

Severe Maternal Morbidity in Pennsylvania, 2016-2022:

Individual level & Regional Factors

**Bureau of Epidemiology &
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Executive Summary

For every pregnancy, there is a continuum of potential outcomes, from uncomplicated pregnancy, the most common occurrence, to maternal death, the rarest but most severe outcome (Figure 1).¹ Severe maternal morbidity (SMM) is defined as the unexpected outcomes of labor and delivery that result in significant short- or long-term consequences to a

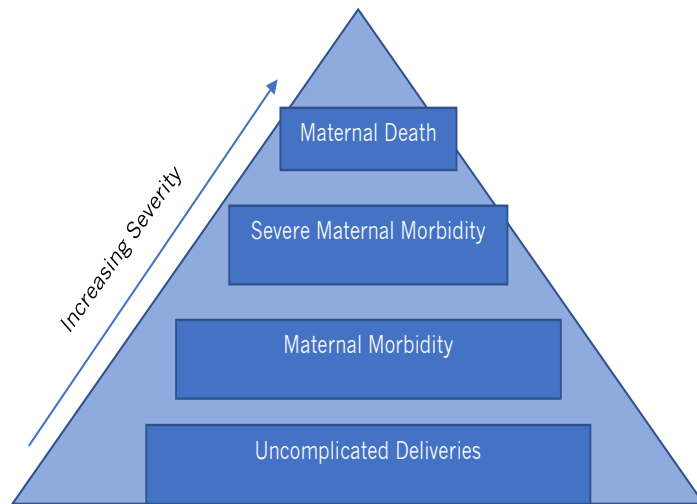


Figure 1 Continuum of Pregnancy Outcomes

woman's health.² Although SMM is considered a rare outcome of pregnancy, the rates of SMM in the United States (US) have steadily increased in recent years.² The negative effects of SMM include increased postpartum hospitalization, and a higher financial burden for more intense medical care. Preventing SMM and identifying opportunities to improve access and quality of maternal health care to reduce SMM would also in turn decrease the rate of maternal mortality.³

Generally, SMM risk factors include both adolescent and older maternal age, plurality (twins, triplets, etc.), and pre-existing health conditions.³⁻⁵ There are persistent disparities in SMM rates by race/ethnicity. With trends similar to those seen in maternal mortality rates, non-Hispanic Black women are at the highest risk for SMM in the US. Furthermore, the trends show a disproportionate burden on historically marginalized groups regardless of educational attainment, age, and/or socioeconomic status. In acknowledging the individual-level factors, the coexisting influence of regional and systemic factors can increase the likelihood of SMM for many across the US. Research shows that pregnant individuals living in the Northeast and Southern states, from lower-income communities, and giving birth in public hospitals experience higher rates of SMM on average than their respective counterparts.³ Policy-level factors such as housing affordability have also been linked to higher rates of SMM.⁶

Although the SMM rate in Pennsylvania has been steadily increasing over time, thus far, there have not been any in-depth characterizations of the individual and regional factors associated with SMM in this state. The most recent comparison to national data showed that in 2020, the SMM rate in Pennsylvania was 92.4 per 10,000 delivery hospitalizations, compared to 88.2 per 10,000 delivery hospitalizations nationally.⁷

The goal of this report is to assess trends and identify key contributing factors for SMM in Pennsylvania using Pennsylvania Health Care Cost Containment Council (PHC4) data from 2016 to 2022. Twenty-one SMM indicators identified by the Centers for Disease Control and Prevention (CDC) were categorized into seven SMM indicator groups for this analysis.^{2,8} The individual-level factors that were available to assess include maternal age, racial/ethnic

group, health insurance, mode of delivery, and discharge status. At the regional level, the geographic area of residence and the region of the healthcare facility were assessed. In addition, spatial and descriptive analyses were conducted to examine how social determinants of health relate to the prevalence of SMM within counties, using measures of social vulnerability as defined by the CDC. Hospital facility characteristics included average length of stay and average total charges. Below are key findings from this report:

- From 2016 to 2022, the annual rate of SMM in Pennsylvania increased from 75.2 per 10,000 delivery hospitalizations in 2016 to 105.2 per 10,000 delivery hospitalizations in 2022, with a 7% (percent) average annual increase.
- The overall rate of SMM in Pennsylvania from the 883,804 total in-hospital deliveries between 2016 and 2022 was 89.3 per 10,000 delivery hospitalizations.
- Hemorrhage complications represented the highest rates among all SMM indicator groups.
- Among the patient characteristics, the highest rate of SMM over the analysis period was observed among women aged 35 years and older, non-Hispanic Black women, women residing in urban geographic areas, those with Medicaid/Medicare as their primary payer, and women who delivered by cesarean section. Women who died in hospital following a delivery were also more likely to have experienced an SMM.
- Women who experienced an SMM had an average length of stay that was 3 days longer and a total charge of over \$60,000 on average compared to those who did not experience an SMM event.

The initiation of this report preceded the 2023 amendment of the Maternal Mortality Review Act to include surveillance of SMM in Pennsylvania.⁹ With continuous monitoring, the findings will help prioritize programming and interventions on an individual and systems level to reduce SMM rates and improve maternal health outcomes in the Commonwealth.

Methods

Data Source and Identification of Severe Maternal Morbidity

The data source for this report is the inpatient hospitalization data and healthcare facility information from the Pennsylvania Health Care Cost Containment Council (PHC4) from 2016 to 2022. The inpatient hospitalization data contain patient demographic characteristics such as age, gender, and race/ethnicity, in addition to the International Classification of Diseases-10-Clinical Modification (ICD-10-CM) diagnoses and procedure codes (including Medicare Severity Diagnosis Related Groups (MS-DRG) codes), and patient county of residence at the time of hospitalization (Appendix).

The Centers for Disease Control and Prevention (CDC) developed an algorithm to identify SMM events during hospitalization. This algorithm consists of 21 indicators of SMM, with 16 being diagnoses (serious complications during pregnancy or labor and delivery) and 5 being procedural (procedures used to manage serious conditions). Each indicator has one or more corresponding ICD-10-CM, ICD-10-PCS, or MS-DRG diagnosis and procedure codes (Appendix). The ICD-10-CM and ICD-10-PCS codes were used in this analysis to categorize SMM conditions into seven groups using the recommended grouping of SMM indicators by the Alliance for Innovation on Maternal Health (AIM, Table 1).⁸

Table 1: Severe Maternal Morbidity Indicators and Indicator Groups

SMM Indicator Groups	SMM Indicators
Hemorrhage Complications	Disseminated intravascular coagulation Shock Hysterectomy
Respiratory Complications	Adult respiratory distress syndrome Temporary tracheostomy Ventilation
Cardiac Complications	Acute myocardial infarction Aneurysm Cardiac arrest/ventricular fibrillation Conversion of cardiac rhythm Heart failure/arrest during surgery or procedure Pulmonary edema/acute heart failure
Renal Complications	Acute renal failure
Sepsis Complications	Sepsis
Other Obstetric Complications	Amniotic fluid embolism Eclampsia Severe anesthesia complications Air and thrombotic embolism
Other Medical Complications	Puerperal cerebrovascular disorders Sickle cell disease with crisis

As it is possible for a patient to have multiple SMM indicators, including diagnoses of complications and managing procedures, the inputs of this data set were analyzed as events, and the SMM rate was calculated per 10,000 delivery hospitalizations for women ages 12-55

years. In addition, only the initial inpatient hospitalization for delivery was included in this analysis; any subsequent hospitalizations were not included. To ensure that only the SMM cases were captured, the following inclusion criteria were applied:

Census	Delivery hospitalizations excluded	Case Definition
<ul style="list-style-type: none"> •Female •Ages 12-55 years at admission of delivery hospitalization •Deliveries occurring at General Acute Care Hospitals, Specialty Hospitals, and Specialty General Acute Care Hospitals 	<ul style="list-style-type: none"> •Missing age or sex •Indication of an abortion •All other hospital types 	<ul style="list-style-type: none"> •A diagnosis or procedure indicating SMM •A diagnosis, Medicare Severity-Diagnosis Related Group (MS-DRG), or procedure indicating an in-hospital delivery •Delivery hospitalizations with only a blood transfusion are not included in the numerator

Social Vulnerability Index

Social vulnerability is defined as the “degree to which a community exhibits certain social conditions, including high poverty, low percentage of vehicle access, or crowded households, may affect that community’s ability to prevent human suffering and financial loss in the event of a disaster.”¹⁰ The Social Vulnerability Index (SVI) has been widely used in resource allocation and effort mitigation in the field of emergency preparedness. However, the application of this index has expanded, and more studies are using the SVI to understand the impacts of the social determinants of health in formulating purposeful recommendations in program and policy change, including maternal and child health research.

The SMM prevalence and rates in Pennsylvania from 2016 to 2022 were assessed by SVI, which used data from the 2016-2020 American Community Survey (ACS) to formulate the estimates. Per the recommendation of the CDC, four themes were included in the analysis: Socioeconomic Status, Household Composition, Racial & Ethnic Minority Status, and Housing Type & Transportation (Appendix). The overall SVI was also analyzed.¹⁰ The ranking of vulnerability was evaluated in quartiles (a ranking of 0-0.25 was designated as low, 0.25-0.5 then as low to moderate, 0.5-0.75 as moderate to high, and greater than 0.75 as high vulnerability).¹⁰

Findings

SMM Rates in Pennsylvania, 2016-2022

There was a total of 883,804 delivery hospitalizations between 2016 and 2022, 7,894 (0.89%) of which experienced at least one SMM indicator. The overall rate of any SMM per 10,000 total delivery hospitalizations was 89.3.

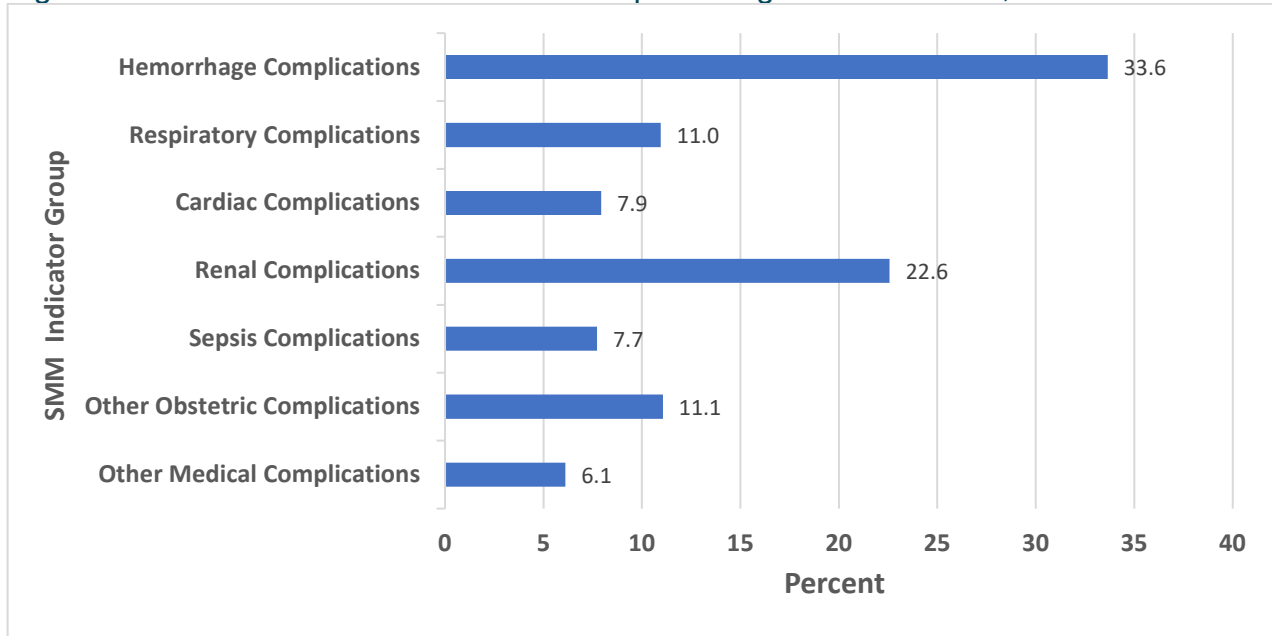
The number of SMM among in-hospital deliveries increased each year from 2016 to 2022, while the total number of in-hospital deliveries in Pennsylvania decreased during the same period (Table 2). 2016 had the lowest reported number of cases (995, with an SMM rate of 75.2 per 10,000 delivery hospitalizations) in the state across the 2016–2022 time span; 2021 had the highest observed SMM count at 1,359 and an SMM rate of 110.0 per 10,000 delivery hospitalizations. From 2016 to 2022, there was a 7% average increase annually.

