth, low birth weight, failure to thrive, increased need for medical intervention, or death.<sup>3</sup> Additionally, women who experience an SMM event are at higher risk of postpartum mental illness or emotional distress, including Post-Traumatic Stress Disorder (PTSD), which can affect their ability to parent or bond with their infant.<sup>11,12</sup>

**Figure 1. Spectrum of Maternal Morbidity**

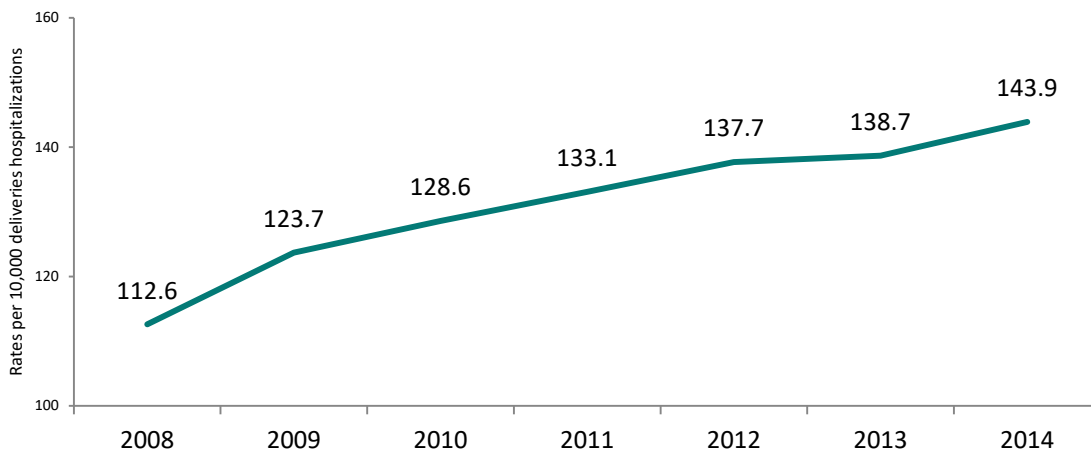


*Adapted from: New York City Department of Health and Mental Hygiene (2016). Severe Maternal Morbidity in New York City, 2008–2012. New York, NY.*

The financial implications of SMM using hospital discharge data have not been studied in Arizona. However a 2016 economic analysis on Severe Maternal Morbidity in 13,505 cases from 2008-2012, completed by the New York City Health Department of Health and Mental Hygiene, discovered that the average cost of delivery increased when a women had an SMM. After adjusting for other maternal, clinical, and hospital level factors, the average cost of delivery with SMM was \$15,714 compared to \$9,357 for deliveries without SMM in New York City.<sup>5</sup> This reflects a 68% increase in the cost of delivery possibly due to longer hospital stays, emergency surgeries, and unplanned medical interventions needed to treat an SMM case to prevent mortality. According to the analysis, SMM cases had an adjusted difference in cost of \$6,357 per case, with the total excess costs related to SMM exceeding \$85 million.<sup>5</sup>

As seen in Figure 2 below, SMM in the United States has been steadily increasing in recent years with an almost 200% increase since 1993, driven largely by increases in blood transfusions.<sup>1</sup> In 2014, the last full year of data available nationally, SMM affected more than 50,000 women in the United States.<sup>1</sup> SMM in **Figure 2** is defined as the “number of delivery hospitalizations with an indication of severe morbidity from ICD-9 diagnosis or procedure codes (e.g. heart or kidney failure, stroke, embolism, hemorrhage) over the number of delivery hospitalizations.”

**Figure 2. Severe Maternal Morbidity Rates, United States, 2008-2014**



Data source: HCUP State Inpatient Databases; Adapted from: HRSA National Outcome Measures Dashboard <https://mchb.tvisdata.hrsa.gov/PrioritiesAndMeasures/NationalOutcomeMeasures>

Technical note: This measure follows the CDC-developed definition of severe maternal morbidity identified from hospital discharge procedure and diagnosis codes that indicate a potentially life-threatening condition or maternal complication. Specific ICD-9-CM diagnosis and procedure codes have been reduced to 18 in preparation for the transition to ICD-10-CM:

<http://www.cdc.gov/reproductivehealth/MaternalInfantHealth/SevereMaternalMorbidity.html>

With the exception of hospitalizations with in-hospital mortality, transfer, or severe complications identified by procedure codes (e.g., hysterectomy, blood transfusion, ventilation), cases of severe maternal morbidity identified by diagnostic codes were reclassified as hospitalizations without severe maternal morbidity if they had an implausibly short length of stay (<= 3 days for vaginal, < 4 days for primary cesarean, and < 5 days for repeat cesarean deliveries). Delivery hospitalizations were identified by diagnosis codes for an outcome of delivery, diagnosis-related group delivery codes, and procedure codes for selected delivery-related procedures.

**United States estimates are calculated using the available state data and are not nationally weighted; therefore, United States estimates may not be comparable across years due to the different states included in any given year.**



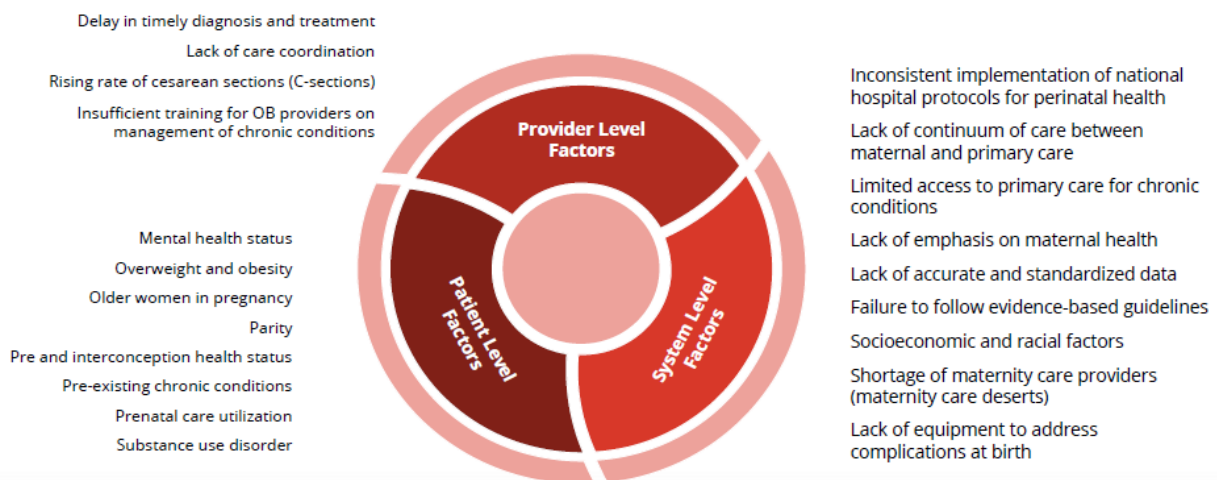
While the reason for this increase in SMM is not entirely understood, decreasing overall health among women giving birth, including those with chronic conditions such as diabetes, cardiovascular disease, and hypertension, may be partly responsible for the increase in SMM, as well as increasing maternal age and multiple gestational births.<sup>1,13</sup> Additional provider and systemic factors likely also contribute to SMM, including delay in diagnosis and treatment, lack of care coordination, limited access to care, method of delivery, and other socioeconomic and racial factors.<sup>3</sup>

Women of color carry a disproportionate burden of SMM and maternal mortality, and this disparity in adverse maternal health outcomes is increasing along with increases in overall SMM.<sup>13,14</sup> Non-Hispanic Black women are three (3) times as likely as non-Hispanic White women to experience maternal death in the United States.<sup>14,15</sup> Similarly, a [report from the Arizona Maternal Mortality Review Program](#) found among pregnancy-related maternal deaths, Native American women died at four (4) times the rate compared to Non-Hispanic White women despite Non-Hispanic Native American Women representing only 6.0% of births for the same data years.<sup>16</sup> Consistent with maternal mortality, non-Hispanic Black women and other women of color also have higher rates of SMM.<sup>13,15</sup> A study of 2008-2010 delivery hospitalizations in 7 states found that Non-Hispanic Black, Hispanic/Latina, Asian/Pacific Islander, and Non-Hispanic American Indian/Alaska Native women had 2.1, 1.3, 1.2, and 1.7 times, respectively, higher rates of SMM compared with non-Hispanic White women.<sup>15</sup>

A review of the literature describes a variety of factors that affect maternal morbidity and mortality. These factors interplay at the patient, provider, and systemic levels. **Figure 3** displays the factors that affect maternal mortality and morbidity cited in the literature.

**Figure 3. Diagram of factors that affect maternal mortality and morbidity**

### Factors that affect Maternal Mortality and Morbidity



Most pervasive is the inconsistent implementation of hospital protocols for perinatal health and insufficient training for OB providers on management of chronic conditions.<sup>3</sup> Implicit bias and racism in healthcare can also contribute to adverse maternal health outcomes.<sup>17</sup> In addition, social determinants of health, or factors in the environment in which people live and function that can affect health, risk, and quality of life such as poverty, inadequate housing, lower educational attainment, and lack of access to healthcare services, exacerbate the risk for women to experience SMM in their communities.<sup>18</sup>

The data presented in this report is intended to continue conversations on how Arizona can effectively design and implement statewide interventions aimed at improving women's overall health and directed at populations disproportionately burdened by SMM.

## METHODOLOGY

### Data Source

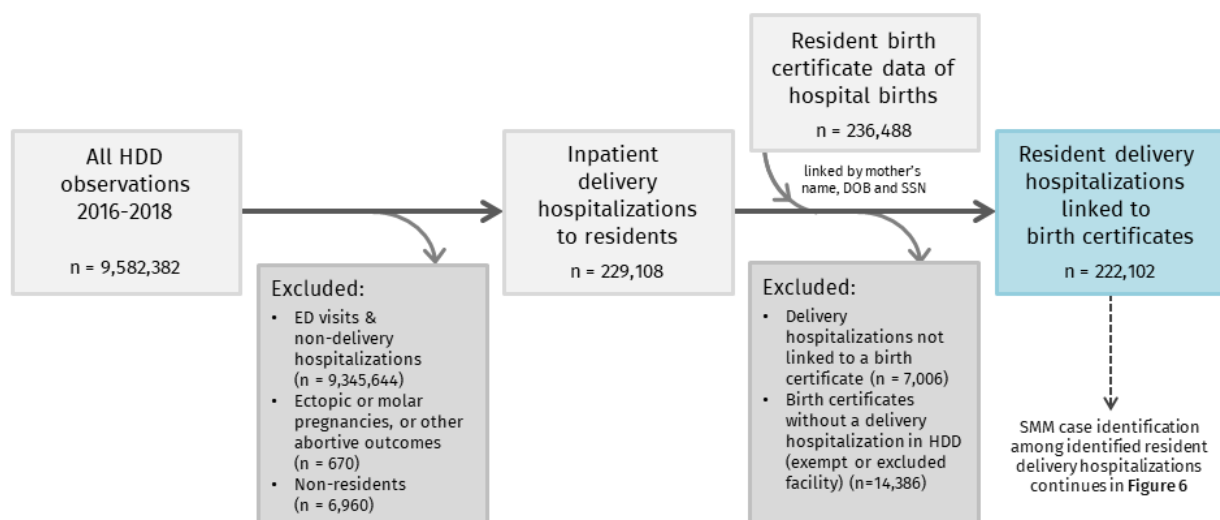
Hospital Discharge Data: Hospital discharge data is a valuable source of information about the patterns of care, public health, and the burden of chronic disease and injury morbidity. ADHS collects hospital discharge records for inpatient and emergency department visits from all Arizona licensed hospitals. This collection is required by Arizona Revised Statute (A.R.S.) § 36-125-05, and Arizona Administrative Code Title 9, Chapter 11, Articles 4 and 5. This data is released every 6 months.

Birth Certificate Data: Information on births is compiled from the original documents filed with the Arizona Department of Health Services' Office of Vital Records and from transcripts of original birth and death certificates filed in other states but affecting Arizona residents (does not include births outside of the United States). It is made available annually following completion of the previous calendar year.

### SMM Case Identification Procedure

All hospital records with a discharge date between January 1, 2016 and December 31, 2018 (n=9,582,382) were analyzed to identify in-state delivery hospitalizations (n=229,108). Delivery hospitalizations with an ectopic pregnancy or a pregnancy with abortive outcome (spontaneous or elective) and delivery hospitalizations from non-Arizona residents were excluded (n=7,630). The remaining hospital discharge records were then linked to birth certificate data using a combination of the mother's first and last names, date of birth, and social security number. The final number of linked birth certificate and delivery hospitalizations for Arizona residents in an Arizona facility that reports to the Arizona Hospital Discharge Database at the time of analysis was 222,102 (95.2% overall match rate and 96.8% for singleton deliveries). **Figure 4** depicts the process of identifying delivery hospitalizations and their linkage to birth certificate data.

**Figure 4. Identification protocol for delivery hospitalizations in the HDD dataset, 2016-2018**



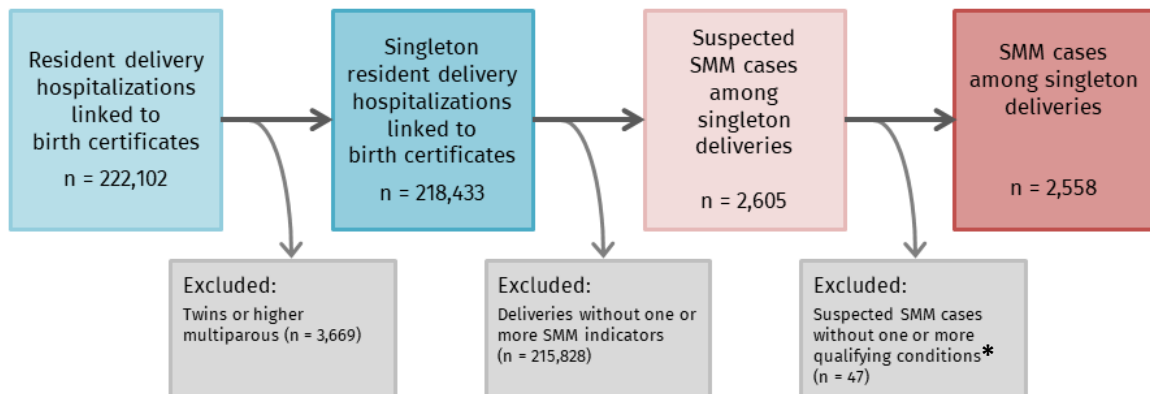
SMM cases were identified among delivery hospitalizations using an algorithm developed by Centers of Disease Control and Prevention and adopted by the American College of Gynecologists and Obstetrician’s (ACOG) Alliance for Innovation in Maternal Health Initiative (AIM).<sup>6</sup> This algorithm identifies 21 indicators of SMM that represent either serious complications of pregnancy or delivery such as cardiac arrests and acute renal failure- or procedures used to manage serious conditions – such as blood transfusions and hysterectomies. All indicators were identified using ICD-10CM diagnosis and procedures codes. Due to the late 2015 to early 2016 transition from ICD-9CM to ICD10CM diagnoses and procedure codes the interpretation of 2016 rates and counts should be cautionary. The diagnosis and procedures based indicators can be found in **Figure 5** and the definitions and ICD-10CM codes used to identify SMM cases can be found in **Appendix B**.

**Figure 5. Diagnosis and procedures based indicators used to identify SMM cases**

Diagnosis based indicators:	Procedures based indicators:
<ul style="list-style-type: none"> <li>▪ Acute myocardial infarction</li> <li>▪ Acute Renal Failure diagnosis</li> <li>▪ Adult Respiratory Distress Syndrome diagnosis</li> <li>▪ Amniotic fluid embolism</li> <li>▪ Aneurysm</li> <li>▪ Cardiac arrest/ventricular fibrillation</li> <li>▪ Disseminated Intravascular Coagulation</li> </ul>	<ul style="list-style-type: none"> <li>▪ Eclampsia</li> <li>▪ Heart failure/arrest during procedure or surgery</li> <li>▪ Puerperal Cerebrovascular Disorder</li> <li>▪ Acute Heart Failure / Pulmonary edema</li> <li>▪ Severe anesthesia complications</li> <li>▪ Sepsis</li> <li>▪ Shock</li> <li>▪ Sick Cell Disease with Crisis</li> <li>▪ Air and thrombotic embolism</li> </ul>
	<ul style="list-style-type: none"> <li>▪ Blood transfusion</li> <li>▪ Conversion of cardiac rhythm</li> <li>▪ Hysterectomy</li> <li>▪ Temporary tracheostomy</li> <li>▪ Ventilation</li> </ul>

Out of all these delivery hospitalizations 2,777 had at least one indicator for Severe Maternal Morbidity (SMM). For inclusion in the final sample, cases with an indicator of SMM must also have at least one *qualifying factor*: length of hospital stay of at least 4 days for vaginal or primary cesarean delivery or at least 5 days for repeat cesarean delivery; the mother was transferred before or after delivery to a different facility; the mother died during the delivery hospitalization; or at least one of the five procedure indicators was present. This was adapted from the methods published in the [New York City Department of Health and Mental Hygiene’s most recent report of SMM](#) and the HRSA National Outcome Measure of SMM.<sup>5</sup> Additionally, only singleton deliveries were included in the final analysis. There were **2,558** qualifying SMM cases amongst singleton deliveries. **Figure 6** depicts the SMM case identification process using the HDD dataset.

**Figure 6. Identification protocol for SMM cases among delivery hospitalizations, 2016-2018**



\* Cases with an SMM indicator must also have one of five qualifying conditions: 1) maternal transfer into or 2) out of the birthing facility; 3) maternal death during the hospitalization; 4) one of five procedure based indicators; or 5) a length of stay greater than 3 days for vaginal and primary cesarean deliveries or greater than 4 days for repeat cesarean deliveries.

## Definitions

Additional definitions can be found in **Appendix C**.