Table 2: Number and rate of SMM In-Hospital Deliveries by All Inpatient stays, 2016 to 2022

Year	SMM In Hospital Deliveries	Total in hospital deliveries	Rate per 10,000 delivery hospitalizations
2016	995	132320	75.2
2017	1006	130359	77.2
2018	1014	128428	79.0
2019	1121	126329	88.7
2020	1133	122433	92.5
2021	1359	123569	110.0
2022	1266	120366	105.2
Total	7894	883804	89.3

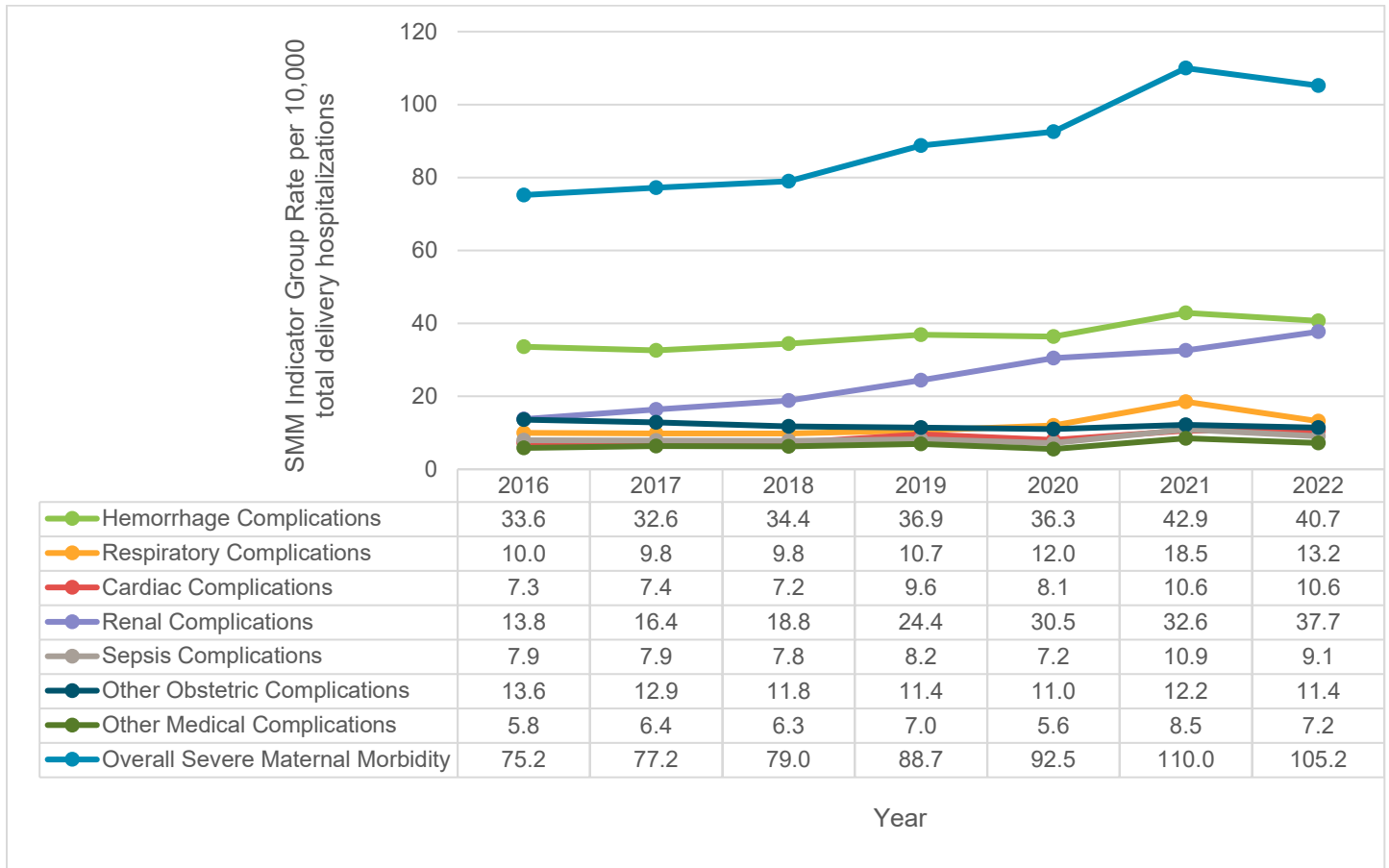
Among all SMM events from 2016 to 2022, Hemorrhage Complications had the highest prevalence among all SMM indicator groups (33.6%), followed by Renal Complications (22.6%; Figure 2). Other Medical Complications had the lowest prevalence (6.1%).

Figure 2: Distribution of SMM Indicator Groups among all SMM events, 2016-2022



When examining rates by year for each SMM indicator group, Hemorrhage Complications had the highest rate in 2022 (40.7 per 10,000 total delivery hospitalizations), while Other Medical Complications had the lowest rate (7.2 per 10,000 total delivery hospitalizations; Figure 3). Other than Renal Complications, which have continued to increase through 2022, the rates of all SMM indicator groups peaked in 2021.

Figure 3: Rates per 10,000 Total Delivery Hospitalizations of SMM Indicator Groups by Year, 2016-2022



Patient Characteristics

Table 3 summarizes the proportion and rates of SMM by the available patient characteristics, for which the rates are subsequently further explored by SMM indicator group. A comparison of the proportions of patient characteristics among all hospital births and births that experienced an SMM is in the Appendix.

Looking at the rates within the different patient characteristics:

- The highest rate of SMM was observed among women aged 35 years and older (131.6 per 10,000 delivery hospitalizations), while the lowest was among women age 20-29 years (76.1 per 10,000 delivery hospitalizations).
- Non-Hispanic Black women had the highest rate of SMM (150.2 per 10,000 delivery hospitalizations), while Non-Hispanic White women had the lowest rate (72.3 per 10,000 delivery hospitalizations)
- Regarding geographic area of residence, urban areas had a higher rate of SMM (92.0 per 10,000 delivery hospitalizations) compared to rural areas (80.9 per 10,000 delivery hospitalizations).
- For primary payer/health insurance type, women with Medicaid/Medicare coverage had the highest rates of SMM (108.9 per 10,000 delivery hospitalizations), and those with Other Public insurance had the lowest rates of SMM (75.1 per 10,000 delivery hospitalizations).
- Assessing mode of delivery and discharge status as additional patient characteristics associated with SMM, higher rates of SMM were among deliveries conducted by cesarean section (185.8 per 10,000 delivery hospitalizations) compared to vaginal deliveries. The majority of women who died in-hospital following a delivery also experienced an SMM event and had a higher rate of SMM than those who were discharged or transferred after delivery (9523.8 per 10,000 delivery hospitalizations).

Table 3: Characteristics of Women ages 12-55 years who experienced an SMM event, Pennsylvania, 2016-2022

Patient characteristics	Number of deliveries with any SMM	Percent of Deliveries with any SMM N=7894	Total delivery hospitalizations (% of total) N=883,804	Rate of any SMM per 10,000 total delivery hospitalizations	P-value
Age group (years)					
<20	503	6.4	59,255 (6.7)	84.9	<0.0001
20-24	1003	12.7	128,613 (14.6)	78.0	
25-29	1931	24.5	253,654 (28.7)	76.1	
30-34	2328	29.5	280,553 (31.7)	83.0	
35+	2129	27.0	161,729 (18.3)	131.6	
Race/Ethnicity					
Hispanic	823	10.4	79,316 (9.0)	103.8	<0.0001
Non-Hispanic American Indian/Alaska Native	22	0.3	2791 (0.3)	78.8	
Non-Hispanic Asian	288	3.7	28,376 (3.2)	101.5	
Non-Hispanic Black	1991	25.2	132,529 (15.0)	150.2	
Non-Hispanic Native Hawaiian or Pacific Islander	14	0.2	1277 (0.1)	109.6	
Non-Hispanic White	4225	53.5	584,439 (66.1)	72.3	
Other *	531	6.7	55,076 (6.2)	96.4	
Geographic area of Residence					
Rural	1712	21.7	211,609 (23.9)	80.9	<0.0001
Urban	6182	78.3	672,195 (76.1)	92.0	
Health Insurance **					
Medicaid/Medicare	3805	48.2	349,545 (39.6)	108.9	<0.0001
Other Public	1792	22.7	238,695 (27.0)	75.1	
Commercial Insurance	2155	27.3	279,551 (31.6)	77.1	
Uninsured	142	1.8	16,013 (1.8)	88.7	
Mode of Delivery					
Vaginal	2733	34.6	606,064 (68.6)	45.1	<0.0001
Cesarean Section	5161	65.4	277,740 (31.4)	185.8	
Discharge Status					
Discharged/Transferred	7854	99.5	883,762 (99.9)	88.9	<0.0001
Died in-hospital	40	0.5	42 (0.005)	9523.8	

*Other race/ethnicity includes individuals who had two or more races and unknown

**Health insurance status indicates the primary payer for the delivery as recorded on the hospital discharge form. Commercial insurance includes Blue Cross, commercial carriers, private health maintenance organizations (HMOs), and preferred provider organizations (PPOs); Other Public Insurance includes military insurance, Indian Health Service, and other federal, state, or local government payment sources; Uninsured includes self-pay and charity/indigent care.

SMM & Maternal Age

Among women aged 12-55 years old, the rate of SMM was highest among those aged 35 years and older (131.6 per 10,000 total delivery hospitalizations, Figure 4). The group with the second highest rate of SMM were women aged 19 years or younger (84.9 per 10,000 total delivery hospitalizations).

Figure 4: Rates of SMM by age group for women aged 12-55, 2016-2022

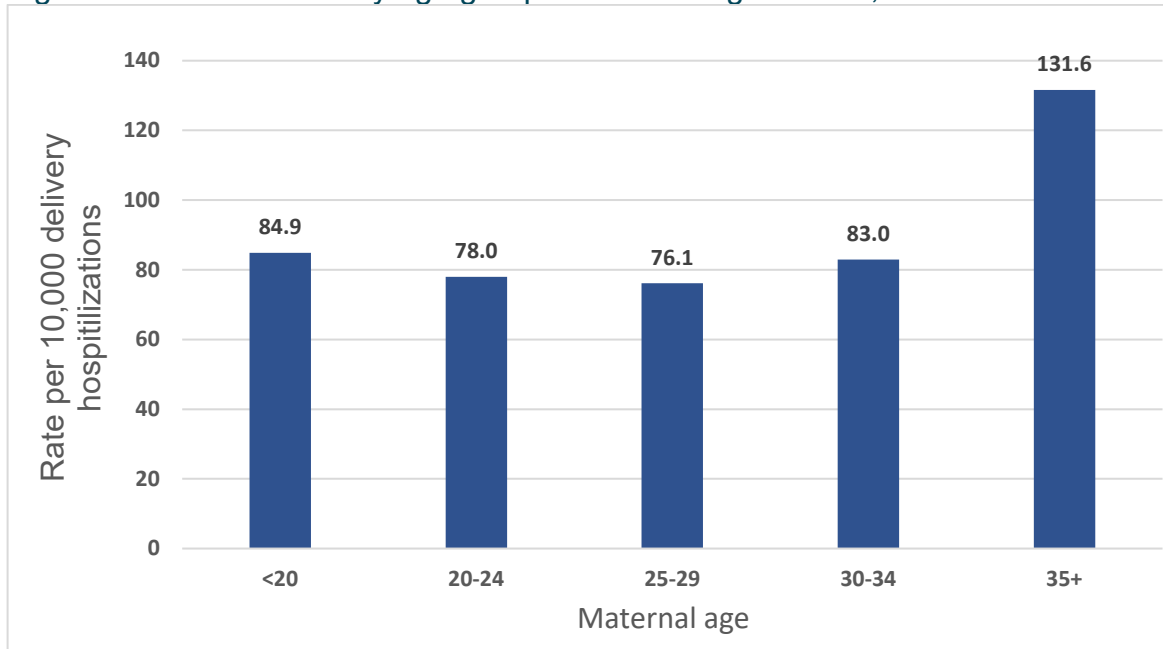


Figure 5 shows the distribution of each SMM indicator group by age category. Hemorrhage Complications comprised the largest prevalence of SMM among all age groups, and the proportion increased with increasing age groups, from 31% in the <20-year-old group to 47.2% in the 35+ age group. Conversely, Other Medical Complications comprised the highest proportion among the <20 age group (9.9%) and the proportion decreased with increasing age group (6% among 35+ year old). Sepsis and Other Obstetric Complications had a similar trend of decreasing with increasing age, while the prevalence of Cardiac Complications increased with age. Renal Complications comprised almost a third of SMM for each age group, and the proportion of Respiratory Complications ranged between 11.7% and 14% within all age groups.