- **Severe maternal morbidity (SMM):** unexpected conditions or outcomes of pregnancy, delivery, or postpartum that aggravate or lead to significant negative effects on a woman's health and wellbeing.
- **Maternal mortality:** the death of a woman while pregnant or within 1 year of the end of a pregnancy – regardless of the outcome, duration or site of the pregnancy – from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.
- **Singleton birth:** the birth of only one child during a single delivery.
- **SMM cases:** includes women with a delivery hospitalization and a diagnosis or a procedure code indicator for SMM, as well as a qualifying condition indicating severity, including transfer in or out of the birth facility, death, length of stay longer than expected, or one of the procedure codes.
- **Indicator of SMM:** a list of 21 diagnoses or procedures considered an indication of SMM during the delivery hospitalization, identified by a set of ICD-10 billing codes in the Hospital Discharge Data (HDD) record. See **Appendix B** for a complete list and definition of these indicators.
- **Qualifying Condition of SMM:** at least one of five conditions that must be met for inclusion of an SMM case in this study – transfer into or out of the delivery hospitalization, death during the delivery hospitalization, one of the five SMM procedure indicators, or a length of stay of 4 or more days for vaginal or primary cesarean deliveries, or 5 or more days for repeat cesarean deliveries.
- **SMM rate:** Number of delivery hospitalizations with an indication of an SMM diagnosis or procedure codes along with a qualifying condition over the total number of delivery hospitalizations calculated per 10,000 delivery hospitalizations.
- **Arizona Perinatal Trust Levels of Care:** Based on the Arizona Perinatal Trust Voluntary Certification Program (VCP) which is a peer review/quality assurance process for the purposes of reducing morbidity and mortality and improving the care of patients. Full description of each level of care can be found in **Appendix D**.
- **Resident:** Arizona residency was determined by the county of residence as listed on the birth certificate at the time of delivery. This is not an indication of citizenship or legal residence in Arizona.
- **Primary Care Areas:** A Primary Care Area (PCA) denotes the geographic area generally served by a common primary health provider. For example, it is used by the Health Resources and Services Administration to designate areas of workforce shortage.

## RESULTS

### Population Demographics

**Table 1** shows the distribution of resident singleton delivery hospitalizations during 2016-2018 in this analysis. Additional information on delivery characteristics can be found in **Appendix A**.

**Table 1. Singleton Delivery Hospitalizations of Arizona Residents, 2016-2018 (n=218,433)**

Year	# of Deliveries	% of Deliveries	# of SMM Cases	% of SMM Cases
2016	75,647	34.6	960	37.5
2017	71,256	32.6	811	31.7
2018	71,530	32.7	787	30.8
<b>Maternal Race and Ethnicity</b>				
American Indian or Alaska Native	8,578	3.9	251	9.8
Asian or Pacific Islander	9,078	4.2	115	4.5
Black or African American	12,604	5.8	193	7.5
Hispanic or Latina	91,508	41.9	1,205	47.1
White	96,665	44.3	794	31.0
<b>Rural vs Urban County of Residence*</b>				
Rural	24,172	11.1	373	14.6
Urban	194,261	88.9	2,185	85.4
<b>Maternal Age</b>				
≤ 19 Years	13,469	6.2	214	8.4
20-29 Years	116,914	53.5	1,264	49.4
30-39 Years	82,199	37.6	974	38.1
≥ 40 Years	5,851	2.7	106	4.1
<b>Parity</b>				
No Previous Births	78,915	36.1	1,075	42.0
1 Previous Birth	65,960	30.2	547	21.4
2 Previous Births	39,419	18.0	386	15.1
3 Previous Births	19,346	8.9	269	10.5
4 or More Previous Births	14,683	6.7	281	11.0
<b>Primary Payer of Birth</b>				
Private Insurance	91,975	42.1	795	31.1
Self-Pay	5,571	2.6	61	2.4
AHCCCS	113,976	52.2	1,563	61.1
IHS	1,915	0.9	19	2.3
Other Government (TRICARE, etc.)**	1,272	0.6	61	0.7
Other/Unknown**	3,724	1.7	59	2.4
<b>Method of Delivery</b>				
Primary Cesarean	31,931	14.6	948	37.1
Repeat Cesarean	25,792	11.8	465	18.2
Vaginal Delivery After Cesarean (VBAC)	5,432	2.5	65	2.5
Vaginal Delivery	155,278	71.1	1,080	42.2

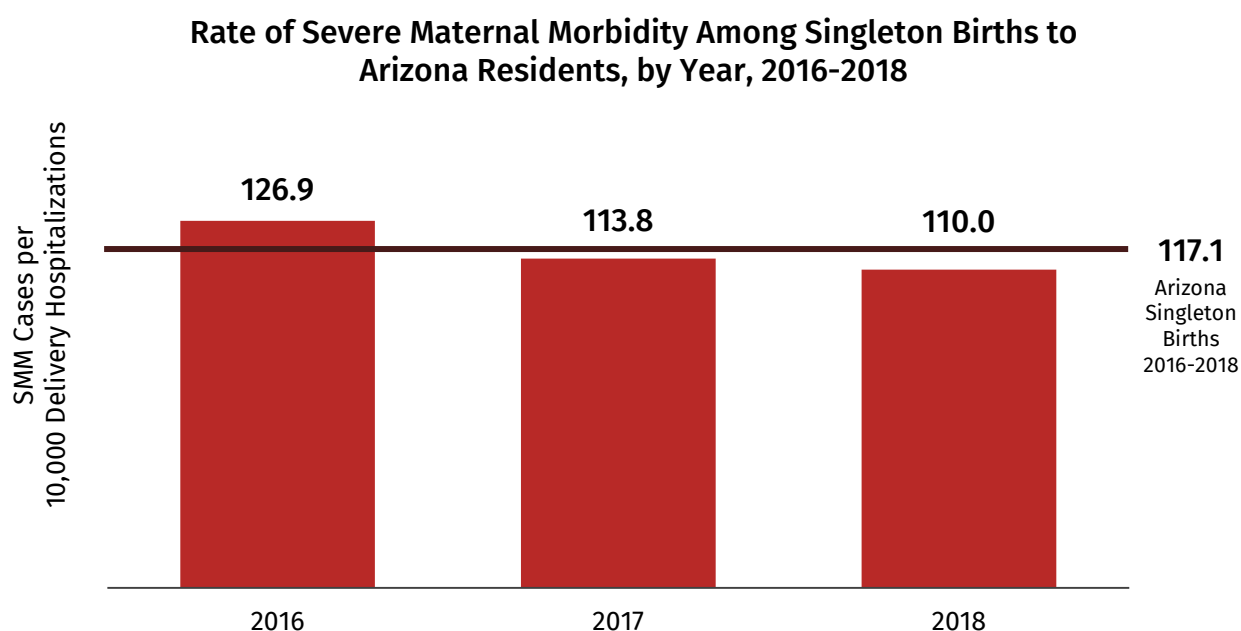
\* Rural counties are Apache, Cochise, Coconino, Gila, Graham, Greenlee, La Paz, Mohave, Navajo, Santa Cruz, and Yavapai; Urban counties are Maricopa, Pima, Pinal, and Yuma.; Based on definitions used by the ADHS Bureau of Public Health Statistics.

\*\* Other government payers include Department of Defense TRICARE, the Children's Health Insurance Program (CHIP), and the Veteran's Health Administration (VHA). Other/Unknown includes those with unlisted or missing payer information.

## Overall Rate of SMM

Based on the SMM case identification protocol described earlier, Arizona's 2016-2018 overall SMM rate for singleton deliveries was 117.1 per 10,000 delivery hospitalizations. Trend analysis shows that between 2016 and 2017, the total number of cases and the SMM rate decreased by 15.5% and 10.3%, respectively while the number of total deliveries decreased by only 5.8%. This could be due to continued transition to ICD-10 from ICD-9 throughout the end of 2015 and early 2016, and can be seen with the much smaller change from 2017 to 2018 (3.0% decrease in cases and 3.3% decrease in overall rate). Thus the 2016 counts and rates should be interpreted with caution, and where possible the overall 2016-2018 rate should be used.

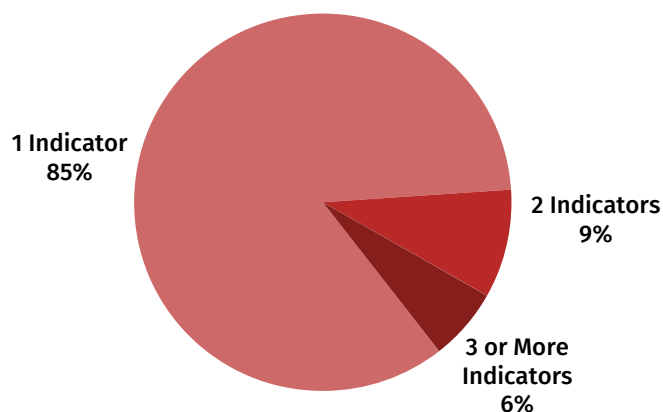
**Figure 7. SMM Overall Rate and SMM Cases by Year among Resident Singleton Deliveries, 2016-2018**



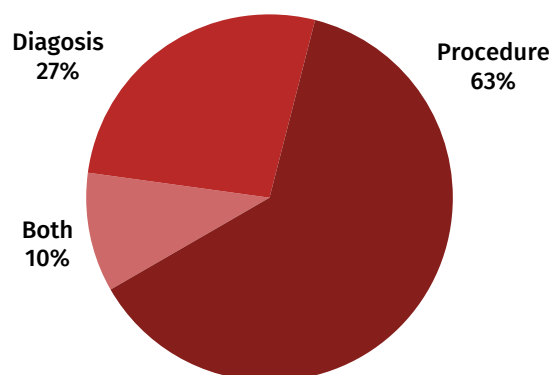
## Indicators of Severe Maternal Morbidity

The majority of SMM cases (84.5%) had one indicator out of a total of 21 SMM indicators, 9.3% of cases had two indicators, and a smaller proportion of cases (6.2%) had 3 or more indicators. **Figure 8** shows the distribution of the number of SMM indicators per case.

**Figure 8. Distribution of SMM Indicators among Singleton SMM cases, 2016-2018**



**Figure 9. Types of SMM Indicators among Singleton SMM cases, 2016-2018**



Most of the SMM cases (73%) had at least one of the 5 procedure indicators, with 63% having procedure indicators only and 10% having both procedure and diagnosis indicators (**Figure 9**). This is driven by transfusions, which were present in nearly 65% of all SMM cases (**Table 2**). Meanwhile, 37% of SMM cases had one of the 16 diagnosis indicators, with 27% having diagnosis indicators only.

**Table 2. Frequency of Indicators of SMM among Singleton Delivery Hospitalizations, 2016-2018**

Diagnosis Indicators <sup>‡</sup>	Frequency	Percent (%)
Adult Respiratory Distress Syndrome	208	8.1
Sepsis	208	8.1
Disseminated Intravascular Coagulation	203	7.9
Acute Renal Failure	186	7.3
Pulmonary Edema	144	5.6
Shock	136	5.3
Eclampsia	56	2.2
Puerperal Cerebrovascular Disorders	47	1.8
Thrombotic Embolism	30	1.2
Cardiac Arrest/Ventricular Fibrillation	20	0.8
Amniotic Fluid Embolism	18	0.7
Sickle Cell Anemia with Crisis	14	0.6
Aneurysm	9	0.4
Severe Anesthesia Complications	8	0.3
Acute Myocardial Infarction	*	**
Heart Failure/Arrest during Procedure or Surgery	*	**
Procedure Indicators <sup>‡</sup>		
Blood Transfusion	1653	64.6
Hysterectomy	199	7.8
Ventilation	106	4.1
Conversion of Cardiac Rhythm	17	0.7
Temporary Tracheostomy	*	**

<sup>‡</sup> See **Appendix B** for a complete list of and definition of SMM indicators

\* Cell suppressed due to value < 6

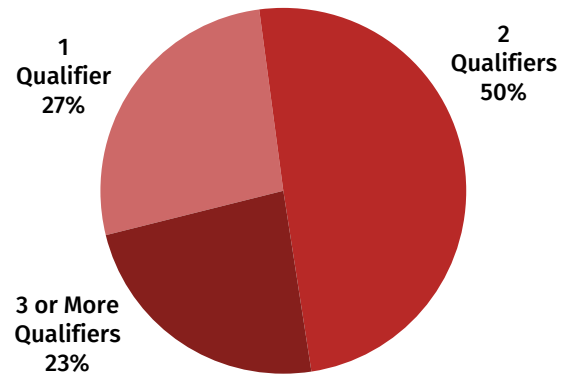
\*\* Not calculated due to suppressed cell



The most common SMM diagnosis indicators were adult respiratory distress syndrome (208, 8.1%), sepsis (208, 8.1%), and disseminated intravascular coagulation (203, 7.9%). The most common SMM procedure indicators were blood transfusion (1653 cases, 64.6%); hysterectomy (199, 7.8%); and ventilation (106, 4.1%). The frequency of SMM indicators among the identified SMM cases is depicted in **Table 2**. An SMM case can have more than 1 indicator as described in **Figure 8**. See **Appendix B** for a complete list of and definition of SMM indicators.

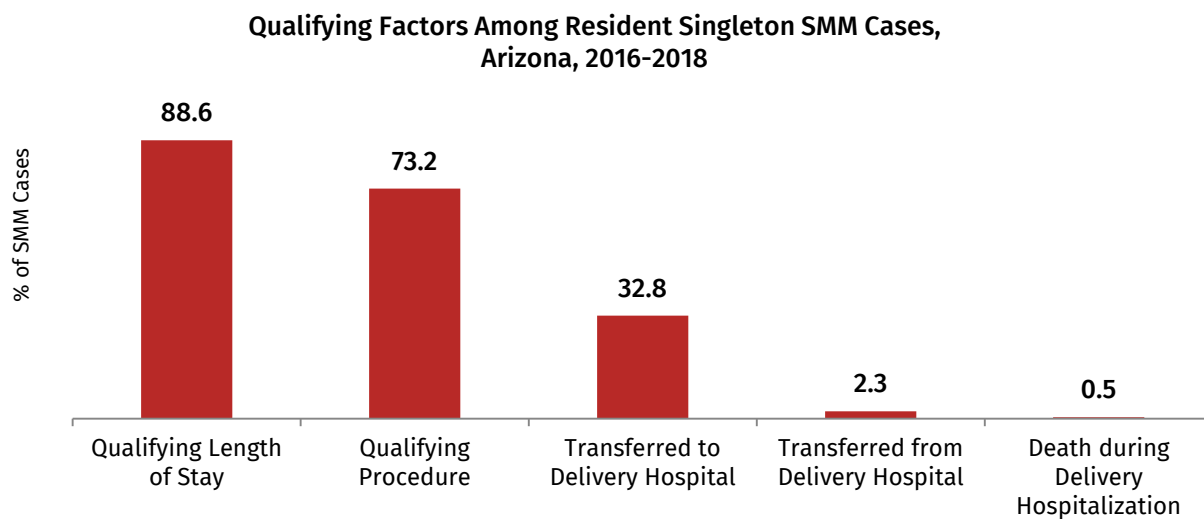
In addition to the presence of an SMM indicator, SMM cases must also have met at least one qualifying condition for inclusion in this analysis. Just over a quarter of SMM cases had only one of the qualifying conditions (27%), as seen in **Figure 10**, while 50% of SMM cases met 2 qualifying conditions and 23% had 3 or more qualifiers.

**Figure 10. Number of Qualifying Conditions per Singleton SMM cases, 2016-2018**



The most common qualifier was length of stay (LOS) based on method of delivery, with 88.6% of SMM cases having a longer than expected LOS (4 or more days for vaginal or primary cesarean or 5 or more days for a repeat cesarean). While not significantly different, the mean LOS for SMM cases was 5.0 days, while only 2.4 days for non-SMM births (not shown). Nearly three quarters of SMM cases had a procedure indicator, and almost a third of SMM cases were transferred into the delivery hospital (**Figure 11**). Transfer from the delivery hospital and death during hospitalization were much less common, with 2.3% and 0.5% (or 5 per 1,000) SMM cases, respectively.

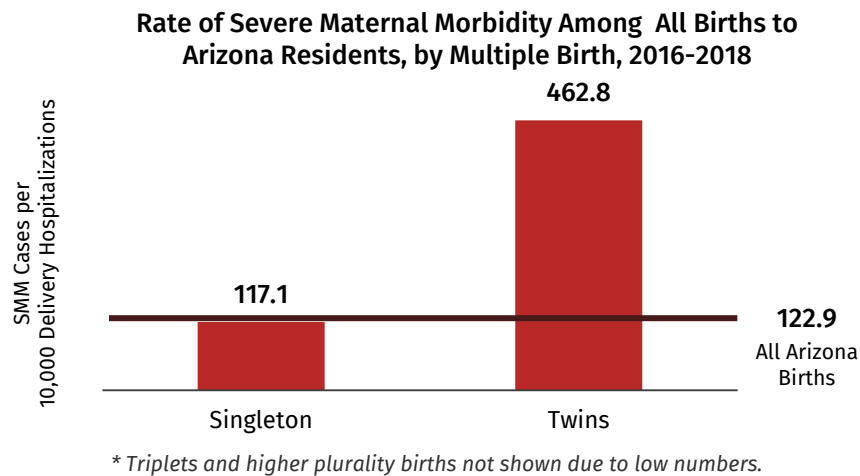
**Figure 11. Distribution of Qualifying Conditions among Singleton SMM Cases, 2016-2018**



## SMM Rate for Multiple Births

Twins and higher multiple births accounted for only 1.7% (n=3,669) of all resident delivery hospitalizations. While the SMM rate for singleton deliveries was 117.1 cases per 10,000 delivery hospitalizations, the SMM rate amongst twins (n=3,587) was 462.8 cases per 10,000 delivery hospitalizations (**Figure 12**). In order to identify contributing factors of SMM besides pregnancies of multiples, which are often born preterm and considered high risk pregnancies, births of twins or higher multiples were excluded, and singletons were the focus of this study.