Figure 5: Distribution of SMM indicator grouping within each age category, 2016-2022

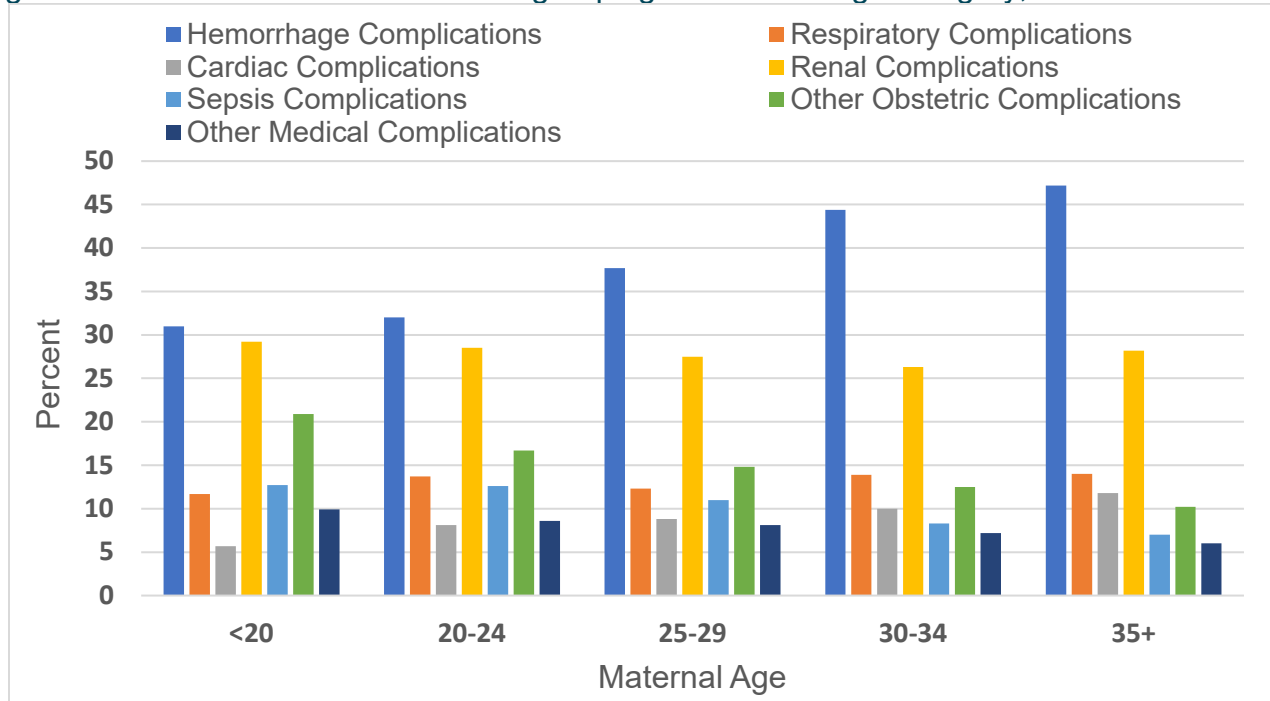
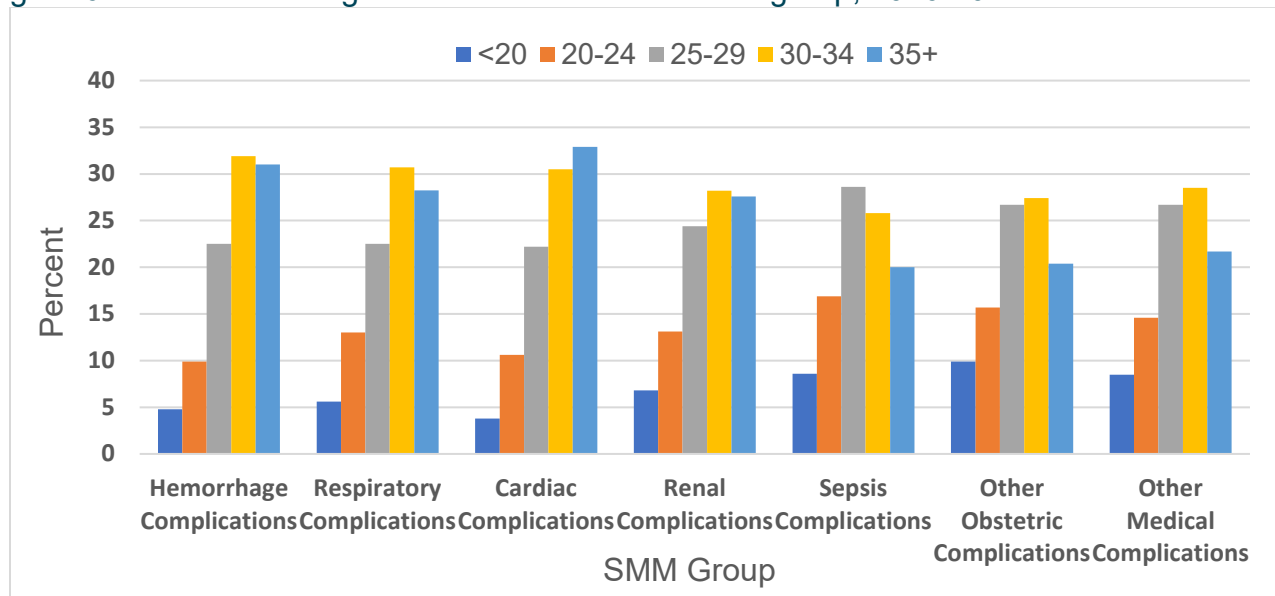


Figure 6 shows the distribution of maternal age within each SMM Indicator group. The 30-34 years age group comprised the largest proportion of cases in the Hemorrhage (31.9%), Respiratory (30.7%), Renal (28.2%), Other Obstetric (27.4%), and Other Medical Complications (28.5%). The largest age group comprising Cardiac Complications was 35+ year-olds (32.9%). The 25-29 years old age group comprised the largest proportion of Sepsis Complications (28.6%).

The difference between age groups within SMM Indicator Groups was statistically significant for Hemorrhage, Cardiac, Sepsis, Other Obstetric, and Other Medical Complications.

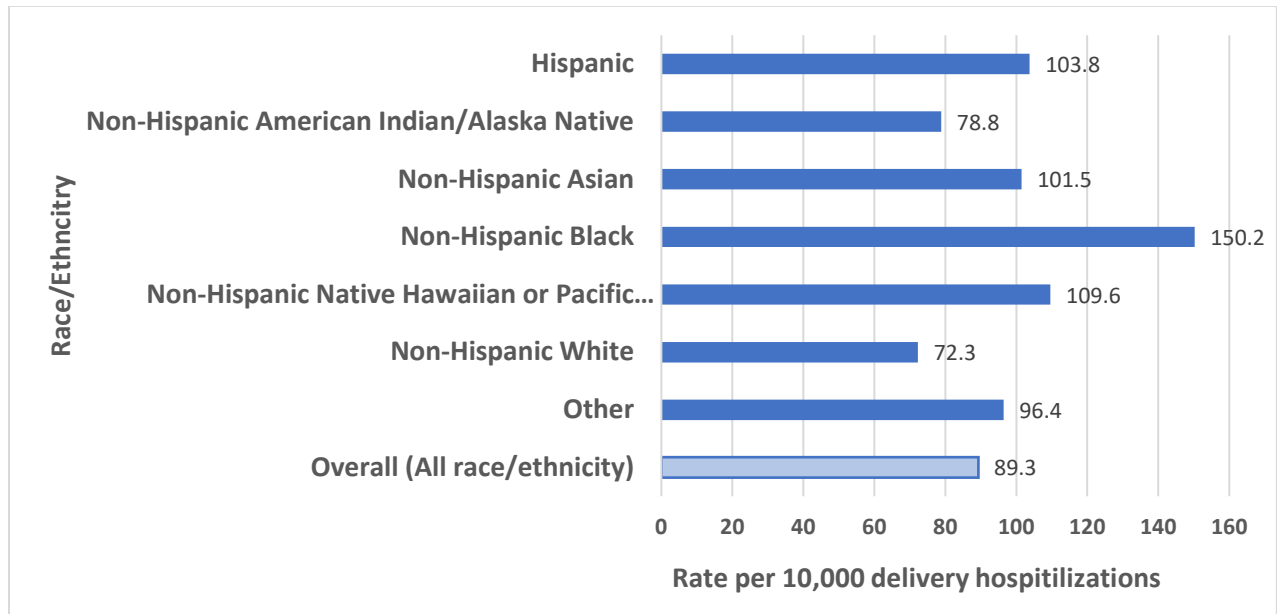
Figure 6: Distribution of age within each SMM Indicator group, 2016-2022



Severe Maternal Morbidity & Maternal Race/Ethnicity

When comparing 2016-2022 overall SMM rates by race and ethnicity, the highest rate was among non-Hispanic Black women at 150.2 per 10,000 delivery hospitalizations (Figure 7). Non-Hispanic Native Hawaiian or Pacific Islander women had the second highest rate (109.6 per 10,000 delivery hospitalizations), followed by Hispanic women (all races) (103.8 per 10,000 delivery hospitalizations). Next in order of overall SMM rate per 10,000 delivery hospitalizations were Non-Hispanic Asian (101.5), Other race (96.4), Non-Hispanic American Indian/Alaska Native women (78.8), and Non-Hispanic White women who had the lowest SMM rate (72.3 per 10,000 delivery hospitalizations).

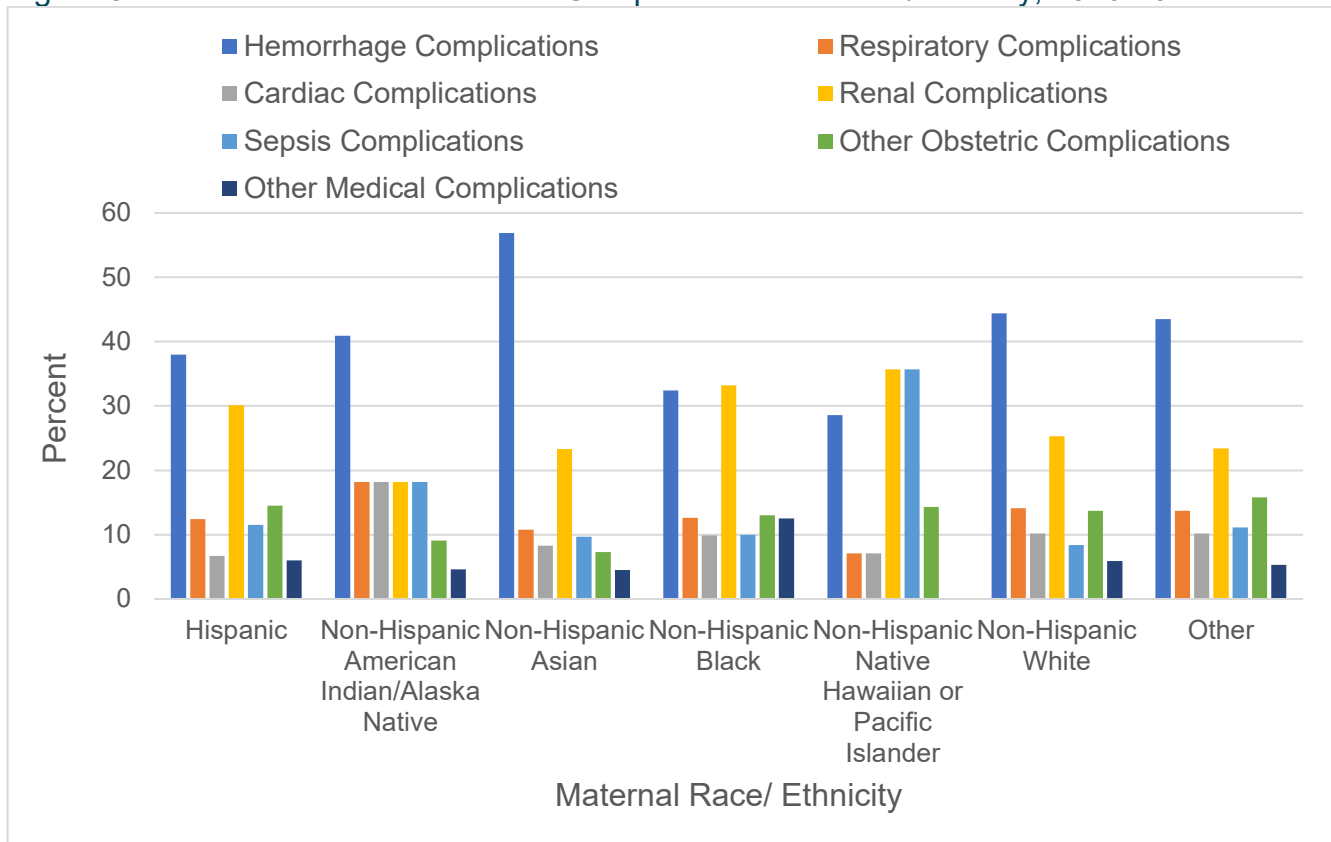
Figure 7: Rates of SMM among hospitalizations for women aged 12-55 by race and ethnicity, 2016-2022



Note: Racial and ethnic groups Non-Hispanic American Indian/Alaska Native and Native Hawaiian or Pacific Islander should be interpreted with caution due to low number of events

Looking at the distribution of the SMM Indicator groups by race/ethnicity (Figure 8), Hemorrhage Complications comprised the largest proportion of SMM for Hispanic women (38.0%), Non-Hispanic American Indian/Alaska Native (40.9%), Non-Hispanic Asian (56.9%), Non-Hispanic White (44.4%), and Other race (43.5%). Renal Complications comprised the largest proportion of SMM among non-Hispanic Black women (33.2%), followed closely by Hemorrhage Complications (32.4%). Non-Hispanic Native Hawaiian or Pacific Islander women had both Renal and Sepsis Complications as their leading SMM Indicator Groups (both at 35.7%).