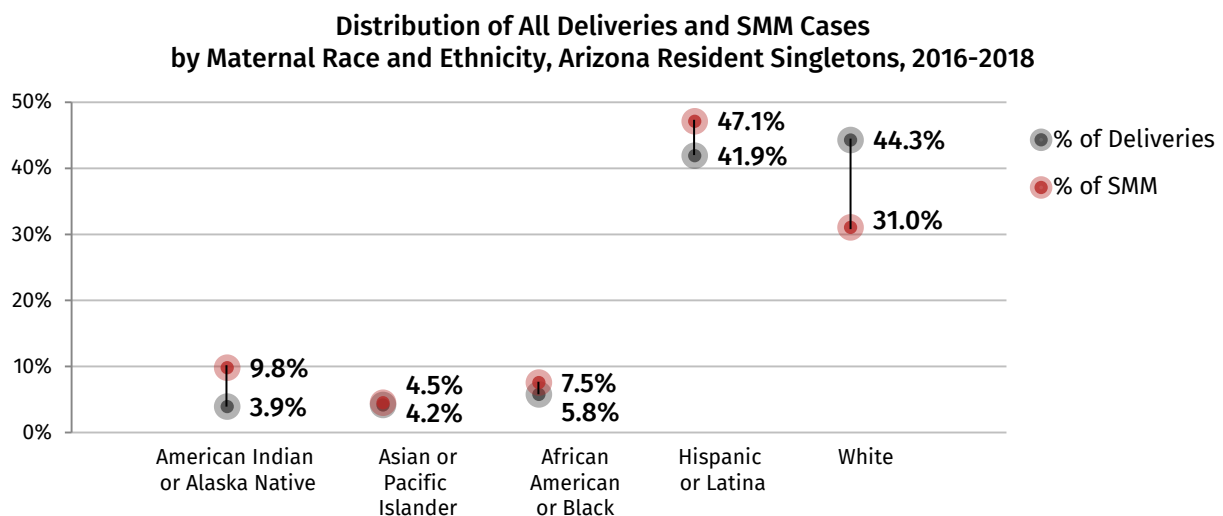
**Figure 12. SMM Rate by Plurality, 2016-2018**



## SMM Rate by Maternal Race and Ethnicity

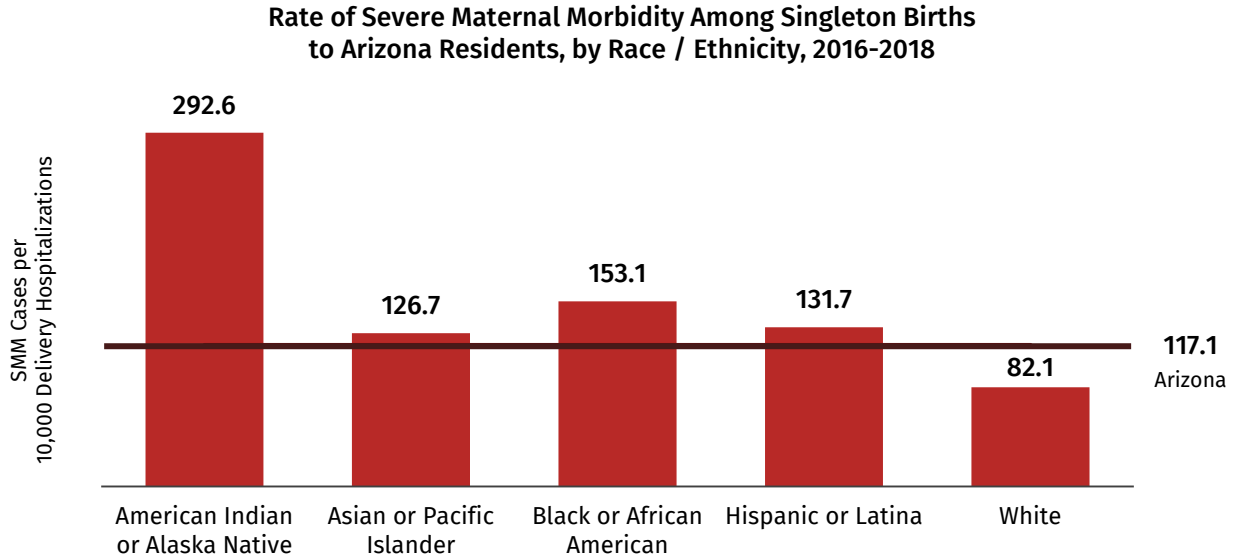
Severe maternal morbidity disproportionately affected women of color, as shown in **Figure 13**. Despite making up less than 4% of delivery hospitalizations, nearly 10% of SMM cases were American Indian or Alaska Native women, and just over 47% of SMM cases were to Hispanic or Latina women, who make up only 42% of deliveries. Conversely, 31% of SMM cases were among non-Hispanic White women, who made up 44% of deliveries.

**Figure 13. Distribution of Singleton Deliveries and SMM Cases by Maternal Race & Ethnicity, 2016-2018**



The SMM rate for American Indian or Alaska Native women was the highest at 292.6 SMM cases per 10,000 delivery hospitalizations, or over 3.5 times the SMM rate for non-Hispanic White women (82.1). Black or African American women had an SMM rate of 153.1 (1.9x the rate among non-Hispanic White women), followed by 131.7 among Hispanic or Latina women (1.6x the rate among non-Hispanic White) and 126.7 among Asian or Pacific Islander women (1.5x the rate among non-Hispanic White). A comparison of these SMM rates by maternal race and ethnicity can be seen in **Figure 14**.

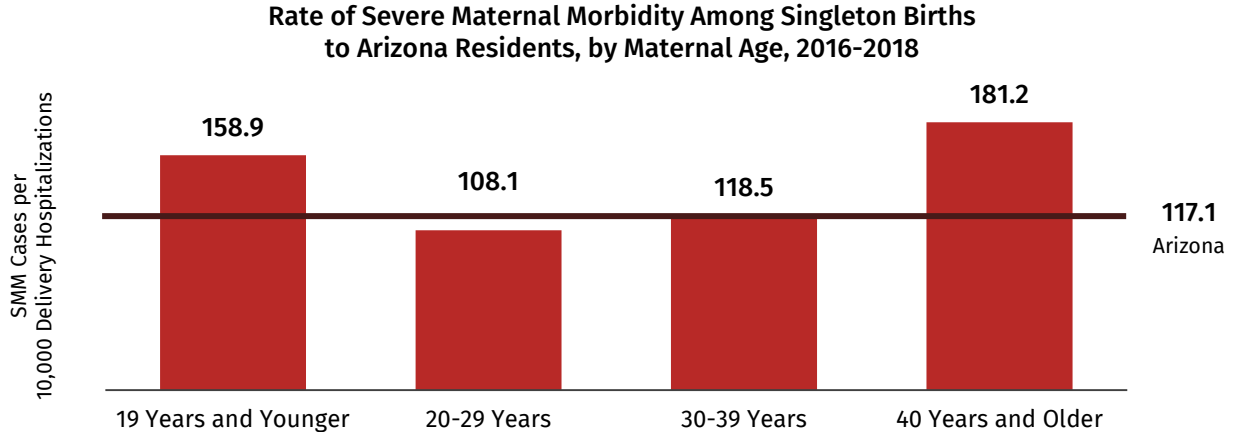
**Figure 14. Singleton SMM Rate by Maternal Race and Ethnicity, 2016-2018**



**SMM Rate by Maternal Age**

As can be seen in **Figure 15**, SMM was higher for women at the youngest and oldest ages. The highest rates of SMM were for women 40 and over (181.2) and women 19 and younger (158.9). Women between 20-29 years old (108.1) and 30-39 years old (118.5) had much lower rates.

**Figure 15. Singleton SMM Rate by Mother’s Age, 2016-2018**

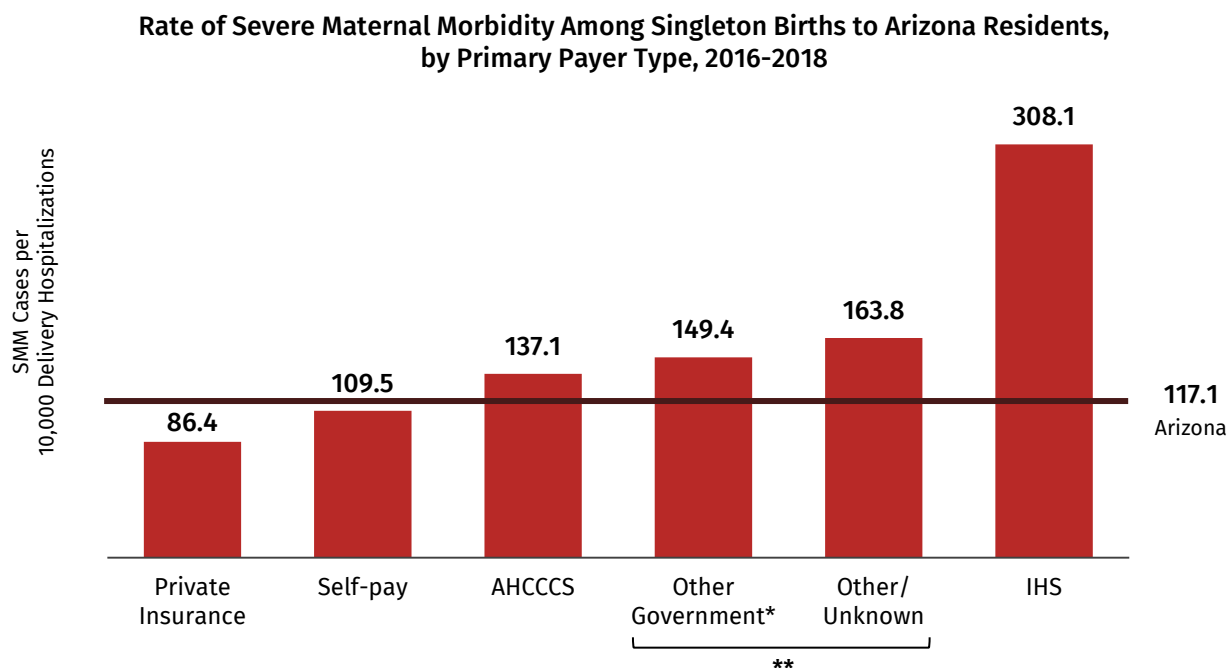


## SMM Rate by Other Socioeconomic and Demographic Indicators

The rate of SMM also varied by other socioeconomic and demographic variables, including primary payer type of delivery hospitalization, relative poverty of Primary Care Area (PCA) of maternal residence, and highest level of maternal education.

Over 52% of delivery hospitalizations were paid primarily through Medicaid (the Arizona Health Care Cost Containment System (AHCCCS)), and had an SMM rate of 137.1 (**Figure 16**). Women with private insurance or who paid out of pocket for their deliveries had lower rates of SMM at 86.4 and 109.5, respectively. Despite representing a small portion of delivery hospitalizations, the SMM rate was highest among births paid primary by the Indian Health Service (IHS) at 308.1 SMM cases per 10,000 delivery hospitalizations. This data is based on the listed primary payer on the birth certificate, and no data was collected or used from IHS facilities.

**Figure 16. Singleton SMM Rate by Primary Payer Type for Birth, 2016-2018**



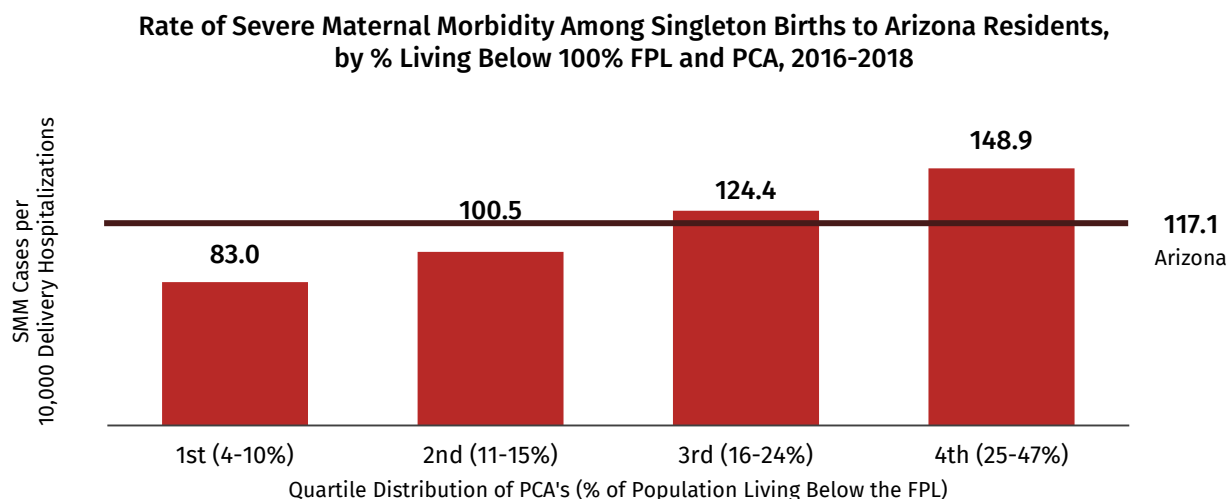
\* Rate using value less than 20; interpret with caution.

\*\* Other government payers include Department of Defense TRICARE, the Children's Health Insurance Program (CHIP), and the Veteran's Health Administration (VHA). Other/Unknown includes those with unlisted or missing payer information.

The percentage of people within a PCA who lived below 100% of the federal poverty level (FPL) was used as an indication of socioeconomic status and other environmental factors. PCAs were divided into 4 quartiles based on the percent of their population living below FPL: the 1<sup>st</sup> quartile of PCAs had 4-10% living below the FPL (most affluent), the 2<sup>nd</sup> quartile had 11-15% below the FPL, the 3<sup>rd</sup> quartile had 16-24% below the FPL, and the 4<sup>th</sup> quartile had 25-47% below the FPL (poorest).

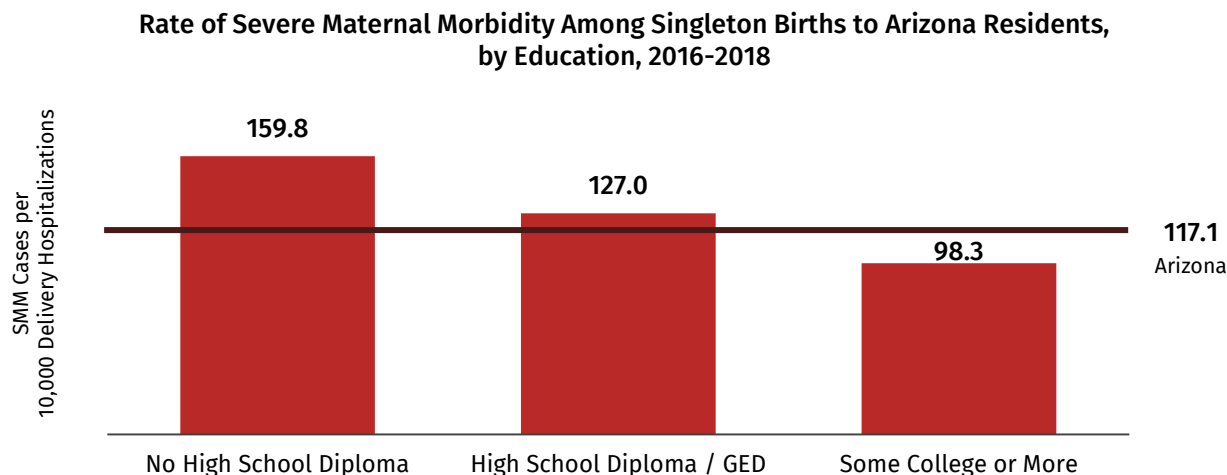
Women who lived in the poorest quartile of PCAs had an SMM rate of 148.9, or 1.8 times the rate of women who lived in the most affluent quartile of PCAs, which was 83.0. As seen in **Figure 17**, a nearly linear trend existed across all 4 quartiles, with rates of SMM increasing as the relative poverty level increased. The distribution of poverty rates within each PCA and quartile is available in **Appendix E**.

**Figure 17. Singleton SMM Rate by % of Population Living Below FPL and Primary Care Area, 2016-2018**



Meanwhile, the rate of SMM decreased with increasing maternal education. Women who never received a high school diploma or GED had the highest SMM rate at 159.8, as seen in **Figure 18**. Women with some college education or more, regardless of if a degree was awarded, had the lowest SMM rate at 98.3, and women who received a high school diploma or GED but did not attend any post-secondary education had an SMM rate of 127.0. This indicates that maternal education might be preventative for SMM. Additionally, education often corresponds to other measures of socioeconomic status including income, geographic location, and access to care.

**Figure 18. Singleton SMM Rate by Maternal Education, 2016-2018**



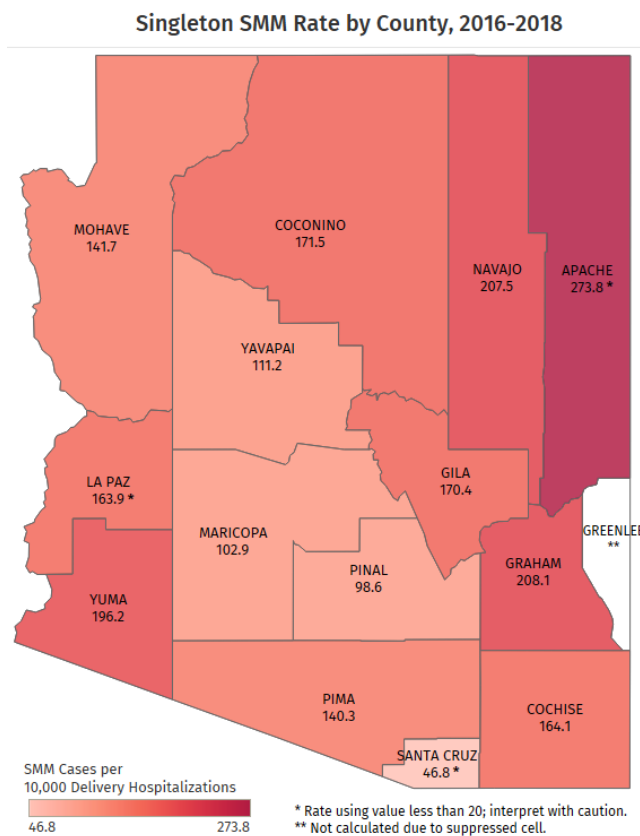
## SMM Distribution by Maternal Residence

The SMM rate by county of maternal residence at the time of delivery varied greatly, as shown by the map in **Figure 19**. Santa Cruz County and Pinal County had the lowest rates of SMM in the state, with rates of 46.8 and 98.6, respectively. The county with the highest rates of SMM was Apache County with a rate of 273.8, followed by Graham County (208.1), Navajo County (207.5), and Yuma County (196.2). It should be noted that for Apache County, La Paz County, and Santa Cruz County there were less than 20 SMM cases for 2016-2018 and thus their rates should be interpreted with caution. Greenlee county had less than 6 cases for 2016-2018 and thus the rate was not calculated.

**Appendices A and F** show the distribution of SMM rates by Primary Care Area (PCA) of maternal residence. Among PCAs with 6 or more cases per year, the SMM rate ranged from 39.2 in the Scottsdale Central PCA to 736.8 in the Hopi Tribe PCA.

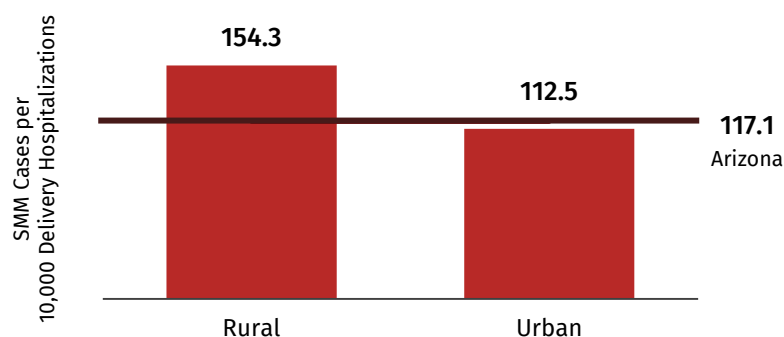
Overall, the SMM rate was higher for women living in rural counties (as defined by the Bureau of Public Health Statistics: Apache, Coconino, Cochise, Gila, Graham, Greenlee, La Paz, Mohave, Navajo, Santa Cruz, and Yavapai) with a rate of 154.3, compared to women living in urban counties (Maricopa, Pima, Pinal, and Yuma) whose SMM rate was 112.5, shown in **Figure 20**.

**Figure 19. Singleton SMM Rate, by Mother's County of Residence, 2016-2018**



**Figure 20. Singleton SMM Rate by Urban vs Rural County of Residence, 2016-2018**

### Rate of Severe Maternal Morbidity Among Singleton Births to Arizona Residents, by Rural/Urban County of Residence, 2016-2018



**Urban counties** included Maricopa County, Pima County, Pinal County, and Yuma County.

**Rural counties** included Apache County, Cochise County, Coconino County, Gila County, Graham County, Greenlee County, La Paz County, Mohave County, Navajo County, Santa Cruz County, and Yavapai County.

Urban and rural status as defined by the ADHS Bureau of Public Health Statistics.

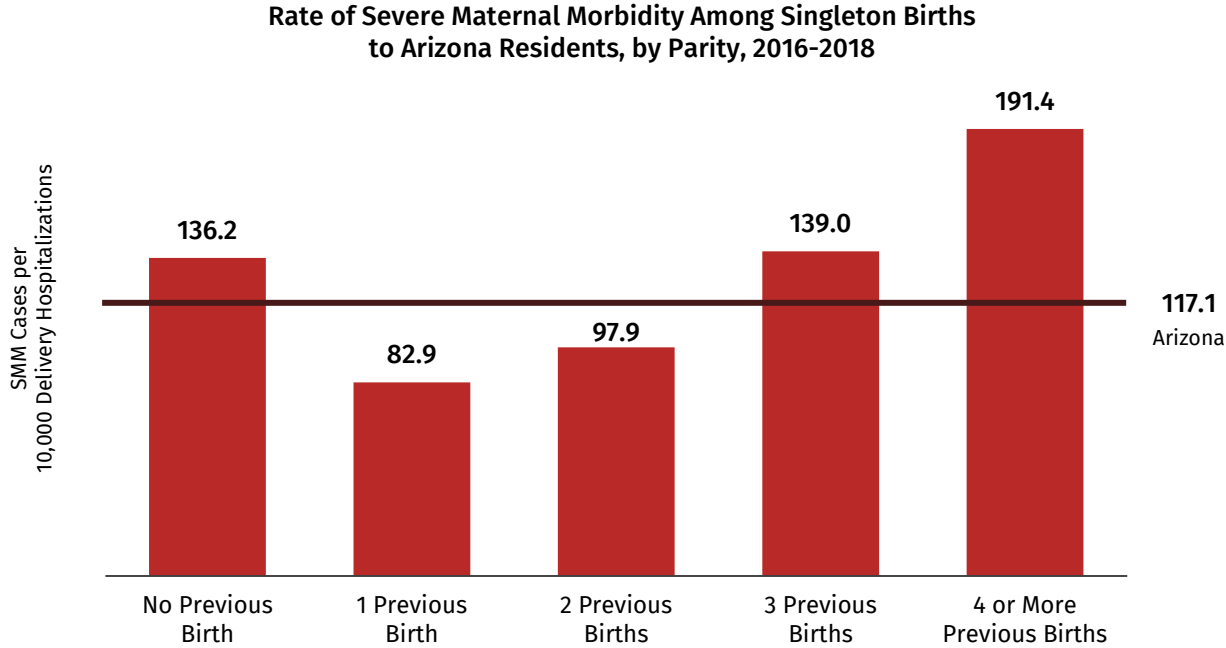
### SMM Rate by Obstetric History and Maternal Health

The rate of SMM varied based on the mother’s obstetric history, including number of previous births and time between pregnancies, as well as the mother’s preconception health status.

Women with one previous birth had the lowest rates of SMM at 82.9 SMM cases per 10,000 delivery hospitalizations. This was lower than the SMM rate of women without a previous live birth (136.2); these findings are consistent with studies that have found women with at least one previous birth tend to have lower adverse outcomes than women without a previous birth, in part because some high risk women elect not to have more than one child.<sup>19</sup> Women with only one previous live birth also had a lower SMM rate than women with 2 previous births (97.9), 3 previous births (139.0) and 4 or more previous births (191.4).

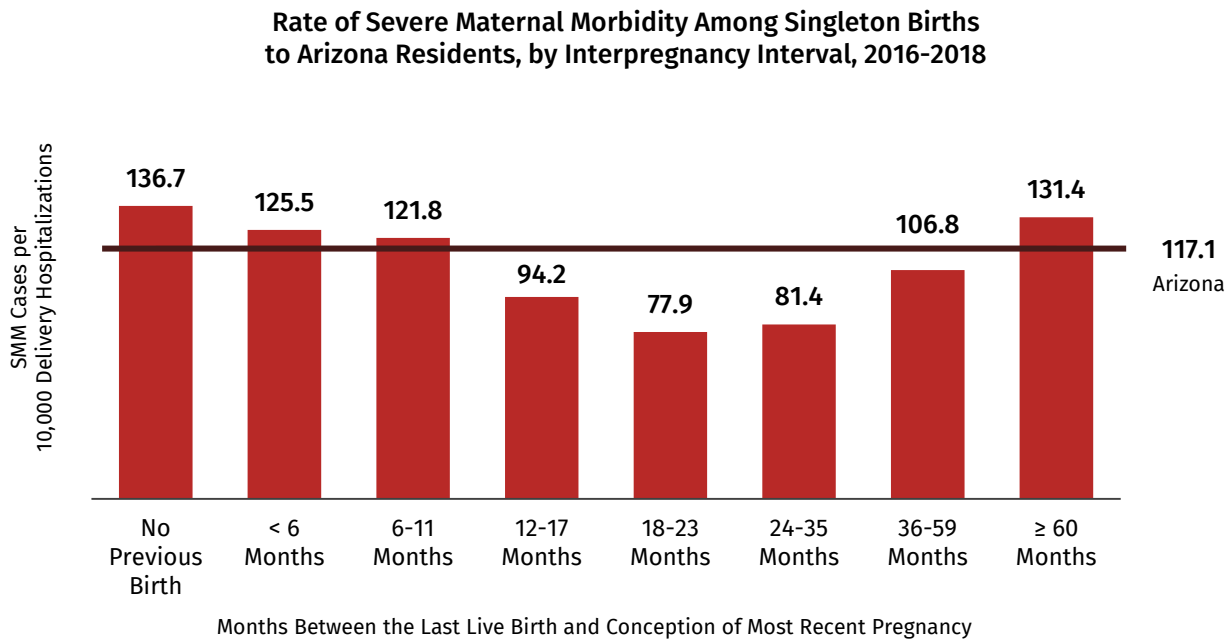
These differences are shown in **Figure 21**.

**Figure 21. Singleton SMM Rate by Number of Previous Live Births, 2016-2018**



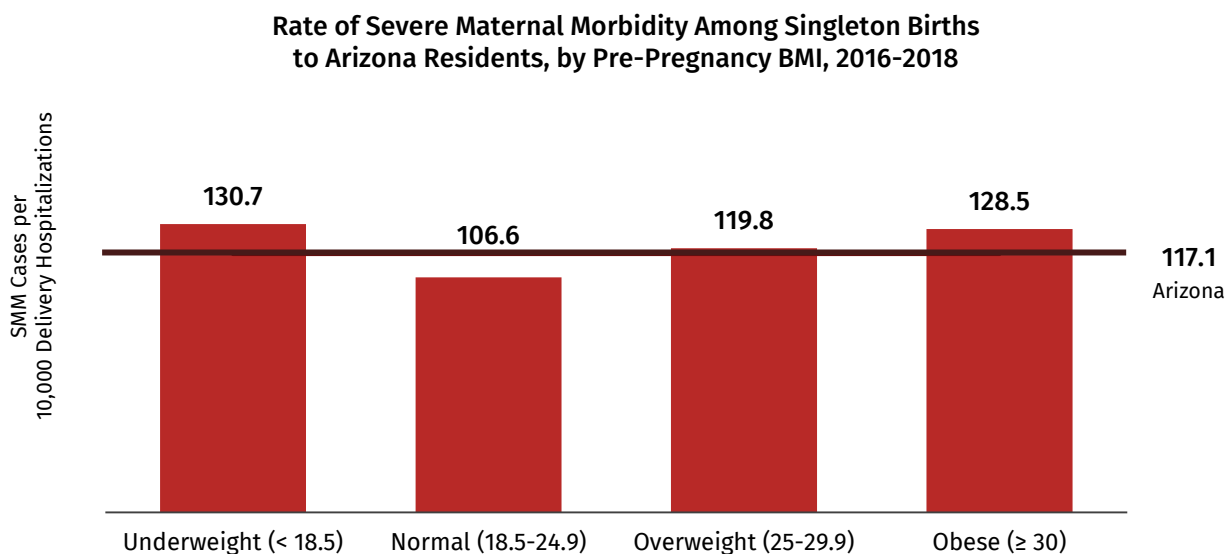
For women with at least one previous birth, SMM rates were increased among the shortest and longest interpregnancy intervals, or the time between the previous birth and the conception of the subsequent recent pregnancy (**Figure 22**). The intervals with the highest SMM rates were 60 months or longer (138.6), less than 6 months (131.8), and between 6 and 11 months (129.5) Women who got pregnant between 18 and 35 months after a previous birth had the lowest SMM rate (84.9 collectively, not shown).

**Figure 22. Singleton SMM Rate by Interpregnancy Interval, 2016-2018**



Overall there were only minor differences in SMM rates based on maternal pre-pregnancy body mass index (BMI), as can be seen in **Figure 23**. Women who were either underweight or obese had the most elevated SMM rates (130.7 and 128.5, respectively) compared to women with a normal BMI (106.6).

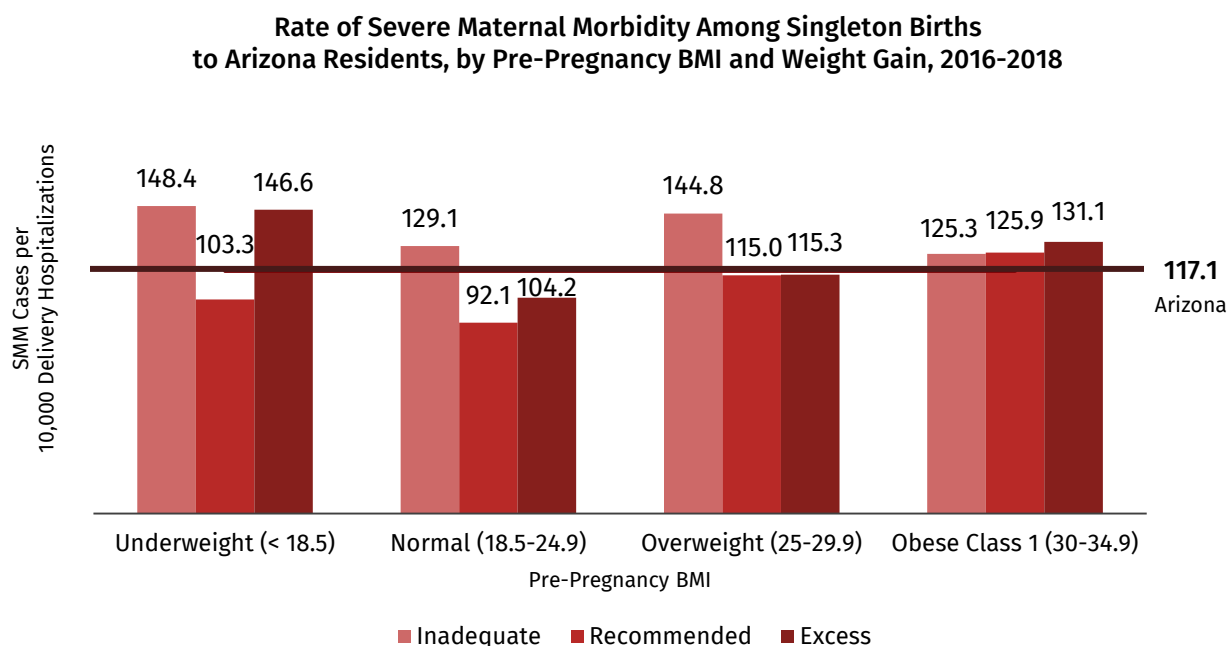
**Figure 23. Singleton SMM Rate by Mother’s Pre-Pregnancy BMI, 2016-2018**





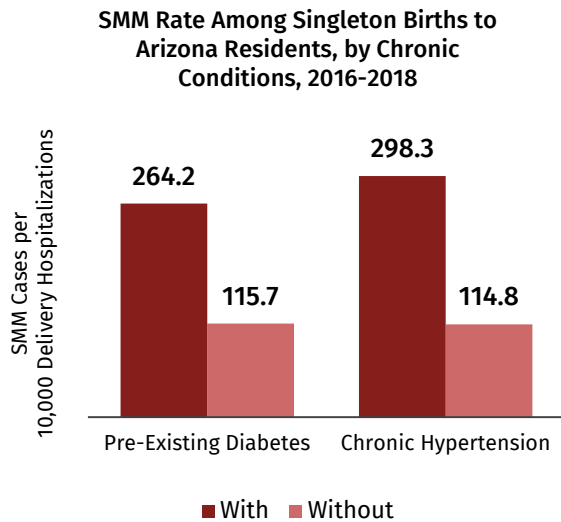
When assessed by weight gain during pregnancy across all BMI groups, the SMM rate was elevated among women with inadequate weight gain (132.1) and excess weight gain (117.3) compared to women achieving the recommended weight gain (105.6), using ACOG’s recommendations for weight gain during pregnancy based on pre-pregnancy BMI (not shown). However, as seen in **Figure 24**, there were more drastic differences in SMM rates by weight gain during pregnancy when also grouped by pre-pregnancy BMI groups. Underweight women had much higher SMM rates with both inadequate (148.4) and excess (146.6) weight gain during pregnancy compared to gaining the recommended amount for their pre-pregnancy BMI (103.3). For women with a normal or overweight BMI, gaining inadequate weight during pregnancy, but not excess weight gain, increased SMM rates compared to gaining the recommended amount of weight. There was no difference in SMM rates for obese women by weight gain during pregnancy. Visit [acog.org](http://acog.org) for information on their recommendations for weight gain in pregnancy.

**Figure 42. SMM Rate by Weight Gain during Pregnancy and Mother’s Pre-Pregnancy BMI, 2016-2018**

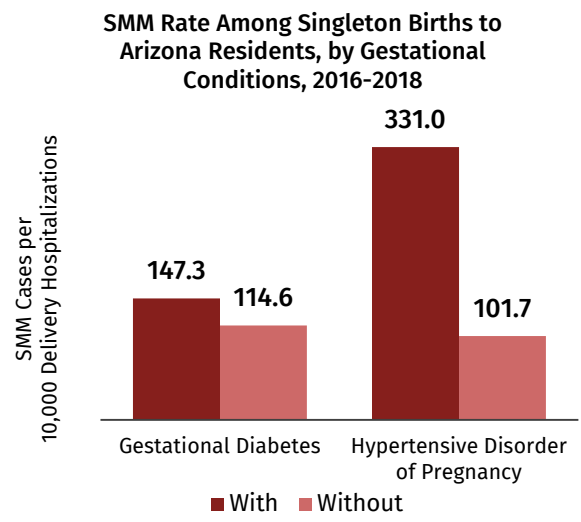


The presence of a chronic condition prior to pregnancy notably increased SMM rates during delivery, as shown in **Figure 25**. Women with pre-existing diabetes had an SMM rate 2.3 times that of women without pre-existing diabetes, with rates of 264.2 versus 115.7, respectively. Meanwhile, chronic hypertension had an even greater increase in SMM, with a rate 2.6 times that of women without chronic hypertension; the SMM rate for chronic hypertension was 298.3 and the rate without chronic hypertension was 114.8.

**Figure 25. Singleton SMM Rate by Pre-Existing Diabetes and Chronic Hypertension, 2016-2018**



**Figure 26. Singleton SMM Rate by Gestational Diabetes and Hypertensive Disorders of Pregnancy, 2016-2018**

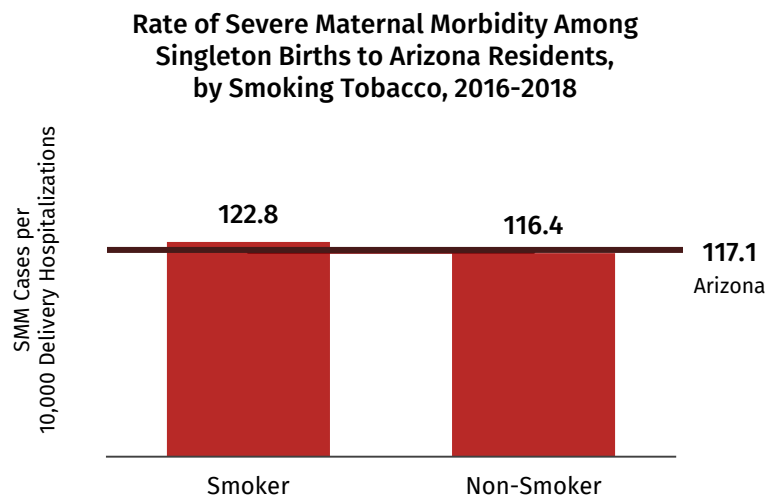


*Hypertensive Disorders of Pregnancy include gestational hypertension, preeclampsia, and eclampsia.*

The presence of gestational diabetes or hypertension during pregnancy also increased SMM rates (**Figure 26**). Women with gestational diabetes had an increased SMM rate (147.3 with versus 114.6 without), while women with a hypertensive disorder of pregnancy (including pregnancy-induced hypertension, pre-eclampsia, and eclampsia) had 3.3 times the SMM rate of women without a hypertensive disorder of pregnancy (331.0 with versus 101.7 without). By definition, the women with these gestational conditions did not have either pre-existing diabetes or chronic hypertension, and these conditions arose only during and as a result of the pregnancy.

SMM rates were relatively unchanged by smoking tobacco any time before or during pregnancy, shown in **Figure 27**. Non-smokers had an SMM rate of 116.4, while mothers who smoked tobacco previously but quit before pregnancy had a rate of SMM of 111.2 and women who smoked at all during pregnancy had an SMM rate of 129.1 (not shown).