Figure 8: Distribution of SMM Indicator Groups within each race/ethnicity, 2016-2022

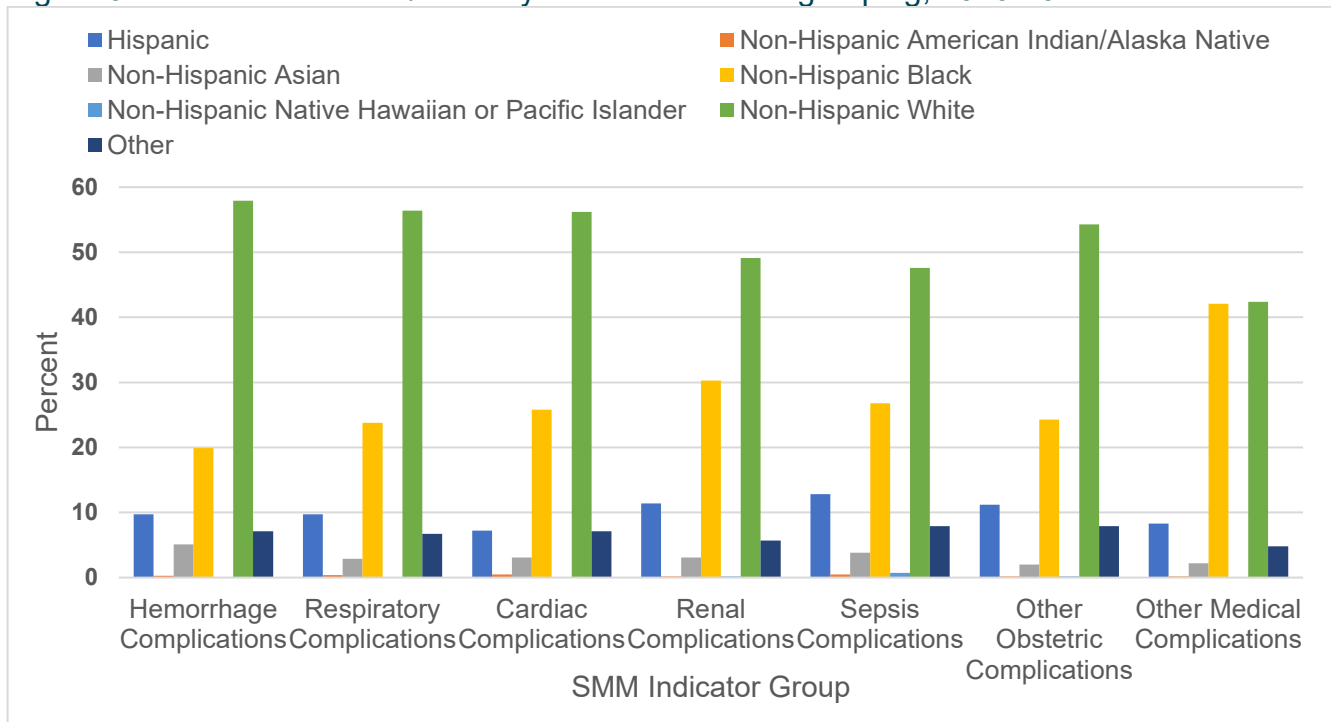


Note: Racial and ethnic groups Non-Hispanic American Indian/Alaska Native and Native Hawaiian or Pacific Islander should be interpreted with caution due to low number of events

Figure 9 shows the Race/Ethnicity proportions among each SMM Indicator group. Hemorrhage Complications is the group with the largest proportion of Non-Hispanic Asian (5.1%) and Non-Hispanic White (57.9%) women. Cardiac and Sepsis Complications both have the largest proportions of Non-Hispanic American Indian/Alaska Native (0.5%), and Sepsis Complications also has the largest proportion of Hispanic women (12.8%), Non-Hispanic Native Hawaiian or Pacific Islanders (0.7%) and women of Other race (7.9%). The indicator group with the largest proportion of Non-Hispanic Black women (30.3%) is Renal Complications.

The difference between race/ethnic groups within SMM Indicator Groups was statistically significant for all groups except for Respiratory and Cardiac Complications.

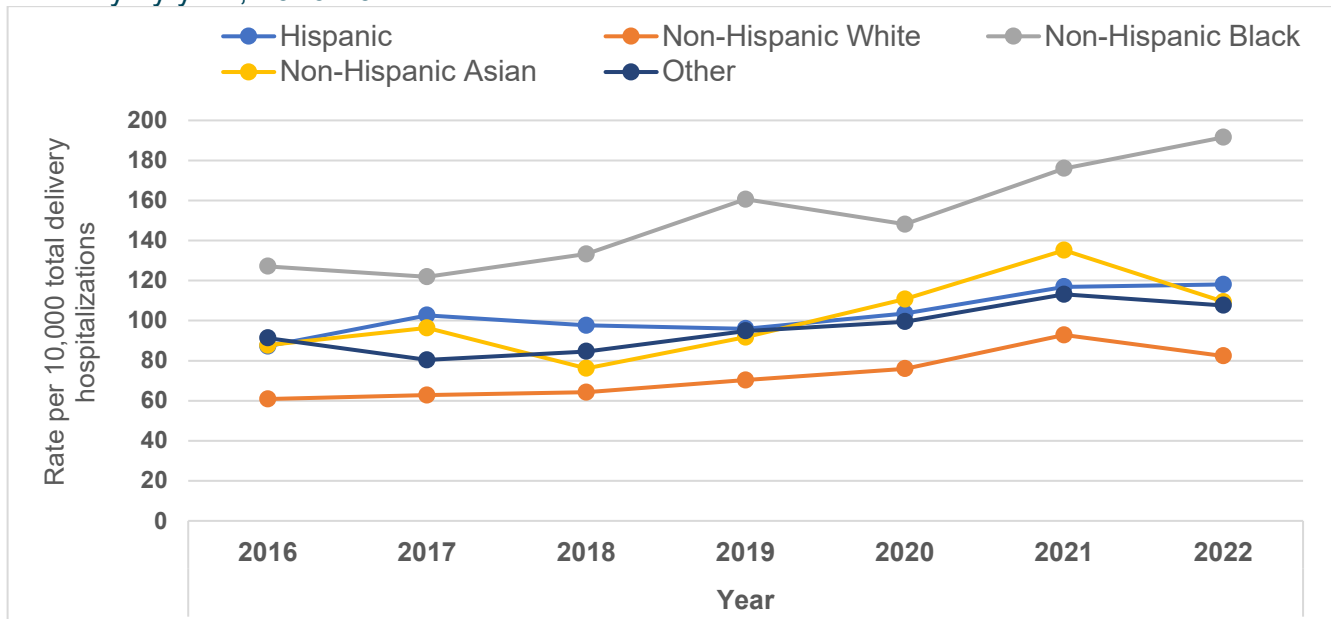
Figure 9: Distribution of race/ethnicity within each SMM grouping, 2016-2022



Note: Racial and ethnic groups Non-Hispanic American Indian/Alaska Native and Native Hawaiian or Pacific Islander should be interpreted with caution due to low number of events

Figure 10 and Table 4 provide insights into trends in the rate of overall SMM by race/ethnicity in Pennsylvania from 2016 to 2022. Within each year, there was a statistically significant difference between the SMM rates by race/ethnicity.

Figure 10: Rates of SMM among hospitalizations for women aged 12-55 in each race and ethnicity by year, 2016-2022



*Other: Racial and ethnic groups Non-Hispanic American Indian/Alaska Native and Native Hawaiian or Pacific Islander were combined with Other due to low number of events (≤ 7 /year)

Table 4 tabulates the rates of SMM for each race/ethnicity group by year. Rates are indicated per 10,000 delivery hospitalizations. The table also includes the average annual percent change. The SMM rates for Hispanic and Non-Hispanic Black women were the only rates that increased between 2021 and 2022 (116.9 to 118.1 per 10,000 delivery hospitalizations, and 176.0 to 191.5 per 10,000 delivery hospitalizations, respectively).

The overall trend in SMM across all race/ethnicity groups indicates an increase in rates across the seven-year time period. The increasing trend was statistically significant for all race/ethnicity groups. The race/ethnicities with the most prominent average annual percent increase were Non-Hispanic Black women (7.8% increase), Non-Hispanic White women (7.0% increase), and Non-Hispanic Asian women (6.5% increase).

Table 4: Rates of SMM among hospitalizations for women aged 12-55 in each race and ethnicity by year, 2016-2022

Race/Ethnicity	Year							Annual percentage change	P-value for trend
	2016	2017	2018	2019	2020	2021	2022		
Hispanic	87.3	102.6	97.6	95.9	103.6	116.9	118.1	4.5	0.013
Non-Hispanic Asian	87.7	96.3	76.2	91.7	110.7	135.1	109.5	6.5	0.033
Non-Hispanic Black	127.1	121.9	133.2	160.6	148.2	176.0	191.5	7.8	<.0001
Non-Hispanic White	60.9	62.8	64.2	70.3	75.9	92.8	82.4	7.0	<.0001
Other**	87.5	80.6	80.1	93.4	101.1	112.3	112.9	6.1	0.004

**Other race/ethnicity includes individuals who had two or more races, unknown, Non-Hispanic American Indian/Alaska Native, and Non-Hispanic Native Hawaiian or Pacific Islander

SMM & Geographic Area of Residence

County of residence at the time of hospitalization for each patient was categorized into urban or rural based on the definitions provided by The Center for Rural Pennsylvania.¹¹ When examining urban or rural geography based on the patient’s residential location, 78.3% of deliveries with an SMM occurred among women living in an urban county at the time of hospitalization, and 21.7% were among those living in rural counties. Of the total delivery hospitalizations in Pennsylvania from 2016-2022, 23.9% were among women living in rural counties and 76.1% among women living in urban counties.

Looking at the rates of the SMM Indicator groups by urban or rural areas of residence (Table 5):

- The SMM Indicator groups with the highest rates for those residing in both urban and rural areas were Hemorrhage, Renal, Respiratory, and Other Obstetric Complications.
- The rates for the Respiratory, Cardiac, and Other Obstetric Complications SMM Indicator groups were higher for those residing in rural areas than urban areas. However, these differences were not statistically significant.
- The rates for Renal, Sepsis, and Other Medical Complications were higher in urban areas than in rural areas (statistically significant).

As previously noted, it is possible for a patient to have multiple SMM indicators; thus, in the following tables, the sum of all indicators may be greater than the overall number of individuals who experienced at least one SMM.

Table 5: SMM Indicator Groupings and Rate by Geographic Area, 2016-2022

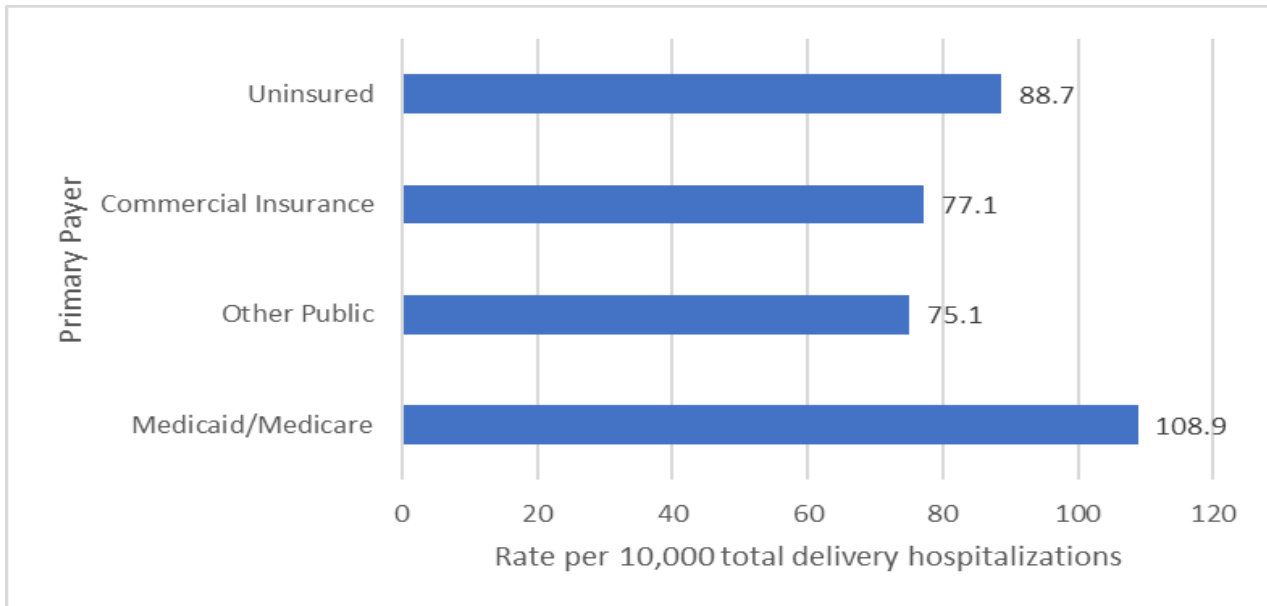
Severe Maternal Morbidity Indicator Group	Geographic Area				p-value
	Urban		Rural		
	N	Rate	N	Rate	
Overall	6182	92	1712	80.9	<.0001
Hemorrhage Complications	2510	37.3	733	34.6	0.073
Respiratory Complications	790	11.8	266	12.6	0.342
Cardiac Complications	564	8.4	200	9.5	0.148
Renal Complications	1763	26.2	413	19.5	<.0001
Sepsis Complications	593	8.8	151	7.1	0.020
Other Obstetric Complications	804	12.0	262	12.4	0.627
Other Medical Complications	483	7.2	106	5.0	0.001

Note: rate of SMM calculated per 10,000 delivery hospitalizations

SMM & Health Insurance

Rates of SMM were highest for women whose primary insurance was Medicaid/Medicare (108.9 per 10,000 total delivery hospitalizations, Figure 11). Rates were lowest for individuals with Other Public Insurance as the primary payer (75.1 per 10,000 total delivery hospitalizations). Other Public Insurance includes military insurance, Indian Health Service, and other federal, state, or local government payment sources.⁸

Figure 11: Rates of SMM among Hospitalizations for Women aged 12-55 by Health Insurance, 2016-2022



When examining the SMM Indicator groups by type of primary health insurance (Table 6):

- Hemorrhage Complication rates were the highest SMM Indicator group among all insurance types, but particularly among the Uninsured (49.3 per 10,000 total delivery hospitalizations)
- Other than Hemorrhage Complications, all other SMM Indicator groups had the highest rates among patients with Medicaid/Medicare as their primary payer.
- All differences in SMM Indicator group rates between health insurance types were statistically significant.

Table 6: SMM Indicator Groups and Rate by Health Insurance 2016-2022

SMM Indicator Group	Health Insurance								P-value
	Medicare/ Medicaid		Other Public		Commercial		Uninsured		
	N	Rate	N	Rate	N	Rate	N	Rate	
Hemorrhage Complications	1457	41.7	762	31.9	945	33.8	79	49.3	<.0001
Respiratory Complications	570	16.3	206	8.6	257	9.2	23	14.4	<.0001
Cardiac Complications	403	11.5	156	6.5	198	7.1	7	4.4^	<.0001
Renal Complications	993	28.4	528	22.1	630	22.5	25	15.6	<.0001
Sepsis Complications	431	12.3	137	5.7	163	5.8	13	8.1	<.0001
Other Obstetric Complications	563	16.1	236	9.9	250	8.9	17	10.6	<.0001
Other Medical Complications	331	9.5	123	5.2	127	4.5	8	5.0^	<.0001

Note: rate of SMM calculated per 10,000 hospitalizations

^ – Rates for <10 events may not be statistically reliable

**Commercial insurance includes Blue Cross, commercial carriers, private health maintenance organizations (HMOs), and preferred provider organizations (PPOs); Other Public Insurance includes military insurance, Indian Health Service, and other federal, state, or local government payment sources; Uninsured includes self-pay and charity/indigent care.

SMM & Mode of Delivery

In comparing the prevalence of SMM overall by mode of delivery, a larger proportion of cesarean section deliveries had an SMM event compared to vaginal deliveries (65.4% vs 34.6%).

The rates of all SMM Indicator groups were higher among cesarean section deliveries compared to vaginal deliveries (p-value for all <0.05). This is consistent with findings that the risk of SMM is increased among cesarean deliveries.⁵ The highest rate of SMM Indicator groups was Hemorrhage Complications among cesarean section deliveries at 76.7 per 10,000 delivery hospitalizations (Table 7).

Table 7: SMM Indicator Groups and Rate by Mode of Delivery, 2016-2022

SMM Indicator Group	Mode of Delivery				p-value
	Vaginal		Cesarean Section		
	N	Rate	N	Rate	
<i>Overall</i>	2733	45.1	5161	185.8	<.0001
Hemorrhage Complications	1114	18.4	2129	76.7	<.0001
Respiratory Complications	298	4.9	758	27.3	<.0001
Cardiac Complications	235	3.9	529	19.0	<.0001
Renal Complications	668	11.0	1508	54.3	<.0001
Sepsis Complications	306	5.0	438	15.8	<.0001
Other Obstetric Complications*	425	7.0	641	23.1	<.0001
Other Medical Complications	269	4.4	320	11.5	<.0001

Note: rate of SMM calculated per 10,000 delivery hospitalizations

SMM & Discharge Status

The majority of all women who delivered in Pennsylvania in the 2016-2022 period were discharged or transferred after delivery (99.5%). However, among the 42 women who died in-hospital after delivery, 40 (95%) experienced an SMM.

Figure 12 shows the annual proportion of in-hospital deaths after delivery from 2016 to 2022 among the 42 in-hospital deaths during this period. Compared to the proportion of SMM events from 2016 to 2022 (Figure 13), in-hospital deaths after delivery steadily increased from 2016 to 2019, while SMM remained relatively stable until 2019. Although the proportion of SMM increased from 2019 to 2021, there was a slight decrease from 2021 to 2022. Conversely, although the proportion of in-hospital deaths after delivery had decreased after 2019, there has been an increasing trend since 2020. These trends are also apparent when comparing the rates of in-hospital deaths per 10,000 total delivery hospitalizations to the SMM rate per 10,000 total delivery hospitalizations (Figure 14).

Figure 12: In-Hospital Deaths by Year, 2016-2022 (N=42)

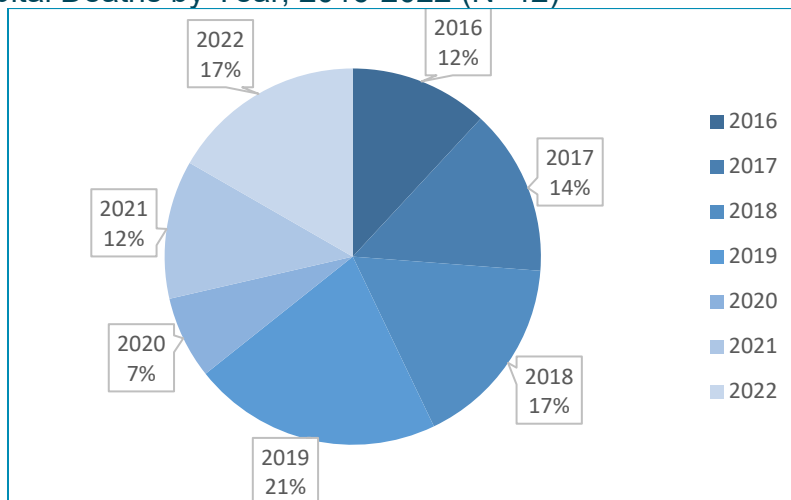


Figure 13: SMM by Year, 2016-2022 (N=7894)

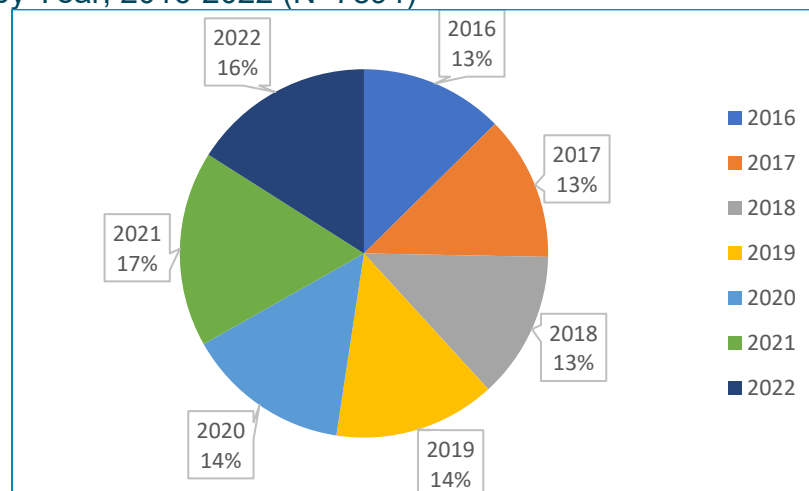
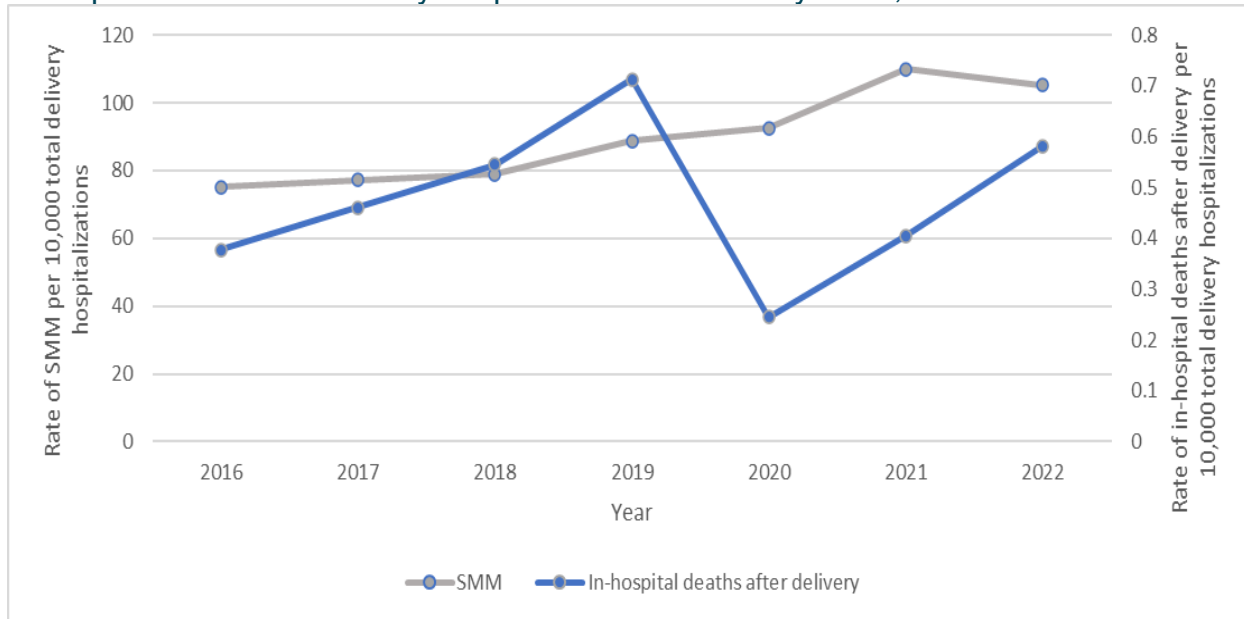


Figure 14. Annual rate of in-hospital deaths after delivery compared to the annual rate of SMM per 10,000 total delivery hospitalizations in Pennsylvania, 2016-2022



The SMM Indicator group that had the highest proportion of in-hospital deaths was Cardiac Complications at 3.93%, followed by Respiratory Complications at 2.75 (Table 8).