**Figure 27. Singleton SMM Rate by Smoking Any Tobacco Before and/or During Pregnancy, 2016-2018**



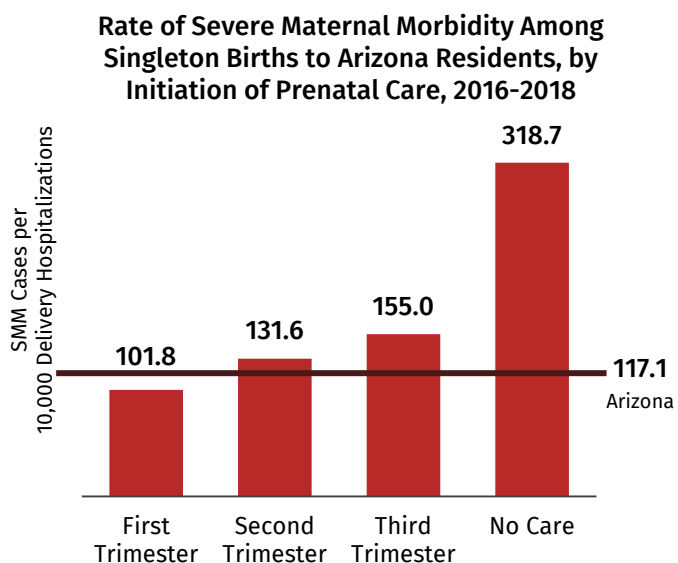
## SMM Rate by Prenatal Care and Method of Delivery

SMM increased with delayed initiation of prenatal care, with the highest rate amongst women without any prenatal care (318.7). Prenatal care begun in the second trimester had an SMM rate of 131.6, increasing to 155.0 amongst women who began prenatal care in their last trimester (**Figure 28**). In contrast, women who began prenatal care in their first trimester of pregnancy had the lowest rate of SMM (101.8).

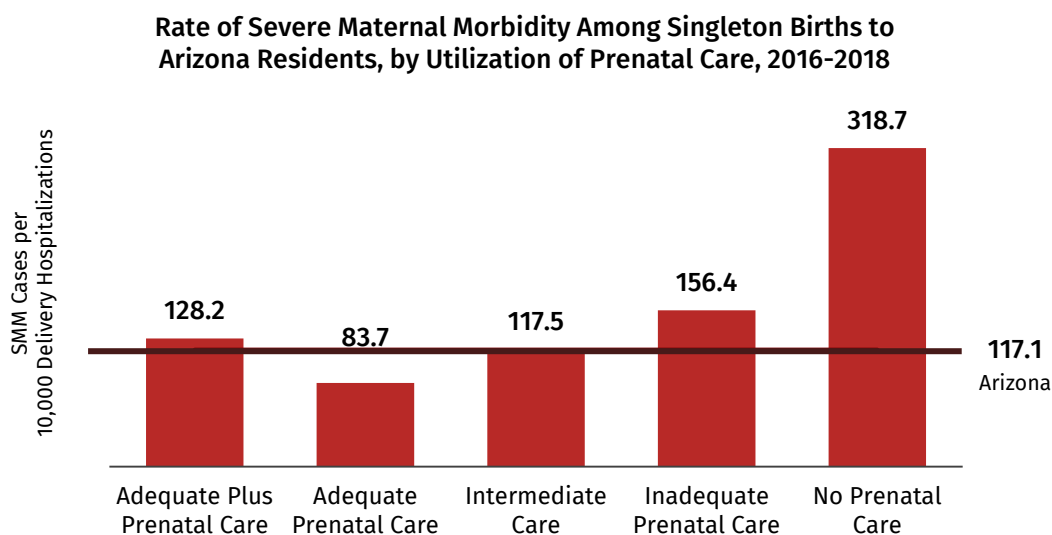
The adequacy of prenatal care utilization also resulted in differences in SMM rates (**Figure 29**). Using the Kotelchuck Index, or the Adequacy of Prenatal Care Utilization Index (APNCU), the adequacy of prenatal care was determined

using timing and number of prenatal care visits the woman received, using ACOG guidelines for prenatal care.<sup>20</sup> Women with adequate prenatal care had the lowest SMM rate at 83.7, followed by women with intermediate levels of prenatal care (117.5). Women who had more than adequate prenatal care, also known as intensive prenatal care utilization due to medical needs for additional monitoring, had an SMM rate of 128.2, which similarly might reflect increased medical risks during pregnancy. Women with inadequate levels of prenatal care had a higher SMM rate of 156.4. More information about this measure can be found in **Appendix C**.

**Figure 28. Singleton SMM Rate by Trimester Initiated Prenatal Care, 2016-2018**

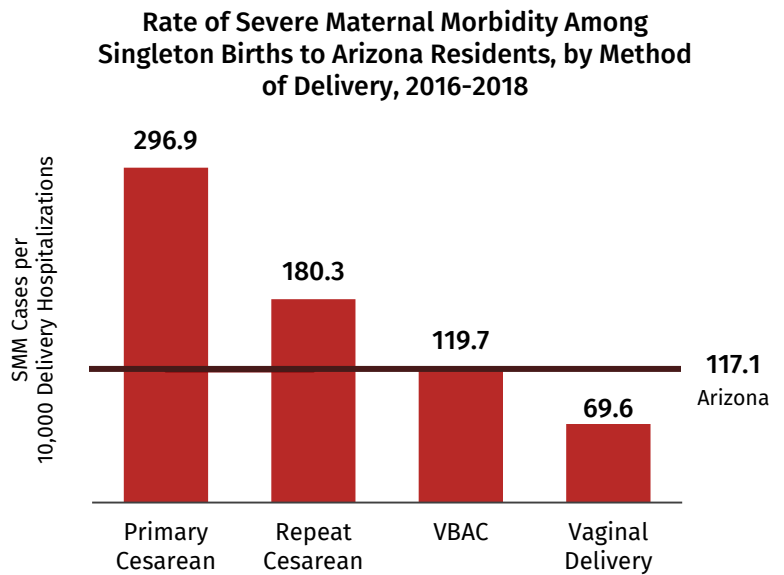


**Figure 29. Singleton SMM Rate by Adequacy of Prenatal Care Utilization, 2016-2018**

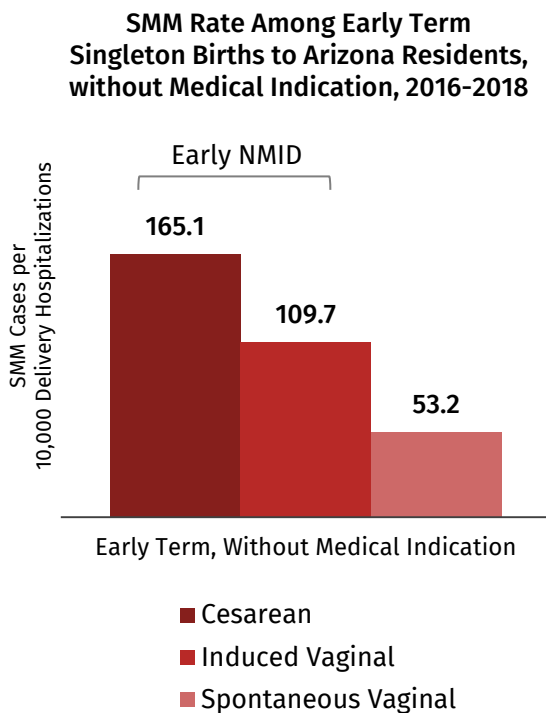


The method of delivery robustly affected SMM rates. Women with cesarean section deliveries had a higher overall SMM rate than women who delivered vaginally (244.8 for cesarean versus 71.2 for vaginal, not shown). High SMM among cesarean deliveries might be the combined effect of the medical risk indications for primary or repeat cesarean, as well as the expected or unexpected complications resulting from those delivery procedures. Women with a primary cesarean delivery had the highest rate of SMM at 296.9, even compared to women with a repeat cesarean delivery (180.3; **Figure 30**). Women with a vaginal delivery after cesarean (VBAC, SMM rate 119.7) had a similar SMM rate as the state overall SMM rate (117.1). Vaginal deliveries without previous cesareans had the lowest SMM rate at 69.6.

**Figure 30. Singleton SMM Rate by Method of Delivery, 2016-2018**



**Figure 31. SMM Rate of Early Term Singleton with No Medical Indication, by Method of Delivery, 2016-2018**

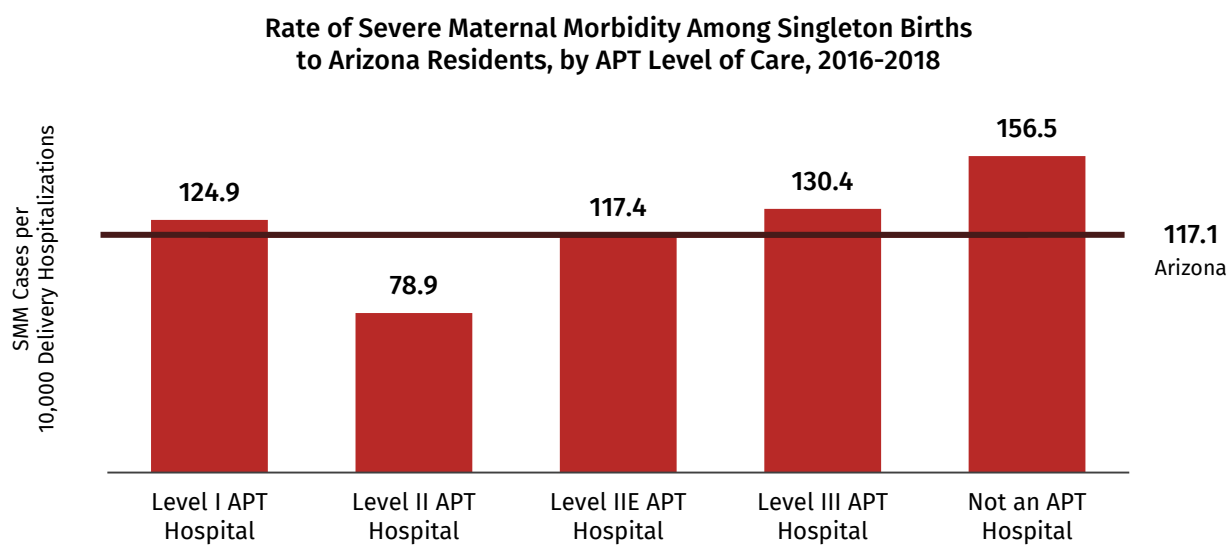


Early non-medically indicated deliveries (early NMID) are either a cesarean section delivery or induced vaginal birth without the medical indications for a cesarean or induction, and occurring after 37 weeks and prior to 39 weeks gestation, which is considered early term. Medical indications include hypertension, diabetes, fetal anomalies, non-vertex presentation, fetal intolerance of labor, premature rupture of membranes, prolonged labor, chorioamnionitis, and a history of previous poor pregnancy outcomes. Women who had an early NMID had a higher rate of SMM than early term spontaneous vaginal deliveries; early NMI cesareans had an SMM rate of 165.1 and early NMI inductions had an SMM rate of 109.7, compared to an SMM rate of 53.2 among early term spontaneous vaginal deliveries without any medical indications (**Figure 31**).

## SMM Rate by Level of Care

The Arizona Perinatal Trust (APT) facilitates the Voluntary Certification Program (VCP) which assigns a certification level to participating facilities based on the services and level of care they provide to mothers and infants during and after labor and delivery. As shown in **Figure 32**, women who delivered in a level II facility had the lowest rate of SMM (78.9), followed by level IIE facilities (117.4). Women with deliveries at the lowest level of care certification (level I) had an SMM rate of 124.9, while women who delivered at level III facilities, usually indicative of high risk pregnancies or deliveries needing the most intensive care services, had the highest rate of SMM among APT certified facilities at 130.4. Among those facilities not currently certified by the APT, women had an SMM rate of 156.5, which includes deliveries in non-birth facilities.

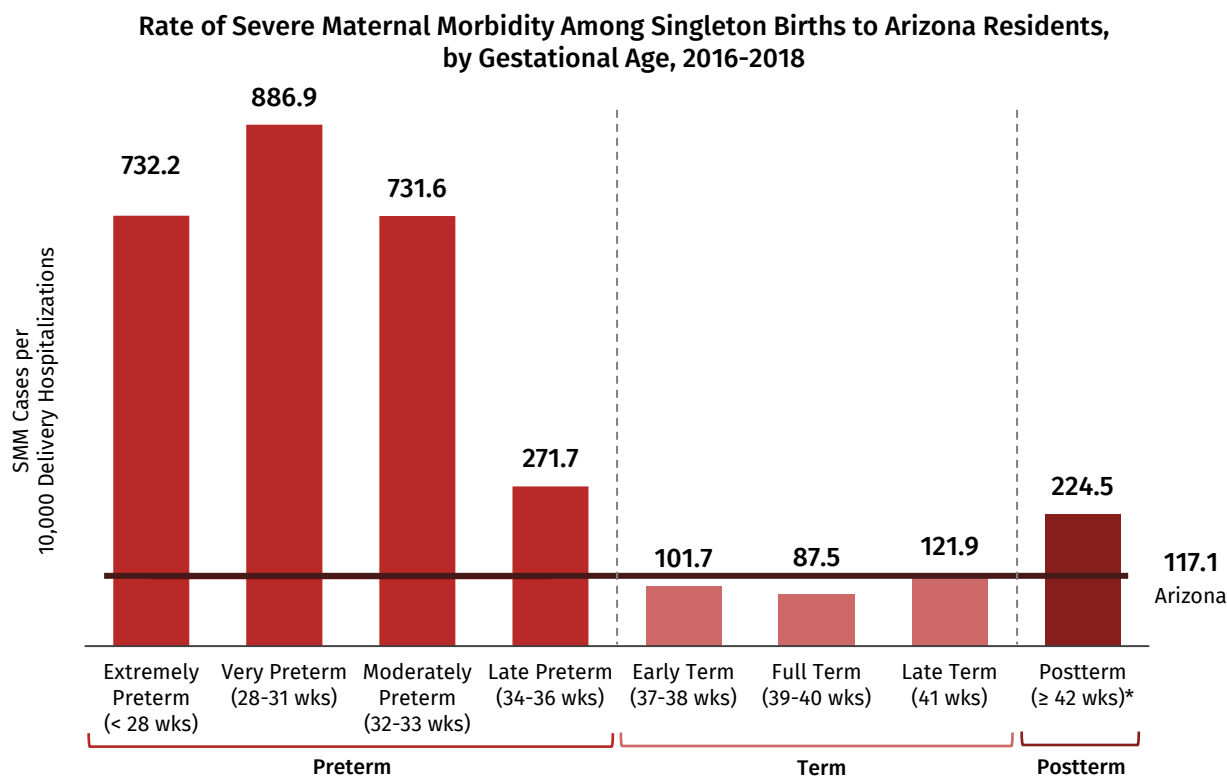
**Figure 32. Singleton SMM Rate by Facility Level of Care, 2016-2018**



## SMM Rate by Infant Health Outcomes

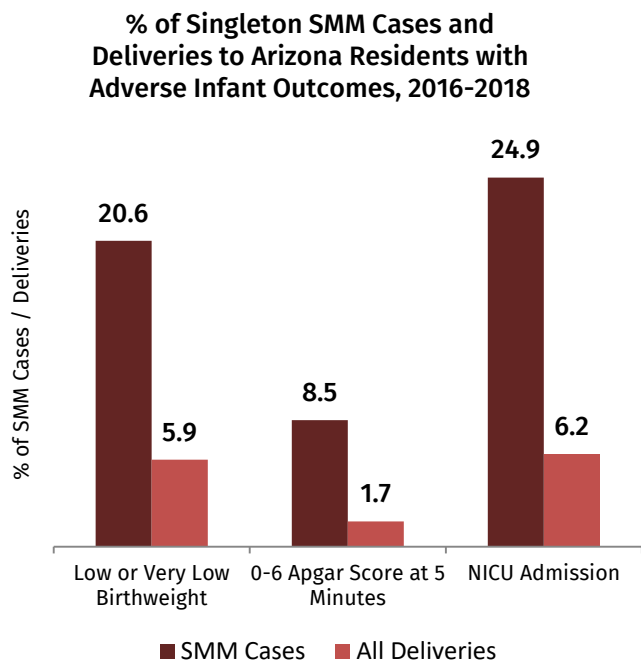
Women who had a preterm delivery (before 37 weeks gestation) had considerably higher rates of SMM than women who delivered at or after term: all preterm births had an SMM rate of 396.0 versus 94.0 for term deliveries (37-41 weeks). **Figure 33** shows the rate of SMM by gestational age groups. Women delivering between 28-31 weeks gestation had the highest SMM rate of 886.9, followed by women delivering before 28 weeks (732.2) and women delivering between 32-33 weeks (731.6). Among preterm births, women delivering between 34-36 weeks had the lowest SMM rate (271.7), although this was still much higher than term deliveries, which ranged from 121.9 among deliveries at 41 weeks to 87.5 for deliveries between 39-40 weeks. Postterm births (after 41 weeks) had an SMM rate of 224.5, which was a bit lower than preterm births between 34-36 weeks.

**Figure 33. Singleton SMM Rate by Gestational Age at Delivery, 2016-2018**



\* Rate using value less than 20; interpret with caution.

**Figure 34. Select Adverse Infant Outcomes among Singleton SMM Cases and Deliveries, 2016-2018**



Women who had an SMM also had higher rates of poor infant outcomes, both of which could be the result of a complication during pregnancy or delivery that affected both mother and baby. As seen in **Figure 34**, among singleton SMM cases, 20.6% had a low birthweight or very low birthweight infant, compared to 5.9% among all hospital deliveries. At 5 minutes after delivery, 8.5% of singleton SMM cases had an Apgar score of 6 or less, compared to 1.7% of all deliveries. Lastly, 24.9% of singleton SMM cases had a baby admitted to the NICU, compared to 6.2% of all singleton deliveries.

## Differences by Maternal Race and Ethnicity

In addition to differences in overall rate of SMM by race and ethnicity, the SMM rate across various risk factors, such as weight gain during pregnancy or method of delivery, differed by race and ethnicity (not shown). These differences indicate that approaches to reducing disparities in maternal morbidity and mortality may require tailoring interventions to individual communities or identifying the most pressing risk factors contributing to these adverse health outcomes. In order to further investigate and discuss these differences, along with potential areas for intervention, a subsequent report is being developed that highlights differences in maternal health and SMM by race and ethnicity, including responses to various risk factors.

## DISCUSSION

Among 2016-2018 residents' singleton hospital births in Arizona, there were 2558 women who experienced a severe maternal morbidity, with an SMM rate of 117.1 cases per 10,000 delivery hospitalizations. One in six SMM cases had more than one SMM indicator, with blood transfusion, hysterectomy, adult respiratory distress, sepsis, disseminated intravascular coagulation, renal failure, pulmonary edema, and shock all occurring in more than 5% of SMM cases. Using the enhanced definition of SMM, all identified cases also had a qualifying condition. Most (73%) had two or more qualifiers, with length of stay (88.6%) and a procedure indicator (73.2%) the most prevalent.

Common themes from this analysis revealed areas of opportunity in preventing SMM, including preconception health, prenatal care and management of gestational conditions, and care during delivery and postpartum.

During the preconception health period, access to care to manage chronic conditions and improve overall health status prior to pregnancy would reduce the risk of SMM, as women with pre-existing diabetes or chronic hypertension, as well as underweight or obese pre-pregnancy BMI, all had increased rates of SMM than their counterparts. Additionally, access to family planning services and effective contraceptives would empower women and their families to appropriately time pregnancies as well as prevent unintended high risk pregnancies.

Care during pregnancy was another area that shows promise in improving SMM. Women with late or inadequate prenatal care, including those with no prenatal care at all, had much higher rates of SMM than women with early and adequate prenatal care. Access to prenatal care would allow for management of risk factors that exist before or arise during pregnancy, including chronic or gestational conditions such as diabetes and hypertension, as well as promote behaviors that improve maternal and neonatal outcomes like healthy weight gain and smoking cessation.

Method of delivery appears closely linked to SMM, as women with a cesarean section had the highest rates of SMM compared to vaginal deliveries. This includes early non-medically indicated deliveries, which had increased rates of SMM for both cesarean and induction during the early term period compared to spontaneous vaginal deliveries among women with no medical risk factors to indicate the need for such intervention. Facility level of care also had differences in SMM: non-APT certified facilities, including non-birthing hospitals, and Level I facilities both had higher rates of SMM compared to Level II facilities, which could be the result of limited skilled staff and resources. Conversely, Level III facilities also had higher SMM rates than Level II or Level IIE facilities, possibly indicating the successful transfer of high risk pregnancies and delivery emergencies to these facilities capable of providing increased care.

In addition to these areas for improved access and quality of care, several disparities were identified by race and ethnicity, socioeconomic status, geography, and maternal demographics. These disparities point to the need for improved health equity and targeted interventions to effectively reduce SMM among the most vulnerable and high risk populations in the state, while being careful that overall efforts to improve maternal health in Arizona do not exacerbate existing health disparities.

## LIMITATIONS

The hospital discharge data used in this report provide a unique opportunity to examine the clinical characteristics of a delivery, such as diagnoses and procedures that occur in the hospital. Despite best efforts to identify and describe SMM cases across clinical characteristics, several limitations should be noted. In administrative data such as hospital discharge records, cases based on ICD codes may be over- or underreported, or the severity of certain cases may not be accurately captured. This is especially true with coding blood transfusions procedures in maternity patients. While most facilities nationally were using ICD- 9-CM transfusion codes to report blood transfusion procedures before 2016, the transition to ICD-10-CM the reporting became more complex and some facilities were electing not to report.<sup>13</sup> Additionally, transfusion codes do not account for the quantity of units transfused. Together, the changes to ICD-10-CM and underreporting make it questionable to conclude that there was a real decrease in SMM rates from 2016-2017. Further, the HDD database is a billing and claims system not designed for public health surveillance purposes therefore quality of billing information in hospital discharge data is known to vary.

This analysis only captures resident births that occurred in a reporting facility, and these facilities do not include any of the IHS facilities in Arizona. Some reporting facilities may have data excluded based on data quality issues that would otherwise be available; this impacted this study by the exclusion of certain quarters of 2017-2018 data among a few birth facilities.



This analysis is also limited to delivery hospitalizations, thus pregnancies not resulting in a live birth, including ectopic and molar pregnancies, spontaneous abortions, and stillbirths, were excluded, as were deliveries outside of a hospital, such as home births or deliveries at birth centers. Postpartum hospitalizations that could have been related to unexpected outcomes of the delivery were also not included in this analysis.

The use of birth certificate data linked to hospital discharge data introduced additional limitations to this study, especially since births without a matching birth certificate and delivery hospitalization were not included. While this represents less than 4% of singleton deliveries among Arizona residents in 2016-2018, it is still meaningful to note. Birth certificate data quality may also influence our analysis of SMM, especially with potential differences in how variables are captured across facilities, such as prenatal care or chronic health conditions. As this analysis used HDD data linked to birth certificate data, comparison of rates with samples using only HDD data may not be valid.

Lastly, the analysis does not consider other social determinants of health such as economic stability, access to health providers, and environmental health that may impact SMM. These can be important contributors of SMM that often are overlooked.

## **CURRENT EFFORTS TO IMPROVE MATERNAL HEALTH IN ARIZONA**

The Arizona Department of Health Services, in partnership with the Arizona Chapter of the March of Dimes and Arizona Perinatal Trust, launched a Maternal Health Task Force (MHTF) in October 2018 to discuss Severe Maternal Morbidity and Mortality in Arizona. This report was developed as an outcome of subsequent stakeholder engagement in the MHTF. Additionally, the Governor's Goal Council selected [Maternal Mortality as a Breakthrough Project](#) in early 2019, and an Action Plan was developed to improve maternal health in the state with an emphasis on five goal areas: 1) improve knowledge and education for pregnant and postpartum women on warning signs and when to seek care, 2) improve access to care, 3) support workforce and workforce capacity, 4) improve surveillance of morbidity and mortality, and 5) support systems of care.

Recently ADHS has secured funding through two grants to support these ongoing efforts. A Preventing Maternal Deaths Grant from the CDC for \$450,000 a year for 5 years will fund the Maternal Mortality Review (MMR) Program and Alliance for Innovation on Maternal Health safety bundle implementation. The aim is to better understand and prevent pregnancy-related deaths by gathering detailed, complete data on causes and circumstances surrounding maternal deaths to develop recommendations for prevention. The outcomes of the grant are 1) timely, accurate, and standardized information available; 2) increased awareness of the existence and recommendations of the MMR Committee; 3) implementation of data driven

recommendations; 4) widespread adoption of patient safety bundles and/or policies; and 5) reduction in maternal complication of pregnancy.

A second award for the Maternal Health Innovation Program for \$1.2 million per year for 5 years was received from HRSA and will fund efforts of the MHTF and Governor's Goal Council action plan, with emphasis on reducing health disparities and improving access to care through the use of technology. The program is designed to assist states in collaborating with maternal health experts and optimizing resources to implement state-specific actions that address disparities in maternal health and improve maternal health outcomes, including the prevention and reduction of maternal mortality and SMM. There are three main components of the Maternal Health Innovation Program: 1) utilize the state-focused MHTF to create and implement a strategic plan that incorporates activities outlined in the state's most recent Title V Needs Assessment; 2) improve the collection, analysis, and application of state-level data on maternal mortality and SMM; and 3) promote and execute innovation in maternal health service delivery, such as improving access to maternal care services, identifying and addressing workforce needs, and/or supporting postpartum and interception care services, among others.

More information about how ADHS, the MHTF, and other partners are working to improve maternal health can be found at [azdhs.gov/maternalhealth](https://azdhs.gov/maternalhealth).

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## APPENDICES

### Appendix A: Supplemental Data Tables

#### Severe Maternal Morbidity among Resident Singleton Hospital Deliveries, Arizona, 2016-2018.

	SMM Overall Cases	SMM Overall Rate per 10,000 deliveries	Total Deliveries	Percent of total deliveries	Percent of SMM Cases
<b>Year</b>					
2016	960	126.9	75,647	34.6	37.5
2017	811	113.8	71,256	32.6	31.7
2018	787	110	71,530	32.7	30.8
<b>Maternal Race and Ethnicity</b>					
American Indian or Alaska Native	251	292.6	8,578	3.9	9.8
Asian or Pacific Islander	115	126.7	9,078	4.2	4.5
Black or African American	193	153.1	12,604	5.8	7.5
Hispanic or Latina	1,205	131.7	91,508	41.9	47.1
White	794	82.1	96,665	44.3	31.0
<b>Maternal Age</b>					
≤ 19 years	214	158.9	13,469	6.2	8.4
20-29 years	1,264	108.1	116,914	53.5	49.4
30-39 years	974	118.5	82,199	37.6	38.1
≥ 40 years	106	181.2	5,851	2.7	4.1
<b>Education</b>					
No high school diploma	37,178	159.8	37,178	17.0	23.2
High school diploma	57,185	127	57,185	26.2	28.4
Some college and more	122,982	98.3	122,982	56.3	47.3
<b>Primary Payer of Delivery Hospitalization</b>					
Private Insurance	795	86.4	91,975	42.1	31.1
Self-pay	61	109.5	5,571	2.6	2.4
AHCCCS	1,563	137.1	113,976	52.2	61.1
IHS	59	308.1	1,915	0.9	2.3
Other Government (TRICARE, CHIP, VHA, etc.)	19	149.4 <sup>†</sup>	1,272	0.6	0.7
Other/Unknown	61	163.8	3,724	1.7	2.4

\* Cell suppressed due to value < 6

\*\* Not calculated due to suppressed cell

† Rate using value less than 20; interpret with caution.

(continued)

	SMM Overall Cases	SMM Overall Rate per 10,000 deliveries	Total Deliveries	Percent of total deliveries	Percent of SMM Cases
<b>Urban / Rural County of Residence</b>					
Rural	373	154.3	24,172	11.1	14.6
Urban	2,185	112.5	194,261	88.9	85.4
<b>County of Residence</b>					
Apache	17	273.8 <sup>†</sup>	621	0.28	0.66
Cochise	64	164.1	3,901	1.79	2.52
Coconino	42	171.5	2,449	1.14	1.70
Gila	26	170.4	1,526	0.65	0.93
Graham	31	208.1	1,490	0.35	0.62
Greenlee	*	**	384	0.09	**
La Paz	9	163.9 <sup>†</sup>	549	0.13	0.18
Maricopa	1,472	102.9	143,105	33.56	29.84
Mohave	60	141.7	4,233	1.43	1.64
Navajo	64	207.5	3,085	0.90	1.51
Pima	427	140.3	30,432	7.50	8.89
Pinal	122	98.6	12,367	2.87	2.44
Santa Cruz	8	46.8 <sup>†</sup>	1,709	0.38	0.15
Yavapai	47	111.2	4,225	0.94	0.88
Yuma	164	196.2	8,357	1.88	3.11
<b>Primary Care Area (PCA) Poverty Quartile (% of Population Below Federal Poverty Level)</b>					
1 <sup>st</sup> Quartile (4-10%)	352	83	42,431	19.4	13.8
2 <sup>nd</sup> Quartile (11-15%)	563	100.5	56,008	25.6	22.0
3 <sup>rd</sup> Quartile (16-24%)	720	124.4	57,857	26.5	28.1
4 <sup>th</sup> Quartile (25-47%)	922	148.9	61,924	28.3	36.0
<b>Parity</b>					
No Previous Births	1,075	136.2	78,915	36.1	42.0
1 Previous Birth	547	82.9	65,960	30.2	21.4
2 Previous Births	386	97.9	39,419	18.0	15.1
3 Previous Births	269	139.0	19,346	8.9	10.5
4 or More Previous Births	281	191.4	14,683	6.7	11.0

\* Cell suppressed due to value < 6

\*\* Not calculated due to suppressed cell

† Rate using value less than 20; interpret with caution.

(continued)

	SMM Overall Cases	SMM Overall Rate per 10,000 deliveries	Total Deliveries	Percent of total deliveries	Percent of SMM Cases
<b>Interpregnancy Interval</b>					
No Previous Births	1,090	136.7	79,734	36.5	42.6
< 6 months	94	125.5	7,489	3.4	3.7
6-11 months	190	121.8	15,605	7.1	7.4
12-17 months	178	94.2	18,904	8.7	7.0
18-23 months	125	77.9	16,047	7.3	4.9
24-35 months	186	81.4	22,860	10.5	7.3
36-59 months	280	106.8	26,221	12.0	10.9
≥ 60 months	415	131.4	31,573	14.5	16.2
<b>Pre-Pregnancy BMI</b>					
Underweight (< 18.5)	112	130.7	8,571	3.9	4.4
Normal (18.5-24.9)	973	106.6	91,287	41.8	38.0
Overweight (25-29.9)	696	119.8	58,111	26.6	27.2
Obese (≥ 30)	777	128.5	60,464	27.7	30.4
<b>Weight Gain During Pregnancy</b>					
Inadequate	669	132.1	50,634	23.2	26.2
Recommended	717	105.6	67,889	31.1	28.0
Excess	1,172	117.3	99,910	45.7	45.8
<b>Weight Gain During Pregnancy by Pre-Pregnancy BMI</b>					
Underweight – Inadequate	49	148.4	3,301	1.5	1.9
Underweight - Recommended	34	103.3	3,292	1.5	1.3
Underweight – Excess	29	146.6	1,978	0.9	1.1
Normal Weight – Inadequate	324	129.1	25,102	11.5	12.7
Normal Weight – Recommended	307	92.1	33,348	15.3	12.0
Normal Weight - Excess	342	104.2	32,837	15.0	13.4
Overweight – Inadequate	129	144.8	8,908	4.1	5.0
Overweight - Recommended	184	115	15,997	7.3	7.2
Overweight – Excess	383	115.3	33,206	15.2	15.0
Obese – Inadequate	167	125.3	13,323	6.1	6.5
Obese – Recommended	192	125.9	15,252	7.0	7.5
Obese - Excess	418	131.1	31,889	14.6	16.3

\* Cell suppressed due to value < 6

\*\* Not calculated due to suppressed cell

† Rate using value less than 20; interpret with caution.

(continued)

	SMM Overall Cases	SMM Overall Rate per 10,000 deliveries	Total Deliveries	Percent of total deliveries	Percent of SMM Cases
<b>Pre-Existing Diabetes</b>					
With Pre-Existing Diabetes	56	264.2	2,120	1.0	2.2
Without Pre-Existing Diabetes	2,502	115.7	216,313	99.0	97.8
<b>Chronic Hypertension</b>					
With Chronic Hypertension	81	298.3	2,715	1.2	3.2
Without Chronic Hypertension	2,477	114.8	215,718	98.8	96.8
<b>Gestational Diabetes</b>					
With Gestational Diabetes	246	147.3	16,699	7.6	9.6
Without Gestational Diabetes	2,312	114.6	201,734	92.4	90.4
<b>Hypertensive Disorders of Pregnancy (HDP)<sup>^</sup></b>					
With HDP	485	331	14,652	6.7	19.0
Without HDP	2,073	101.7	203,781	93.3	81.0
<b>Any Smoking Before or During Pregnancy</b>					
Smoker	196	122.8	15,965	7.3	7.7
Non-Smoker	2,352	116.4	202,102	92.5	91.9
<b>Smoking Tobacco by Timing</b>					
Non-Smoker	2,352	116.4	202,102	92.5	91.9
Smoked Before Pregnancy Only	62	111.2	5,575	2.6	2.4
Smoked Before and During Pregnancy	128	127.3	10,058	4.6	5.0
Smoked During Pregnancy Only	6	184.6 <sup>†</sup>	325	0.1	0.2
<b>Prenatal Care Initiation</b>					
Prenatal Care in First Trimester	1,593	101.8	156,445	71.6	62.3
Prenatal Care in Second Trimester	507	131.6	38,531	17.6	19.8
Prenatal Care in Third Trimester	196	155.0	12,647	5.8	7.7
No Prenatal Care	179	318.7	5,616	2.6	7.0
<b>Adequacy of Prenatal Care Utilization</b>					
Adequate Plus Prenatal Care	730	128.2	56,963	26.1	28.5
Adequate Prenatal Care	783	83.7	93,527	42.8	30.6
Intermediate Prenatal Care	313	117.5	26,649	12.2	12.2
Inadequate Prenatal Care	489	156.4	31,275	14.3	19.1
No Prenatal Care	179	318.7	5,616	2.6	7.0

\* Cell suppressed due to value < 6

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† Rate using value less than 20; interpret with caution.

<sup>^</sup> Hypertensive disorders of pregnancy include gestational hypertension, preeclampsia, and eclampsia.



(continued)

	SMM Overall Cases	SMM Overall Rate per 10,000 deliveries	Total Deliveries	Percent of total deliveries	Percent of SMM Cases
<b>Method of Delivery</b>					
Primary Cesarean	948	296.9	31,931	14.6	37.1
Repeat Cesarean	465	180.3	25,792	11.8	18.2
Vaginal Delivery After Cesarean (VBAC)	65	119.7	5,432	2.5	2.5
Vaginal Delivery	1,080	69.6	155,278	71.1	42.2
<b>Gestational Age at Delivery</b>					
Extremely Preterm (< 28 weeks)	79	732.2	1,079	0.5	3.1
Very Preterm (28-31 weeks)	116	886.9	1,308	0.6	4.5
Moderately Preterm (32-33 weeks)	121	731.6	1,654	0.8	4.7
Late Preterm (34-36 weeks)	341	271.7	12,549	5.7	13.3
Early Term (37-38 weeks)	580	101.7	57,012	26.1	22.7
Full Term (39-40 weeks)	1,150	87.5	131,396	60.2	45.0
Late Term (41 weeks)	155	121.9	12,717	5.8	6.1
Postterm (≥ 42 weeks)	11	224.5 <sup>†</sup>	490	0.2	0.4
<b>Early Term Non-Medically Indicated (NMI) Deliveries</b>					
Early Term NMI Cesarean	93	165.1	5,634	2.6	3.6
Early Term NMI Induction	63	109.7	5,741	2.6	2.5
Early Term Spontaneous Vaginal	138	53.2	25,935	11.9	5.4
<b>APT Level of Care</b>					
Level I APT Hospital	121	124.9	9,690	4.4	4.7
Level II APT Hospital	369	78.9	46,753	21.4	14.4
Level IIE APT Hospital	677	117.4	57,673	26.4	26.5
Level III APT Hospital	1,207	130.4	92,562	42.4	47.2
Not an APT Hospital	184	156.5	11,755	5.4	7.2

\* Cell suppressed due to value < 6

\*\* Not calculated due to suppressed cell

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(continued)

	SMM Overall Cases	SMM Overall Rate per 10,000 deliveries	Total Deliveries	Percent of total deliveries	Percent of SMM Cases
<b>Primary Care Area (PCA)</b>					
AHWATUKEE FOOTHILLS VILLAGE	17	90.5 <sup>†</sup>	1,878	0.9	0.7
AJO	*	**	114	0.1	**
ALHAMBRA VILLAGE	107	172.2	6,215	2.8	4.2
ANTHEM	*	**	360	0.2	**
APACHE JUNCTION	12	103.7 <sup>†</sup>	1,157	0.5	0.5
AVONDALE	41	106.4	3,854	1.8	1.6
BENSON	*	**	294	0.1	**
BISBEE	10	201.6 <sup>†</sup>	496	0.2	0.4
BLACK CANYON CITY	*	**	204	0.1	**
BUCKEYE	33	99	3,332	1.5	1.3
BULLHEAD CITY	21	169.5	1,239	0.6	0.8
CAMELBACK EAST VILLAGE	57	118.2	4,824	2.2	2.2
CASA GRANDE	22	103.6	2,124	1.0	0.9
CASAS ADOBES	31	155.5	1,994	0.9	1.2
CATALINA FOOTHILLS	11	117.3 <sup>†</sup>	938	0.4	0.4
CENTRAL CITY VILLAGE	50	191	2,618	1.2	2.0
CHANDLER CENTRAL	67	153.8	4,356	2.0	2.6
CHANDLER NORTH	23	88.9	2,588	1.2	0.9
CHANDLER SOUTH	15	115.7 <sup>†</sup>	1,297	0.6	0.6
CHINO VALLEY	*	**	595	0.3	**
COLORADO CITY	*	**	*	**	**
COLORADO RIVER INDIAN TRIBE	*	**	196	0.1	**
COOLIDGE	*	**	646	0.3	**
COTTONWOOD\SEDONA	18	187.9 <sup>†</sup>	958	0.4	0.7
DEER VALLEY VILLAGE	44	72.7	6,049	2.8	1.7
DESERT VIEW VILLAGE	*	**	1,325	0.6	**
DOUGLAS & PIRTLEVILLE	9	100.2 <sup>†</sup>	898	0.4	0.4
DREXEL HEIGHTS	7	79.2 <sup>†</sup>	884	0.4	0.3
EL MIRAGE & YOUNGTOWN	19	101.5 <sup>†</sup>	1,872	0.9	0.7
ELOY	6	60.1 <sup>†</sup>	999	0.5	0.2
ENCANTO VILLAGE	40	200.2	1,998	0.9	1.6

\* Cell suppressed due to value < 6

\*\* Not calculated due to suppressed cell

† Rate using value less than 20; interpret with caution.