Table 8: In-Hospital Deaths among SMM Indicator Groups, 2016-2022

SMM Indicator Group	N	In-hospital Deaths with SMM	
		n	%
Overall	7894	40	0.51
Hemorrhage Complications	3243	27	0.83
Respiratory Complications	1056	29	2.75
Cardiac Complications	764	30	3.93
Renal Complications	2176	18	0.83
Sepsis Complications	744	8	1.08
Other Obstetric Complications	1066	17	1.59
Other Medical Complications	589	4	0.68

Note: rate of SMM calculated per 10,000 delivery hospitalizations; Rates calculated for n <10 may not be reliable

Hospital and Medical Characteristics

Table 9 shows the hospital and delivery characteristics provided by the medical facilities.

Hospital Type

The majority of SMM cases occurred at General Acute Care Hospitals (99.9%), which are the most common type of facilities that provide short-term inpatient medical care, as opposed to long-term care facilities (excluded for this analysis).

Hospital Region

The highest prevalence of SMM during this period was observed in PHC4 Region 9 (25.2%), while the lowest prevalence was in Region 3 (1.6%). The difference in SMM prevalence by hospital region was statistically significant ($p < .0001$). PHC4 Region 9 was designated as any hospital in Philadelphia (see Appendix for PHC4 region map).

Type of Visit

- Of all deliveries indicated as an emergency, meaning the patient required immediate medical intervention as a result of severe, life threatening, or potentially disabling conditions, 11.3% were SMM related.
- Of all deliveries indicated as urgent, meaning the patient required immediate attention for the care and treatment of a physical or mental disorder, 42.8% were SMM related.
- Of all deliveries indicated as elective, meaning the patient's condition permitted adequate time to schedule the services, 45.6% were SMM related.
- Of all deliveries indicated as trauma, meaning a visit to a trauma center/hospital as licensed or designated by the state or local government authority authorized to do so, or as verified by the American College of Surgeons and involving a trauma activation, 0.3% were SMM related.

Table 9: Hospital and Delivery Characteristics, Pennsylvania, 2016-2022

Hospital and Delivery Characteristics	Number of deliveries with any SMM	Deliveries with any SMM (%)	Rate of any SMM per 10,000 total delivery hospitalizations	p-value
Hospital Type				
Specialty General Acute Care Hospital	9	0.12	29.1	0.0026
Specialty Hospital	1	0.01	1428.5	
General Acute Care Hospital	7796	99.9	89.4	
Hospital Region*				
1	1389	17.8	88.0	<.0001
2	292	3.7	54.8	
3	125	1.6	47.8	
4	356	4.6	82.6	
5	1004	12.9	71.1	
6	321	4.1	59.7	
7	1139	14.6	123.5	
8	1217	15.6	64.8	
9	1963	25.2	164.2	
Priority (Type) of Visit				
Emergency	892	11.3	169.4	<.0001
Urgent	3379	42.8	110.9	
Elective	3598	45.6	68.5	
Trauma	22	0.3	1111.1	

*See Appendix of Map of Regions Designated by PHC4
 Rates calculated for n <10 may not be reliable

An analysis of the average length of stay and total cost for delivery hospitalizations from 2016 to 2022 indicated that the average length of stay for deliveries with an SMM was 6 days in the hospital, compared to 3 days for deliveries with no SMM (Table 10). The total charge for a delivery discharge with an SMM event was \$89,020.06. For deliveries with no SMM, the average total charge was \$24,541.77. Total charge is defined by PHC4 as the sum of room and board, ancillary, drug, equipment, specialty, and miscellaneous charges (does not include professional fees).

Table 10: Average Length of Stay and Total Cost for SMM Delivery Hospitalizations, 2016 to 2022

	Deliveries with no SMM	Deliveries with any SMM
Average Length of Stay	2.7 days	5.9 days
Average total charge for delivery discharge	\$24, 541.77	\$89,020.06

By health insurance type, the longest average length of stay and highest total charge was among Medicaid/Medicare recipients who experienced any SMM (6.4 days, \$96,857.04; Table 11). Uninsured Patients who did not experience an SMM had the shortest stay and lowest total charges (2.2 days, \$20,337.99).

Table 11: Average Length of Stay and Total Cost by Health Insurance and SMM, 2016 to 2022

Insurance Type	<i>All deliveries</i>		<i>Deliveries with no SMM</i>		<i>Deliveries with any SMM</i>	
	Average Length of Stay (days)	Total Charge	Average Length of Stay (days)	Total Charge	Average Length of Stay (days)	Total Charge
Medicaid /Medicare	2.7	\$ 26,708	2.7	\$ 25,317	6.4	\$ 96,857
Other Public	2.7	\$ 23,696	2.7	\$ 22,586	5.6	\$ 85,639
Commercial Insurance	2.7	\$ 24,636	2.7	\$ 23,514	5.5	\$ 78,475
Uninsured	2.3	\$ 21,658	2.2	\$ 20,338	4.6	\$ 81,720

Geographic Distribution of SMM in Pennsylvania, 2016-2022

The following figures and tables provide insights into trends in SMM among counties in Pennsylvania from 2016 to 2022, based on the patient county of residence at the time of hospitalization.

Figures 15 to 17 show the rates of SMM per 10,000 delivery hospitalizations within each Pennsylvania county overall from 2016 to 2022, in 2016 only, and in 2022 only, respectively. Counties with lower rates of SMM are indicated in a very light blue, and counties with higher rates are a dark blue. Using natural groupings of rates from high to low (Jenks Natural Breaks algorithm),¹² the maps allow for comparison of rates of SMM across counties for the specified period. Table 13 compares SMM rates across counties by year from 2016 to 2022.

Figure 15: Rates of SMM in PA per 10,000 Delivery Hospitalizations, 2016-2022

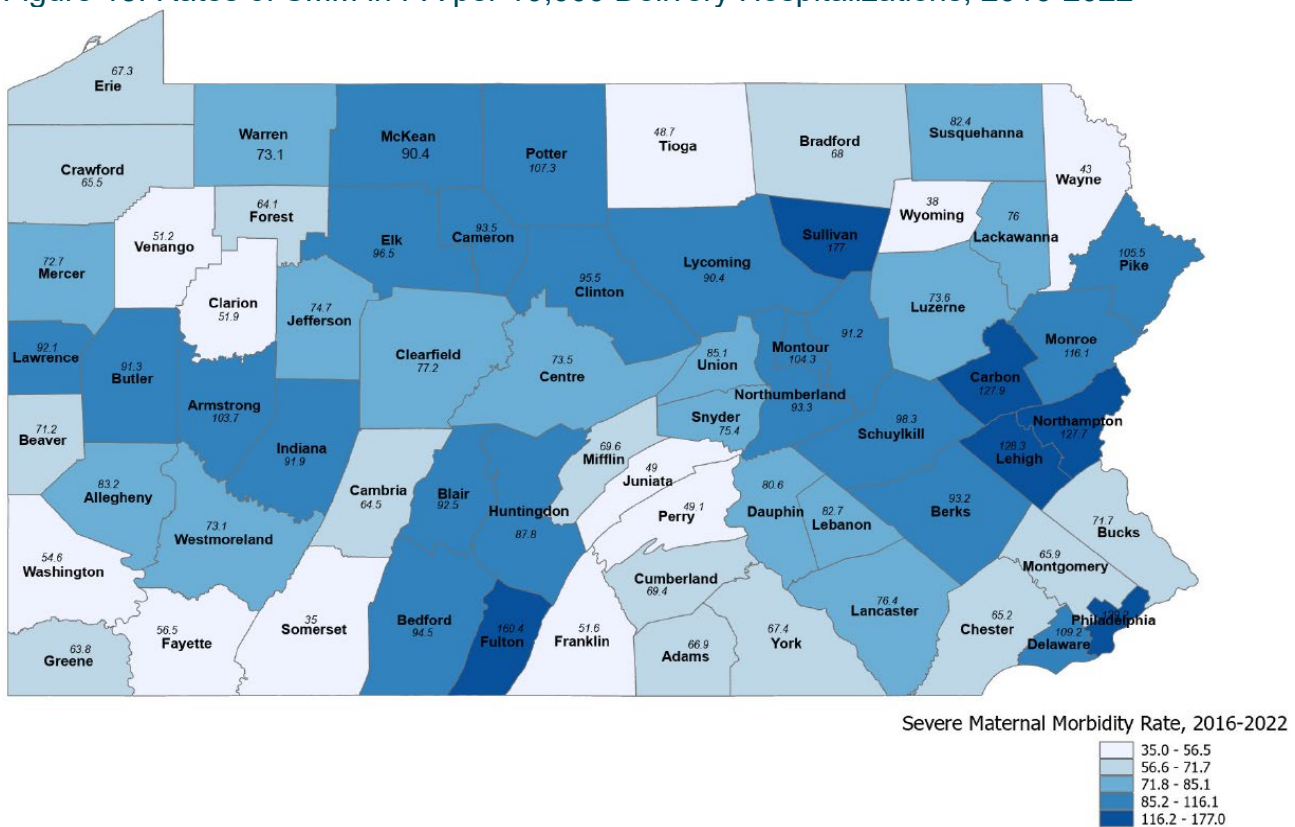


Table 12 shows the tabulated rates of SMM in each county in Pennsylvania based on patient county of residence at the time of hospitalization by year, direction of trend, and average annual percent change. Rates are indicated per 10,000 delivery hospitalizations.

The overall trend in SMM across all counties indicates variations in SMM rates across the seven years. Some counties had an increase over time, while others showed stable or decreasing patterns in SMM rates. Several counties had statistically significant trends in SMM rates over the seven years.

Counties with a statistically significant increasing trend in SMM rates were Allegheny, Armstrong, Blair, Bucks, Crawford, Fayette, Jefferson, Lancaster, Lehigh, Monroe, Montgomery, Philadelphia, Pike, Schuylkill, and Westmoreland.

Table 12: Rates of SMM per 10,000 delivery hospitalizations in each Pennsylvania county by year, 2016-2022

County Name	Year							Trend [^]	Average Annual Percent Change
	2016	2017	2018	2019	2020	2021	2022		
Adams	46.5	65.0	103.2	70.7	36.9	94.8	48.9	+	0.2
Allegheny	71.1	76.8	77.4	81.8	76.4	93.1	110.3	+	6.4*
Armstrong	50.4	61.2	62.3	127.4	131.6	105.8	191.6	+	23.0*
Beaver	80.3	60.7	66.2	80.5	34.4	72.2	106.8	+	2.9
Bedford	96.2	134.5	102.2	134.9	33.3	81.7	80.6	-	-7.9
Berks	108.2	80.8	96.9	74.9	92.5	109.9	89.2	-	-0.18
Blair	38.2	77.3	89.4	86.8	122.2	149.6	80.6	+	12.3*
Bradford	83.2	18.9	39.4	40.7	168.8	63.3	66.4	+	8.5
Bucks	48.2	53.4	46.2	84.3	82.1	86.0	105.0	+	14.6*
Butler	66.8	34.8	100.4	142.0	113.4	81.2	105.7	+	9.4
Cambria	59.4	56.2	66.5	88.9	76.7	69.6	34.2	-	-1.9
Cameron	0.0	250.0	294.1	0.0	0.0	0.0	0.0	-	-28.8
Carbon	121.8	126.9	101.7	163.9	93.3	200.0	86.3	+	1.1
Centre	35.3	103.9	57.7	70.6	61.9	99.4	88.9	+	8.2
Chester	61.1	50.8	74.2	65.5	69.4	59.5	76.0	+	3.1
Clarion	56.2	57.0	30.2	28.2	63.1	98.4	33.3	+	3
Clearfield	42.2	55.7	59.1	105.3	112.0	159.0	15.7	+	9
Clinton	150.6	99.7	0.0	161.3	99.0	66.9	90.4	-	-5.4
Columbia	48.3	91.2	105.4	34.7	72.1	168.1	118.6	+	14.5
Crawford	11.9	58.6	97.1	37.8	27.6	79.2	156.5	+	24.4*
Cumberland	70.4	77.0	41.2	76.5	77.6	72.7	69.7	+	1.3
Dauphin	78.9	77.7	56.3	73.9	88.8	93.2	96.9	+	5.3
Delaware	131.3	112.6	104.0	107.7	98.0	104.1	105.6	-	-3.2
Elk	98.4	223.0	76.9	70.4	161.3	38.5	0.0	-	-19.3
Erie	65.2	67.7	50.3	89.8	84.3	50.5	64.6	-	-0.1