(continued)

	SMM Overall Cases	SMM Overall Rate per 10,000 deliveries	Total Deliveries	Percent of total deliveries	Percent of SMM Cases
ESTRELLA VILLAGE & TOLLESON	49	99.4	4,929	2.3	1.9
FLAGSTAFF	24	149.3	1,607	0.7	0.9
FLORENCE	*	**	707	0.3	**
FLOWING WELLS	6	110.5 <sup>†</sup>	543	0.2	0.2
FORT MCDOWELL YAVAPAI NATION	*	**	39	0.0	**
FORTUNA FOOTHILLS	16	213.3 <sup>†</sup>	750	0.3	0.6
FOUNTAIN HILLS/RIO VERDE	*	**	292	0.1	**
GILA RIVER INDIAN COMMUNITY	*	**	248	0.1	**
GILBERT CENTRAL	42	112.6	3,729	1.7	1.6
GILBERT NORTH	25	101.4	2,465	1.1	1.0
GILBERT SOUTH	29	107.5	2,697	1.2	1.1
GLENDALE CENTRAL	58	114.4	5,069	2.3	2.3
GLENDALE NORTH	36	92.1	3,907	1.8	1.4
GLENDALE WEST	17	106.4 <sup>†</sup>	1,598	0.7	0.7
GLOBE	9	179.3 <sup>†</sup>	502	0.2	0.4
GOLD CANYON	14	229.5 <sup>†</sup>	610	0.3	0.5
GOLDEN VALLEY	*	**	137	0.1	**
GOODYEAR & LITCHFIELD PARK	22	75.2	2,925	1.3	0.9
GRAND CANYON VILLAGE	*	**	141	0.1	**
GREEN VALLEY	*	**	115	0.1	**
HOPI TRIBE	7	736.8 <sup>†</sup>	95	0.0	0.3
HUALAPAI TRIBE	*	**	88	0.0	**
KINGMAN	21	130.1	1,614	0.7	0.8
LAKE HAVASU CITY	13	116.3 <sup>†</sup>	1,118	0.5	0.5
LAVEEN VILLAGE	43	152.4	2,821	1.3	1.7
MARANA	17	91.3 <sup>†</sup>	1,861	0.9	0.7
MARICOPA	24	125.4	1,914	0.9	0.9
MARYVALE VILLAGE	155	134.5	11,522	5.3	6.1
MESA CENTRAL	26	62.7	4,145	1.9	1.0
MESA EAST	12	54.5 <sup>†</sup>	2,202	1.0	0.5
MESA GATEWAY	23	65.4	3,515	1.6	0.9
MESA NORTH	25	84.3	2,967	1.4	1.0

\* Cell suppressed due to value < 6

\*\* Not calculated due to suppressed cell

† Rate using value less than 20; interpret with caution.

(continued)

	SMM Overall Cases	SMM Overall Rate per 10,000 deliveries	Total Deliveries	Percent of total deliveries	Percent of SMM Cases
MESA WEST	58	108	5,372	2.5	2.3
MORENCI	*	**	379	0.2	**
NAVAJO NATION	22	258.5	851	0.4	0.9
NEW RIVER/CAVE CREEK	*	**	296	0.1	**
NOGALES	*	**	921	0.4	**
NORTH GATEWAY/RIO VISTA VILLAGE	*	**	976	0.4	**
NORTH MOUNTAIN VILLAGE	66	103.8	6,361	2.9	2.6
ORO VALLEY	*	**	692	0.3	**
PAGE	*	**	10	0.0	**
PARADISE VALLEY	*	**	159	0.1	**
PARADISE VALLEY VILLAGE	36	66.2	5,440	2.5	1.4
PARKER	*	**	177	0.1	**
PASCUA YAQUI TRIBE	*	**	195	0.1	**
PAYSON	*	**	558	0.3	**
PEORIA NORTH	14	50.4 <sup>†</sup>	2,780	1.3	0.5
PEORIA SOUTH	25	88.8	2,814	1.3	1.0
PICTURE ROCKS	*	**	219	0.1	**
PRESCOTT	*	**	724	0.3	**
PRESCOTT VALLEY	16	104.3 <sup>†</sup>	1,534	0.7	0.6
QUARTZSITE	*	**	152	0.1	**
QUEEN CREEK	12	79.3 <sup>†</sup>	1,514	0.7	0.5
RIO RICO	*	**	728	0.3	**
SADDLEBROOKE	*	**	305	0.1	**
SAFFORD	*	**	475	0.2	**
SAHUARITA	7	68.3 <sup>†</sup>	1,025	0.5	0.3
SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY	*	**	217	0.1	**
SAN CARLOS APACHE TRIBE	34	501.5	678	0.3	1.3
SAN LUIS	40	193.7	2,065	0.9	1.6
SAN TAN VALLEY	27	70.8	3,811	1.7	1.1
SAN XAVIER	*	**	80	0.0	**
SCOTTSDALE CENTRAL	7	39.2 <sup>†</sup>	1,786	0.8	0.3

\* Cell suppressed due to value < 6

\*\* Not calculated due to suppressed cell

† Rate using value less than 20; interpret with caution.

(continued)

	SMM Overall Cases	SMM Overall Rate per 10,000 deliveries	Total Deliveries	Percent of total deliveries	Percent of SMM Cases
SCOTTSDALE NORTH	*	**	1,021	0.5	**
SCOTTSDALE SOUTH	11	69.8 <sup>†</sup>	1,577	0.7	0.4
SHOW LOW	12	145.1 <sup>†</sup>	827	0.4	0.5
SIERRA VISTA	36	198.7	1,812	0.8	1.4
SNOWFLAKE/HEBER	7	118.4 <sup>†</sup>	591	0.3	0.3
SOMERTON	13	196.4 <sup>†</sup>	662	0.3	0.5
SOUTH MOUNTAIN VILLAGE & GUADALUPE	67	115.9	5,780	2.6	2.6
SPRINGVILLE/EAGER	12	234.4 <sup>†</sup>	512	0.2	0.5
SUN CITY	*	**	268	0.1	**
SUN CITY WEST	*	**	13	0.0	**
SUN LAKES	*	**	8	0.0	**
SURPRISE NORTH & WICKENBURG	7	99.7 <sup>†</sup>	702	0.3	0.3
SURPRISE SOUTH	19	58.8 <sup>†</sup>	3,233	1.5	0.7
TANQUE VERDE	*	**	254	0.1	**
TEMPE NORTH	22	79.3	2,776	1.3	0.9
TEMPE SOUTH	13	78 <sup>†</sup>	1,666	0.8	0.5
THATCHER	10	135.5 <sup>†</sup>	738	0.3	0.4
TOHONO O'ODHAM NATION	6	211.3 <sup>†</sup>	284	0.1	0.2
TUCSON CENTRAL	55	158	3,482	1.6	2.2
TUCSON EAST	46	139.8	3,291	1.5	1.8
TUCSON ESTATES	7	227.3 <sup>†</sup>	308	0.1	0.3
TUCSON FOOTHILLS	51	161.2	3,164	1.4	2.0
TUCSON SOUTH	119	171	6,960	3.2	4.7
TUCSON SOUTH EAST	16	107.2 <sup>†</sup>	1,492	0.7	0.6
TUCSON WEST	12	119.8 <sup>†</sup>	1,002	0.5	0.5
VAIL	*	**	580	0.3	**
VALENCIA WEST	11	142.3 <sup>†</sup>	773	0.4	0.4
WHITE MOUNTAIN APACHE TRIBE	18	266.7 <sup>†</sup>	675	0.3	0.7
WILLCOX & BOWIE	*	**	323	0.1	**
WILLIAMSON	*	**	181	0.1	**
WINSLOW	15	216.5 <sup>†</sup>	693	0.3	0.6
YUMA	90	191.7	4,696	2.1	3.5

\* Cell suppressed due to value < 6

\*\* Not calculated due to suppressed cell

† Rate using value less than 20; interpret with caution.

## Appendix B: SMM Indicator Descriptions and ICD-10-CM Codes

Severe Maternal Morbidity Indicators	Description	AIM SMM ICD-10 Codes
<b>Diagnoses</b>		
Acute myocardial infarction	Heart attack	I21.01 I21.02 I21.09 I21.11 I21.19 I21.21 I21.29 I21.3 I21.4 I21.9 I21.A1 I21.A9 I22.0 I22.1 I22.2 I22.8 I22.9
Acute renal failure	Kidney failure	N17.0 N17.1 N17.2 N17.8 N17.9 O90.4
Adult respiratory distress syndrome	Respiratory failure	J80 J95.1 J95.2 J95.3 J95.821 J95.822 J96.00 J96.01 J96.02 J96.20 J96.21 J96.22 R09.2
Amniotic fluid embolism	Condition where amniotic fluid or fetal material enters the mother's bloodstream causing systemic collapse of organ functions	O88.111 O88.112 O88.113 O88.119 O88.12 O88.13
Aneurysm	Abnormal widening of a blood vessel which may cause rupture and acute blood loss	I71.00 I71.01 I71.02 I71.03 I71.1 I71.2 I71.3 I71.4 I71.5 I71.6 I71.8 I71.9 I79.0
Cardiac arrest or ventricular fibrillation	Failure of the heart to pump blood	I49.01 I49.02 I46.2 I46.8 I46.9
Disseminated intravascular coagulation (DIC)	Interruption of blood clotting mechanism leading to bleeding	D65 D68.8 D68.9 O72.3
Eclampsia	Onset of seizures during pregnancy	O15.00 O15.02 O15.03 O15.1 O15.2 O15.9
Puerperal cerebrovascular disorders	Stroke	I60.00 I60.01 I60.02 I60.10 I60.11 I60.12 I60.2 I60.20 I60.21 I60.22 I60.30 I60.31 I60.32 I60.4 I60.50 I60.51 I60.52 I60.6 I60.7 I60.8 I60.9 I61.0 I61.1 I61.2 I61.3 I61.4 I61.5 I61.6 I61.8 I61.9 I62.00 I62.01 I62.02 I62.03 I62.1 I62.9 I63.00 I63.011 I63.012 I63.013 I63.019 I63.02 I63.031 I63.032 I63.033 I63.039 I63.09 I63.10 I63.111 I63.112 I63.113 I63.119 I63.12 I63.131 I63.132 I63.133 I63.139 I63.19

		<p>I63.20 I63.211 I63.212 I63.213  I63.219 I63.22 I63.231 I63.232 I63.233 I63.239  I63.29 I63.30 I63.311 I63.312  I63.313 I63.319 I63.321 I63.322  I63.323 I63.329 I63.331 I63.332  I63.333 I63.339I63.341 I63.342  I63.343 I63.349I63.39 I63.40  I63.411 I63.412I63.413 I63.419  I63.421 I63.422I63.423 I63.429  I63.431 I63.432I63.433 I63.439  I63.441 I63.442I63.443 I63.449  I63.49 I63.50 I63.511 I63.512 I63.513 I63.519  I63.521 I63.522I63.523 I63.529 I63.531 I63.532  I63.533 I63.539I63.541 I63.542 I63.543 I63.549  I63.59 I63.6 I63.8 I63.9 I65.01 I65.02 I65.03  I65.09 I65.1 I65.21 I65.22 I65.23 I65.29 I65.8  I65.9 I66.01 I66.02 I66.03 I66.09 I66.11 I66.12  I66.13 I66.19 I66.21 I66.22 I66.23 I66.29 I66.3  I66.8 I66.9 I67.0 I67.1 I67.2 I67.3 I67.4 I67.5  I67.6 I67.7 I67.81 I67.82 I67.83 I67.841 I67.848  I67.89 I67.9 I68.0 I68.2 I68.8 O22.51 O22.52  O22.53 O87.3 I97.810 I97.811 I97.820 I97.821</p>
Pulmonary edema	Excessive fluid in the lungs not allowing for oxygenation of tissues	<p>J81.0 I50.1 I50.20 I50.21  I50.23 I50.30 I50.31 I50.33  I50.40 I50.41 I50.43 I50.9</p>
Sepsis	Whole body response to an infection causing collapse and lack of organ function	<p>O85 T80.211A T81.4XXA R65.20  A40.0 A40.1 A40.3 A40.8  A40.9 A41.01 A41.02 A41.1  A41.2 A41.3 A41.4 A41.50  A41.51 A41.52 A41.53 A41.59  A41.81 A41.89 A41.9 A32.7</p>
Severe anesthesia complications	Complications resulting from pain control procedures	<p>O74.0 O74.1 O74.2 O74.3  O89.01 O89.09 O89.1 O89.2</p>
Shock	Condition where organs are not getting enough blood flow	<p>O75.1 R57.0 R57.1 R57.8 R57.9 R65.21 T78.2XXA  T88.2XXA T88.6XXA T81.10XA T81.11XA T81.19XA</p>
Sickle cell anemia with crisis	Episodes of acute pain in a person with sickle cell anemia	<p>D57.00 D57.01 D57.02 D57.211  D57.212 D57.219 D57.411 D57.412  D57.419 D57.811 D57.812 D57.819</p>
Thrombotic embolism	Blood clot	<p>I26.01 I26.02 I26.09 I26.90 I26.92 I26.99  O88.011 O88.012 O88.013 O88.019 O88.02  O88.03 O88.211 O88.212 O88.213 O88.219  O88.22 O88.23 O88.311 O88.312 O88.313  O88.319 O88.32 O88.33 O88.811 O88.812  O88.813 O88.819 O88.82 O88.83</p>

## Procedures

Blood transfusion	Transfusion of whole blood and other blood products	30233H1 30233K1 30233L1 30233M1 30233N1 30233P1 30233R1 30233T1 30240H1 30240K1 30240L1 30240M1 30240N1 30240P1 30240R1 30240T1 30243H1 30243K1 30243L1 30243M1 30243N1 30243P1 30243R1 30243T1 30233N0 30233P0 30240N0 30240P0 30243N0 30243P0
Conversion of cardiac rhythm	Procedure that restores an irregular heartbeat to normal rhythm	5A2204Z 5A12012
Hysterectomy	Removal of the uterus	OUT90ZZ OUT94ZZ OUT97ZZ OUT98ZZ OUT9FZZ
Temporary tracheostomy	Procedure where an alternate breathing route is provided through the trachea (windpipe)	OB110Z4 OB110F4 OB113Z4 OB113F4 OB114Z4 OB114F4
Ventilation	Assisted breathing	5A1935Z 5A1945Z 5A1955Z



## Appendix C. Additional Definitions

### Primary Care Areas

A Primary Care Area (PCA) denotes the geographic area generally served by a common primary health provider.

### Federal Poverty Level

Federal poverty levels are measures of income released by the Department of Health and Human Services (HHS) every year to determine eligibility for programs and benefits, such as Medicaid. It is based on the modified adjusted gross income as well as the number of individuals in a family who are reliant on that income.

### Kotelchuck Index or the Adequacy of Prenatal Care Utilization Index (APNCU)

The following information was taken from the March of Dimes PeriStats [website](#):

Adequacy of prenatal care calculations are based on the Adequacy of Prenatal Care Utilization Index (APNCU), which measures the utilization of prenatal care on two dimensions. The first dimension, adequacy of initiation of prenatal care, measures the timing of initiation using the month prenatal care began reported on the birth certificate. The second dimension, adequacy of received services, is measured by taking the ratio of the actual number of visits reported on the birth certificate to the expected number of visits. The expected number of visits is based on the American College of Obstetrics and Gynecology prenatal care visitations standards for uncomplicated pregnancies (1), and is adjusted for the gestational age at initiation of care and for the gestational age at delivery. The two dimensions are combined into a single summary index, and grouped into four categories: Adequate Plus, Adequate, Intermediate, and Inadequate. On PeriStats, the percent of infants whose mothers received Adequate and Adequate Plus prenatal care are combined into one category, Adequate/Adeq+ prenatal care. Definitions for these categories include:

- **Adequate Plus:** Prenatal care begun by the 4th month of pregnancy and 110% or more of recommended visits received.
- **Adequate:** Prenatal care begun by the 4th month of pregnancy and 80-109% of recommended visits received.
- **Intermediate:** Prenatal care begun by the 4th month of pregnancy and 50-79% of recommended visits received.
- **Inadequate:** Prenatal care begun after the 4th month of pregnancy or less than 50% of recommended visits received.

## Appendix D: Arizona Perinatal Trust (APT) Levels of Perinatal Care

### **IN-HOSPITAL BIRTHING CENTERS – IHBC** *(Indian Health Services Only)*

Provide hospital services for uncomplicated obstetrical patients (excluding cesarean delivery) and basic and transitional newborn care. Such centers should not electively deliver infants less than 37 weeks gestation.