Fayette	49.1	0.0	42.1	68.4	47.7	169.5	79.7	+	28.7*
Forest	0.0	0.0	270.3	0.0	0.0	204.1	0.0	+	12.8
Franklin	41.4	44.2	59.2	53.5	34.3	55.8	73.6	+	6.8
Fulton	163.9	41.8	298.5	185.2	238.1	142.9	39.2	-	-5.6
Greene	117.6	77.5	49.0	58.1	0.0	94.3	0.0	-	-24.2
Huntingdon	26.7	138.5	48.7	56.8	114.9	74.1	162.6	+	15.3
Indiana	96.0	60.0	101.3	74.1	60.1	142.9	112.5	+	6.5
Jefferson	0.0	65.9	66.4	65.8	91.3	145.6	93.9	+	25.7*
Juniata	98.0	51.0	46.1	0.0	87.3	49.8	0.0	-	-17.1
Lackawanna	76.9	107.6	64.5	79.8	60.3	68.5	73.4	-	-4.2
Lancaster	60.1	42.2	83.6	69.0	95.0	107.4	80.0	+	10*
Lawrence	69.4	66.6	128.1	36.8	145.3	78.3	124.7	+	8.3
Lebanon	81.2	87.7	56.7	95.1	63.2	102.9	91.2	+	2.9
Lehigh	92.8	126.8	91.7	106.2	129.2	203.2	156.9	+	11.3*
Luzerne	60.8	71.7	77.5	72.6	96.5	71.4	65.3	+	1.6
Lycoming	124.4	79.5	102.1	57.6	90.7	108.9	67.1	-	-4.9
Mc Kean	0.0	65.4	140.8	119.5	125.0	81.3	148.1	+	22.7
Mercer	37.1	70.5	67.8	86.1	85.2	106.5	60.0	+	9
Mifflin	25.4	48.5	23.4	77.3	112.7	108.1	104.7	+	26.5
Monroe	109.7	99.5	56.9	103.2	120.3	204.2	128.4	+	10.7*
Montgomery	47.4	41.8	68.7	60.3	70.6	88.4	84.9	+	12*
Montour	238.1	44.1	49.3	42.6	0.0	217.4	175.4	+	3
Northampton	128.6	111.8	103.2	115.5	180.5	128.1	126.7	+	3
Northumberland	115.1	80.6	48.0	92.7	86.1	148.5	81.6	+	2.9
Perry	20.9	88.7	0.0	105.9	23.8	25.2	73.0	+	4.4
Philadelphia	87.8	110.3	107.8	132.5	131.4	165.6	177.9	+	11.8*
Pike	0.0	65.8	32.91	104.5	121.5	261.4	152.9	+	41.2*
Potter	0.0	150.4	0.0	84.0	157.5	168.1	210.5	+	32
Schuylkill	29.9	78.2	89.1	75.7	105.8	167.7	157.5	+	23.9*
Snyder	29.2	82.9	29.9	96.5	177.9	124.2	0.0	+	7.3
Somerset	16.2	16.6	15.6	72.3	0.0	39.4	93.3	+	31.7
Sullivan	0.0	0.0	212.8	363.6	425.5	196.1	0.0	+	18.9
Susquehanna	71.9	35.6	136.5	78.1	0.0	142.9	105.3	+	8.1
Tioga	32.7	32.2	115.8	74.9	43.1	41.2	0.0	-	-8.3
Union	116.3	0.0	93.5	187.5	60.6	0.0	137.0	+	1.2
Venango	38.7	64.0	44.4	48.0	69.0	68.6	25.3	+	0.4
Warren	92.3	115.3	32.1	68.3	74.3	76.0	41.2	-	-9.4
Washington	54.9	56.5	48.8	41.3	38.2	83.6	58.7	+	3.7
Wayne	0.0	63.5	65.4	93.5	28.7	61.0	0.0	-	-2.8
Westmoreland	64.4	44.4	56.5	82.7	83.5	94.1	88.9	+	10.3*
Wyoming	85.5	0.0	0.0	0.0	0.0	135.1	49.0	+	17.3
York	75.4	64.1	52.1	52.4	59.7	91.6	75.5	+	3.3

[^]Trend = +, increasing trend; Trend = -, decreasing trend.; *p-value for trend < 0.05; Rates calculated for n <10 may not be reliable

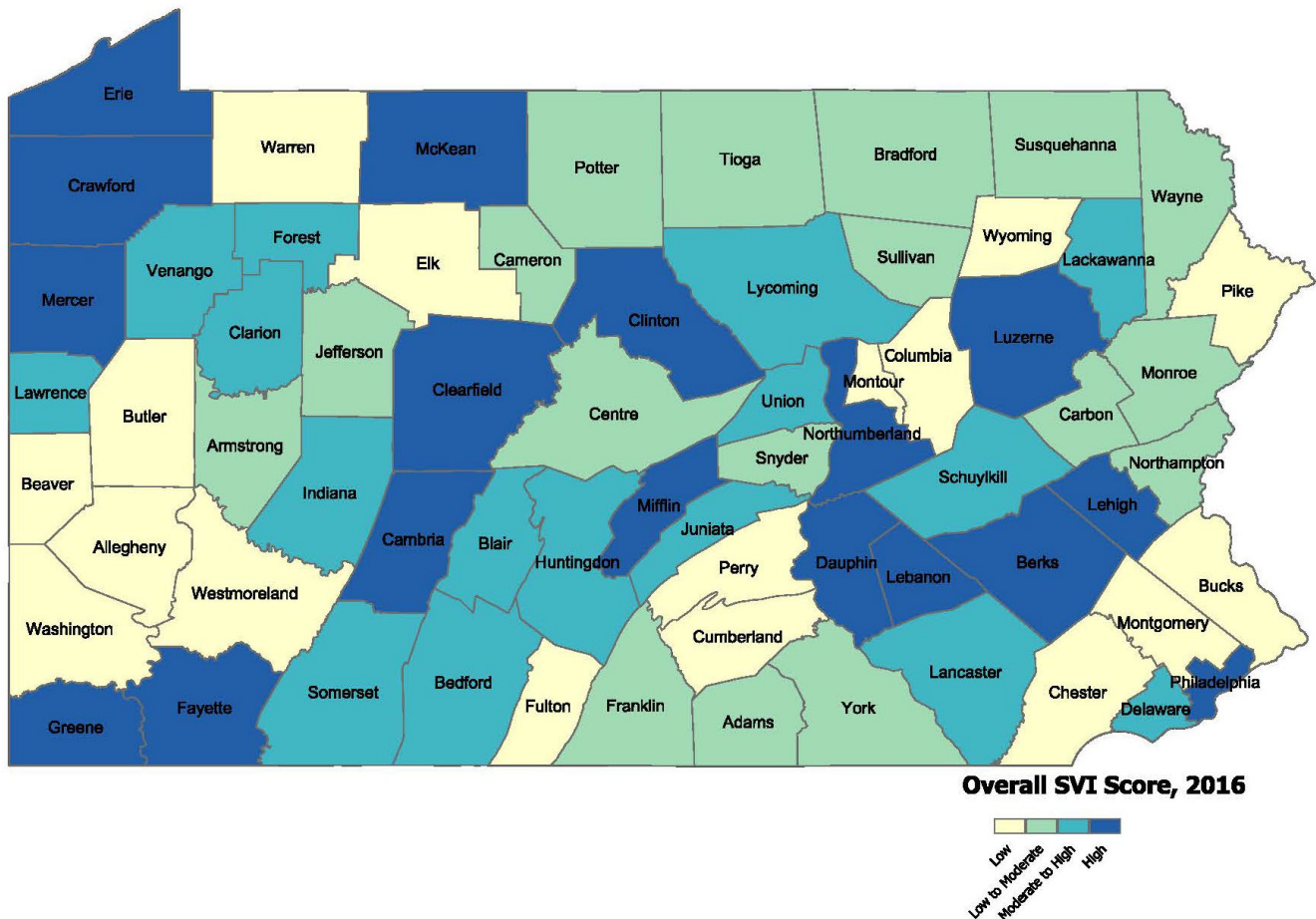
County Level Social Vulnerability & SMM

Figures 18 and 19 show the level of social vulnerability in Pennsylvania by county for 2016 and 2020, respectively. The SVI estimates are derived from the American Community Survey (ACS), 2016-2020 (5-year) data. Overall social vulnerability is measured by summing all four SVI themes (Socioeconomic, Household Composition & Disability, Minority Status & Language, and Housing Type & Transportation). The ranking is presented in quartiles. The lightest color indicates counties in the lowest quartile for overall SVI. The dark blue indicates counties in the highest quartile and are classified as the most socially vulnerable.

2016 Counties in the highest quartile of vulnerability ($\geq 75\%$)

- Berks, Cambria, Clearfield, Clinton, Crawford, Dauphin, Erie, Fayette, Greene, Lebanon, Lehigh, Luzerne, McKean, Mercer, Mifflin, Northumberland, and Philadelphia

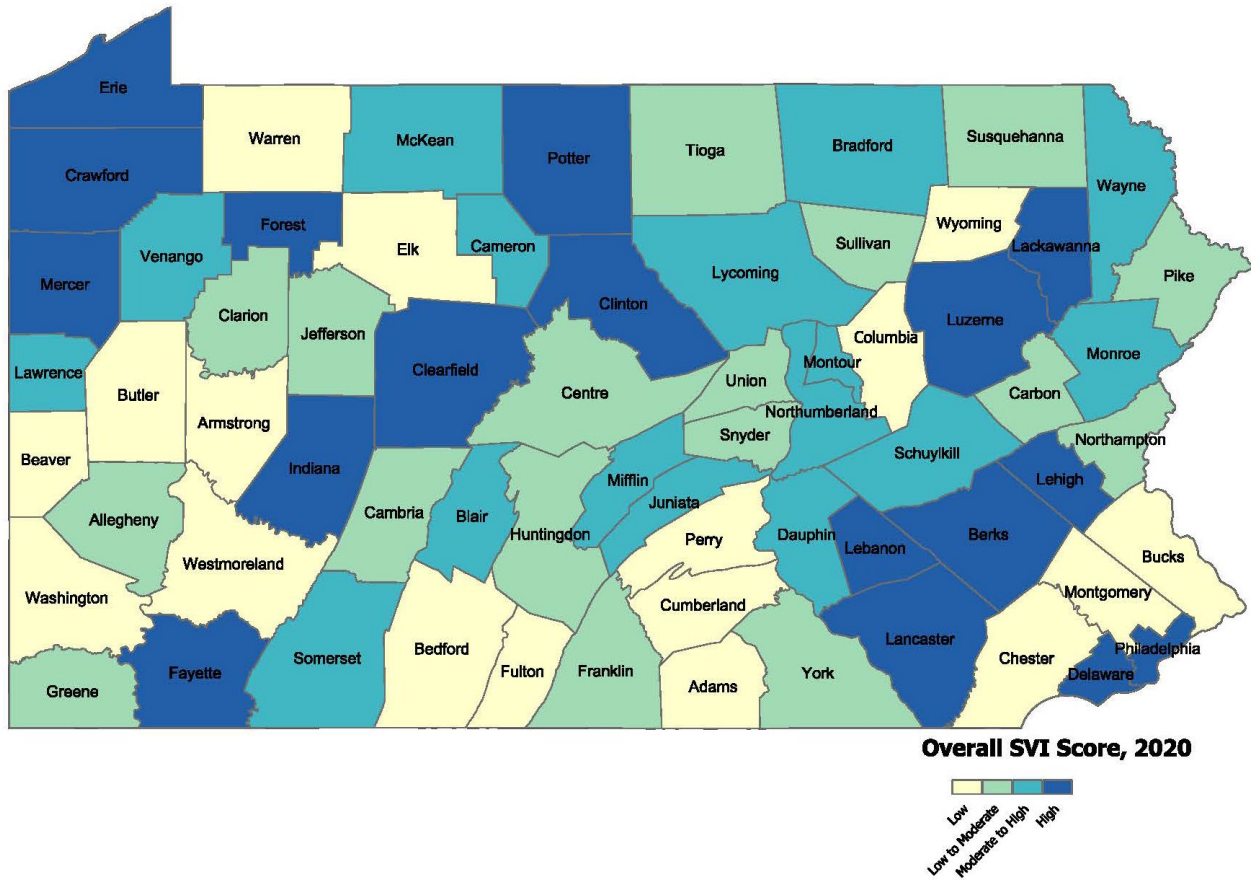
Figure 18: Overall Social Vulnerability Index Score for Pennsylvania in 2016



2020 Counties in the highest quartile of vulnerability (≥75%)

- Berks, Clearfield, Clinton, Crawford, Delaware, Erie, Fayette, Forest, Indiana, Lackawanna, Lancaster, Lebanon, Lehigh, Luzerne, Mercer, Philadelphia, and Potter