### **PERINATAL CARE CENTERS – LEVEL I**

Provide hospital services for low-risk obstetrical patients, including cesarean delivery and basic and transitional newborn care; such centers should not electively deliver infants less than 36 weeks gestation.

### **PERINATAL CARE CENTERS – LEVEL II**

Provides hospital services for selected high risk obstetrical patients and newborns requiring selective continuing care; such centers should not electively deliver infants less than 32 weeks gestation.

### **PERINATAL CARE CENTERS – LEVEL IIE**

Provide hospital services for high-risk obstetrical patients and newborns requiring selective continuing care; such centers should not electively deliver infants less than 28 weeks gestation.

### **PERINATAL CARE CENTERS – LEVEL III**

Provide hospital services for all obstetrical and newborn patients including those patients requiring subspecialty and intensive care at all gestational ages.

### **FREESTANDING NEONATAL CARE CENTERS – LEVEL III**

Provide hospital services for all newborns requiring subspecialty and intensive care at all gestational ages.

## Appendix E. Percent of the Population Living Below the Federal Poverty Level (FPL) by Primary Care Area (PCA)

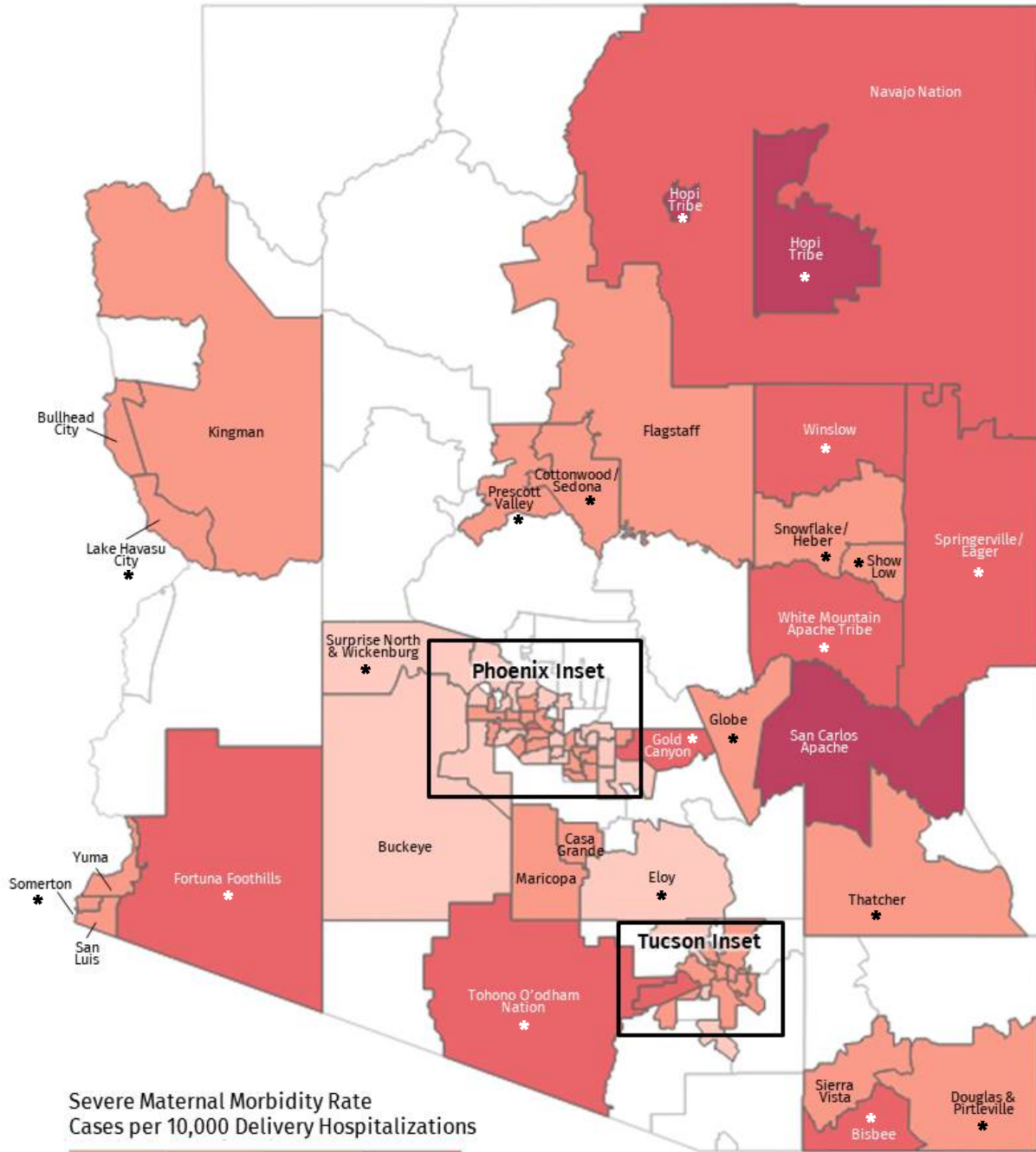
PCA	% Population Below 100% FPL	Quartile
ANTHEM	4.0%	1
DESERT VIEW VILLAGE	4.3%	
NORTH GATEWAY/RIO VISTA VILLAGE	4.5%	
CHANDLER SOUTH	4.7%	
FOUNTAIN HILLS/RIO VERDE	5.0%	
PEORIA NORTH	5.0%	
GILBERT CENTRAL	5.1%	
AHWATUKEE FOOTHILLS VILLAGE	5.4%	
GILBERT SOUTH	5.5%	
GOLD CANYON	5.9%	
TANQUE VERDE	6.0%	
NEW RIVER/CAVE CREEK	6.1%	
SCOTTSDALE NORTH	6.1%	
SUN CITY WEST	6.1%	
PARADISE VALLEY	6.4%	
TUCSON SOUTH EAST	6.4%	
VAIL	6.4%	
SUN LAKES	6.5%	
GLENDALE WEST	6.8%	
SCOTTSDALE CENTRAL	7.3%	
CATALINA FOOTHILLS	7.4%	
GILBERT NORTH	7.7%	
QUEEN CREEK	7.9%	
CHANDLER NORTH	8.0%	
GOODYEAR & LITCHFIELD PARK	8.0%	
ORO VALLEY	8.1%	
TEMPE SOUTH	8.4%	
SUN CITY	8.9%	
WILLIAMSON	8.9%	
MARANA	9.0%	
SAHUARITA	10.1%	
SURPRISE SOUTH	10.3%	
MESA GATEWAY	10.6%	2
CASAS ADOBES	11.0%	
MARICOPA	11.0%	
GREEN VALLEY	11.1%	
TUCSON ESTATES	11.3%	
FORTUNA FOOTHILLS	11.6%	
MESA NORTH	11.6%	2
PEORIA SOUTH	11.7%	
DEER VALLEY VILLAGE	12.0%	

MESA EAST	12.0%	
CHANDLER CENTRAL	12.2%	
PARADISE VALLEY VILLAGE	12.5%	
SADDLEBROOKE	12.6%	
GLENDALE NORTH	12.8%	
SAN TAN VALLEY	13.0%	
PRESCOTT	13.1%	
LAKE HAVASU CITY	13.3%	
MORENCI	13.4%	
RIO RICO	13.7%	
BUCKEYE	13.8%	
PAGE	13.9%	
PAYSON	13.9%	
SNOWFLAKE/HEBER	15.0%	
PRESCOTT VALLEY	15.1%	
COTTONWOOD\SEDONA	15.3%	
SIERRA VISTA	15.4%	
CHINO VALLEY	15.5%	
SPRINGERVILLE/EAGER	15.6%	
QUARTZSITE	15.7%	
SCOTTSDALE SOUTH	15.8%	
PICTURE ROCKS	15.9%	
FLORENCE	16.0%	3
DREXEL HEIGHTS	16.1%	
LAVEEN VILLAGE	16.3%	
TUCSON EAST	16.5%	
WILLCOX & BOWIE	16.5%	
AVONDALE	16.9%	
BENSON	17.1%	
SURPRISE NORTH & WICKENBURG	17.1%	
BULLHEAD CITY	17.8%	
PARKER	17.9%	
SAFFORD	18.0%	
VALENCIA WEST	18.3%	
APACHE JUNCTION	18.8%	
THATCHER	18.8%	
BISBEE	19.4%	
BLACK CANYON CITY	19.5%	
SHOW LOW	19.5%	3
CASA GRANDE	19.6%	
FLAGSTAFF	19.8%	
YUMA	19.9%	
GLOBE	20.2%	
CAMELBACK EAST VILLAGE	20.4%	
EL MIRAGE & YOUNGTOWN	20.7%	

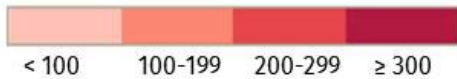
GRAND CANYON VILLAGE	21.1%	
MESA CENTRAL	21.5%	
NORTH MOUNTAIN VILLAGE	21.5%	
TUCSON WEST	21.6%	
ELOY	22.0%	
KINGMAN	23.5%	
TUCSON FOOTHILLS	23.5%	
MESA WEST	23.7%	
GOLDEN VALLEY	25.3%	4
ENCANTO VILLAGE	25.4%	
COOLIDGE	26.0%	
WINSLOW	26.5%	
AJO	27.2%	
SAN LUIS	27.2%	
TEMPE NORTH	28.9%	
ESTRELLA VILLAGE & TOLLESON	29.0%	
SOMERTON	29.0%	
SOUTH MOUNTAIN VILLAGE & GUADALUPE	29.0%	
COLORADO CITY	29.8%	
SALT RIVER PIMA-MARICOPA INDIAN COMMUNITY	30.1%	
TUCSON SOUTH	31.3%	
NOGALES	31.4%	
ALHAMBRA VILLAGE	31.9%	
FLOWING WELLS	32.0%	
TUCSON CENTRAL	32.2%	
DOUGLAS & PIRTLEVILLE	32.3%	
SAN XAVIER	32.5%	
MARYVALE VILLAGE	33.8%	
GLENDALE CENTRAL	34.4%	
COLORADO RIVER INDIAN TRIBE	36.3%	
HUALAPAI TRIBE	36.3%	
HOPI TRIBE	38.0%	
FORT MCDOWELL YAVAPAI NATION	40.8%	
NAVAJO NATION	41.1%	
CENTRAL CITY VILLAGE	45.9%	4
WHITE MOUNTAIN APACHE TRIBE	45.9%	
SAN CARLOS APACHE TRIBE	46.1%	
PASCUA YAQUI TRIBE	46.3%	
GILA RIVER INDIAN COMMUNITY	46.7%	
TOHONO O'ODHAM NATION	47.0%	

Appendix F: Severe Maternal Morbidity by Primary Care Area, 2016-2018

**Severe Maternal Morbidity Rate  
by Primary Care Areas  
Arizona Resident Singleton Deliveries, 2016-2018**



Severe Maternal Morbidity Rate  
Cases per 10,000 Delivery Hospitalizations

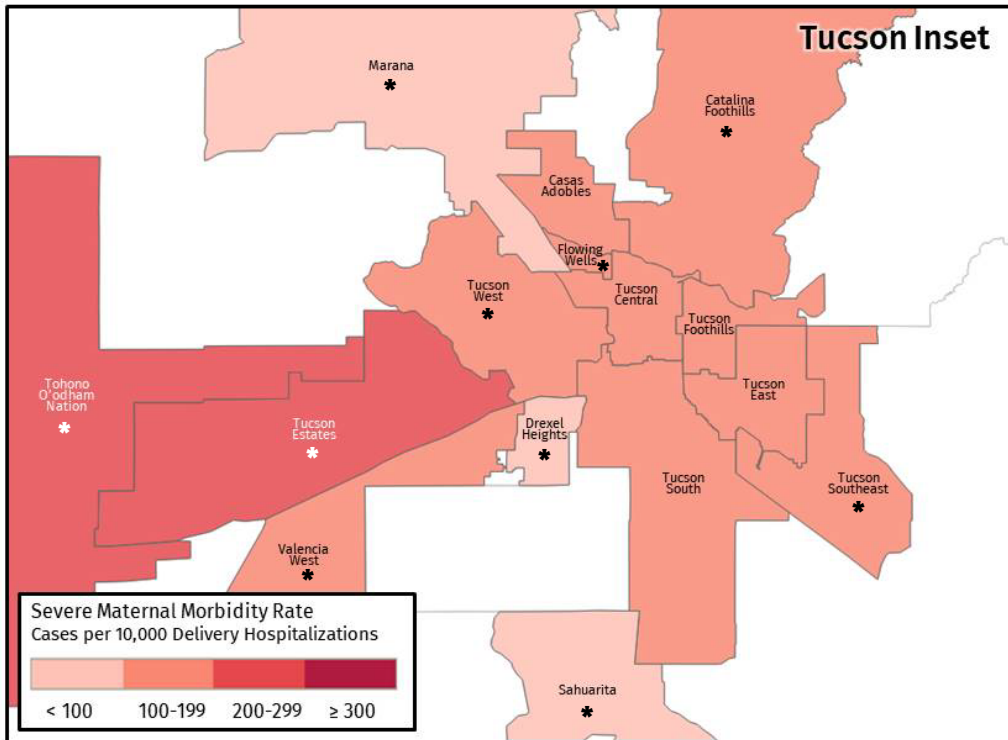


□ PCA suppressed due to <6 SMM cases

\* Rate using value less than 20; interpret with caution.

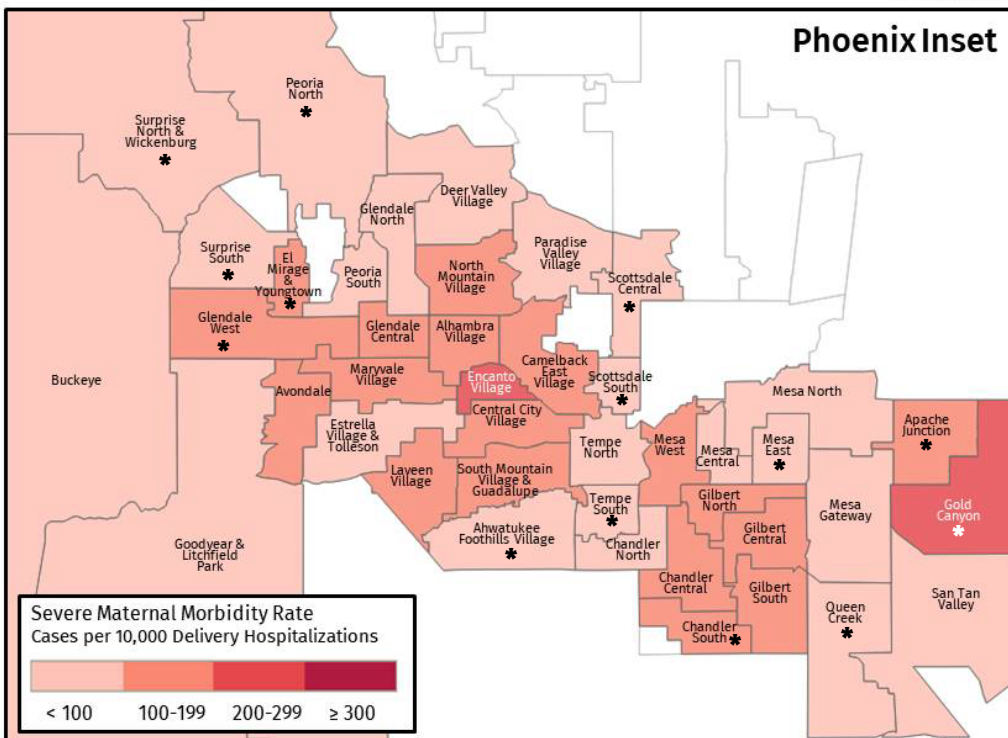
**Severe Maternal Morbidity Rate  
by Primary Care Areas and Primary Care Area Clusters**  
Arizona Resident Singleton Deliveries, 2016-2018

□ PCA Suppressed Due to < 6 SMM Cases



**Severe Maternal Morbidity Rate  
by Primary Care Areas and Primary Care Area Clusters**  
Arizona Resident Singleton Deliveries, 2016-2018

□ PCA Suppressed Due to < 6 SMM Cases



\* Rate using value less than 20; interpret with caution.

## Appendix G: Delivery facilities in the Arizona Hospital Discharge Database

List does not include facilities with less than 20 births for 2016-2018.

ABRAZO ARROWHEAD CAMPUS	HAVASU REGIONAL MEDICAL CENTER
ABRAZO CENTRAL CAMPUS	KINGMAN REGIONAL MEDICAL CENTER
ABRAZO SCOTTSDALE CAMPUS	LITTLE COLORADO MEDICAL CENTER
ABRAZO WEST CAMPUS	DIGNITY HEALTH MERCY GILBERT MEDICAL CENTER
BANNER BAYWOOD MEDICAL CENTER	MOUNTAIN VISTA MEDICAL CENTER
BANNER CASA GRANDE MEDICAL CENTER	MT. GRAHAM REGIONAL MED CTR
BANNER DEL E WEBB MEDICAL CENTER	NORTHWEST MEDICAL CENTER
BANNER DESERT MEDICAL CENTER	HONORHEALTH SCOTTSDALE OSBORN MEDICAL CENTER
BANNER ESTRELLA MEDICAL CENTER	HONORHEALTH SCOTTSDALE SHEA MEDICAL CENTER
BANNER GATEWAY MEDICAL CENTER	DIGNITY HEALTH ST. JOSEPH'S HOSPITAL AND MEDICAL CENTER
BANNER IRONWOOD MEDICAL CENTER	SUMMIT HEALTHCARE REGIONAL MEDICAL CENTER
BANNER PAGE HOSPITAL	TEMPE ST. LUKE'S HOSPITAL
BANNER PAYSON MEDICAL CENTER	TUCSON MEDICAL CENTER
BANNER THUNDERBIRD MEDICAL CENTER	VALLEY VIEW MEDICAL CENTER
BANNER UNIVERSITY MEDICAL CENTER - TUCSON	VALLEYWISE HEALTH (MARICOPA INTEGRATED HEALTH SYSTEM)
BANNER UNIVERSITY MEDICAL CENTER PHOENIX	VERDE VALLEY MEDICAL CENTER
CANYON VISTA MEDICAL CENTER	WESTERN AZ REGIONAL MED CTR
CARONDELET HOLY CROSS HOSPITAL	YAVAPAI REGIONAL MEDICAL CENTER-EAST
CARONDELET ST JOSEPHS HOSPITAL	YUMA REGIONAL MEDICAL CENTER
DIGNITY HEALTH CHANDLER REGIONAL MEDICAL CENTER	
COBRE VALLEY REGIONAL MEDICAL CENTER	
FLAGSTAFF MEDICAL CENTER	