Figure 19: Overall Social Vulnerability Index Score for Pennsylvania in 2020

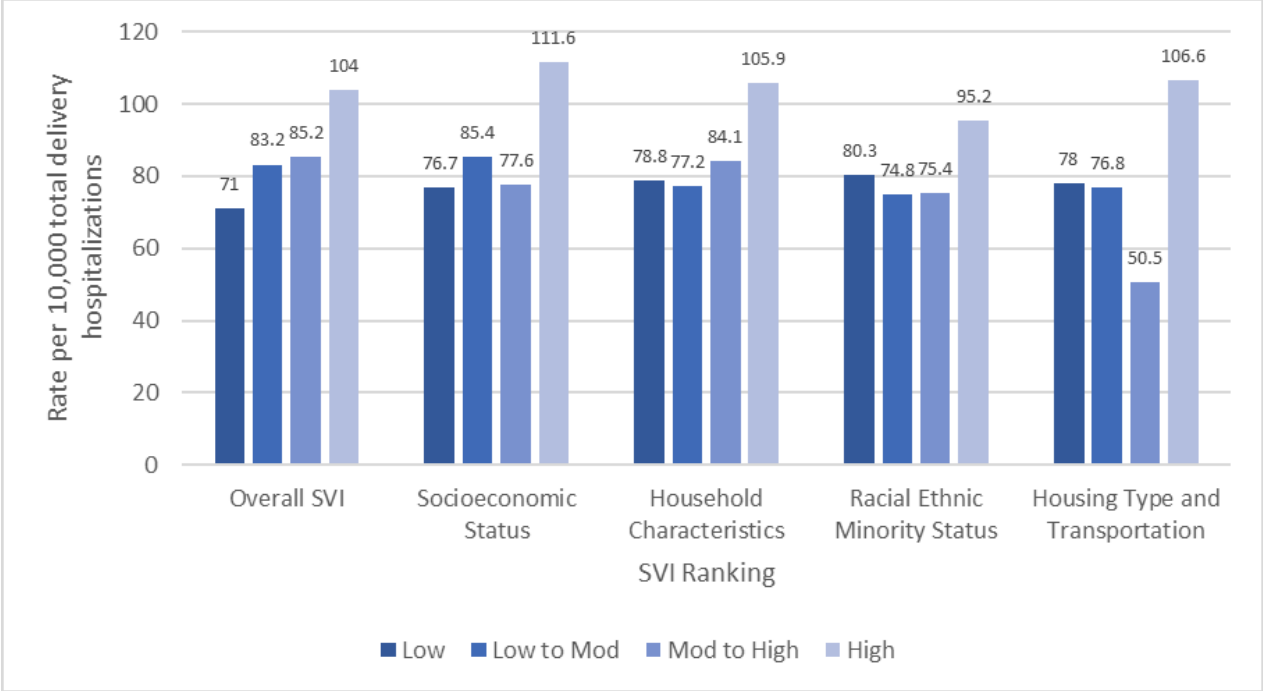


When examining the distribution of all SMM events from 2016 to 2020, 49.8% occurred in counties with a high overall social vulnerability ranking, compared to 20.5% of SMM in areas with low vulnerability.

Within each vulnerability component, the majority of SMM events were concentrated in areas ranked as having high vulnerability; the prevalence of SMM was highest in areas with High Overall Vulnerability (49.8%), High Vulnerability by Socioeconomic status (38.1%), High Vulnerability by Household Characteristics (43.1%), High Vulnerability by Racial/Ethnic Minority Status (73.1%), and High Vulnerability by Housing Type and Transportation (45.3%).

The rates of SMM from 2016 to 2020 within the SVI components were also highest among the areas with high vulnerability (Figure 20). The SVI component with the highest SMM rate is the measure of areas with high vulnerability by Socioeconomic Status at 111.6 per 10,000 delivery hospitalizations, followed by areas with high vulnerability in Housing Type and Transportation at 106.6 per 10,000 delivery hospitalizations.

Figure 20: Rates of SMM by County Level SVI Rankings, 2016-2020



Discussion

Over the seven-year period analyzed in this report, there was a meaningful increase in the rates of SMM within the Commonwealth of Pennsylvania. Continued monitoring of this trend is essential as Pennsylvania continues to mobilize efforts to decrease the burden of SMM.

When we examine the distribution of SMM in Pennsylvania, we see that the majority of all SMM events examined in this dataset were coded as Hemorrhage Complications. In terms of patient characteristics, pregnant women who experienced SMM are disproportionately older and of a racial and ethnic minority group. Although non-Hispanic White women represent a majority of the proportion of SMM events, the rate of SMM in Pennsylvania shows evident racial and ethnic disparities, with the highest rates among non-Hispanic Black women. Furthermore, most of those who experienced SMM events are Medicaid-insured and live in an urban county. Most of the SMM cases observed occurred in hospitals designated as general acute care. The hospital region with the highest SMM rate was Region 9, which only comprises Philadelphia County. Patient characteristics such as maternal age, race/ethnicity, residential area, health insurance status, and mode of delivery were all significantly associated with SMM in the state. The characteristics of SMM cases in Pennsylvania are consistent with studies that examine the individual risk factors associated with SMM.³⁻⁵ There was a higher prevalence of SMM in counties with a higher social vulnerability index ranking, particularly in counties with high vulnerability in socioeconomic status.

The findings of this report mirror those seen nationwide.¹³ It is important to acknowledge the implications of many other social determinants of health, and systemic, structural and institutional racism. A recent study found a significant association between the increasing incidence rates of kidney (renal) failure and residential segregation, specifically redlining.¹⁴ Furthermore, a cross-sectional study conducted in the neighboring state of New Jersey found an association between housing affordability and SMM. The study noted that, particularly among those with less than high school education, the likelihood of SMM increased as municipal housing rental costs also increased, and that this association was attenuated with greater availability of affordable housing units.⁶ Although there is a limited range of patient characteristics available for this analysis, the findings from this report can serve to motivate further exploration of the association between emerging indicators and policy level factors such as affordable housing.

The findings from this report show increasing trends in SMM in Pennsylvania, identifying an opportunity to evaluate current programs and policies. Notable differences in trends among the various race/ethnicity groups, counties, and regions during the seven-year period warrant further research and analysis to better understand the underlying factors contributing to these observed patterns. Further research could help inform public health efforts and policies to improve maternal health outcomes.

While this report provides a solid foundation for understanding SMM and the associated individual and regional level factors, several limitations should be considered when reviewing this report. The primary intended use of inpatient hospital billing and coding data is for reimbursement and therefore may have inaccuracies in patient sociodemographic characteristics and may introduce biases in coding related to variability across facilities.¹⁵ The

findings obtained in this analysis do not capture SMM occurrences outside of the discharge period. It has been noted that 14%-16% of SMM cases occur postpartum, within six weeks after hospital discharge.¹⁶ In addition, the effect of pre-existing conditions, comorbidities, or the diagnosis of more than one SMM indicator was not examined for this report. The indicators used were only primary indicators and only coded once. This report cannot be used to determine SMM rates when two complications occur at the same time (e.g., hemorrhage leading to acute renal failure). An opportunity to improve data quality lies in incorporating a qualitative analysis to capture data outside of the accessible timeframe in addition to expanding the social determinants of health examined in this analysis. Qualitative data in conjunction with quantitative data allows for meaningful intervention, especially for groups whose sample size may be small but are also impacted by SMM.

Conclusion

SMM is an important public health concern. SMM complications such as hemorrhage, acute renal failure, and sepsis, without intervention, can lead to a poor quality of life and mortality. With efforts already underway in Pennsylvania to address the increasing maternal mortality rates and decrease the inequities, a call to include SMM in state and local prevention efforts has started. The health of the Commonwealth of Pennsylvania rests in the health of its women, children, and families. A multilevel and equity centered approach involving people affected by SMM, government, stakeholders, clinicians, researchers, and others would likely yield the most success in reducing SMM. Specific recommendations include:

- Identify and evaluate programs that are that are having an impact in areas or populations in which trends are decreasing.
- Add more passive and active surveillance measures to enhance the data collection process.
 - Example: link PHC4 and birth certificate data to examine comorbidities
- Continue collaboration with the Pennsylvania Perinatal Quality Collaborative in hospital quality improvement.
- Develop or enhance programmatic interventions to address the short term and long-term impacts for those affected by SMM.
- Continue communication on SMM to Pennsylvania's Maternal Mortality Review Committee to further understand SMM impacts on maternal mortality rates.

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Appendix

Key variables from Pennsylvania Health Care Cost Containment Council Inpatient Data used in the assessment of Severe Maternal Mortality in PA

<i>PHC4 Variable/ Variable group</i>	<i>Description</i>
<i>Patient Data</i>	
<i>Patient Sex</i>	Gender
<i>Hispanic/Latino Origin or Descent</i>	Patient's ethnic descent as submitted by the facility - combined with Race
<i>Race</i>	Patient race as submitted by the facility - combined with Hispanic/Latino origin
<i>Patient Age in Years</i>	Age of patient
<i>Patient Home County</i>	PA county code (1 – 67) or Federal County Code
<i>Discharge data</i>	
<i>Patient Discharge Status</i>	The patient disposition or intended destination upon discharge as supplied by the facility.
<i>Length of Stay</i>	The number of days the patient stayed in the facility
<i>Payer identification</i>	
<i>Primary Payer</i>	The primary payer type as submitted by the facility.
<i>Facility Profile</i>	
<i>Facility Type</i>	Describes the type of facility.
<i>Facility ID</i>	
<i>Facility Region</i>	PHC4 assigned Region code (1 - 9)
<i>Admission data</i>	
<i>Priority (Type of Visit)</i>	Defines urgency level of admission: Emergency, Urgent, Elective, Trauma
<i>Summary Charges</i>	
<i>Total Charges</i>	Total charges excluding professional fees/charges

Severe Morbidity Indicators and Corresponding ICD-9-CM/ICD-10-CM/PCS Codes During Delivery Hospitalizations

The table below includes the list of 21 indicators and corresponding ICD codes used to identify delivery hospitalizations with SMM.

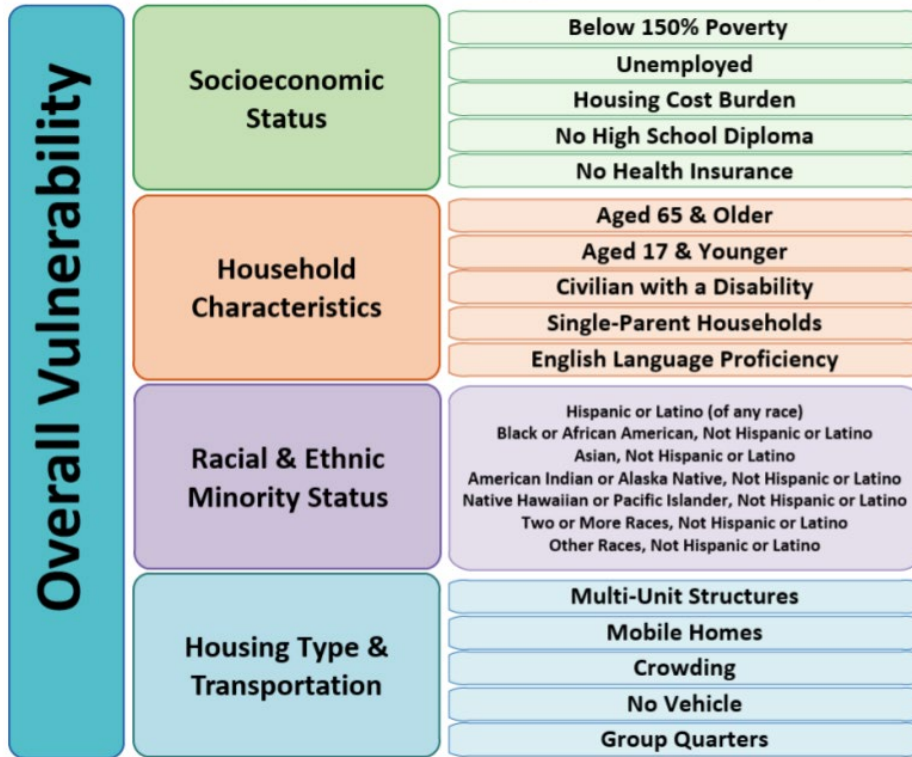
Severe Maternal Morbidity Indicator	Diagnosis (DX) or Procedure (PR) Code	ICD-9	ICD-10
Acute Myocardial Infarction	DX	410.xx	I21.xx, I22.x
Aneurysm	DX	441.xx	I71.xx, I79.0
Acute Renal Failure	DX	584.5, 584.6, 584.7, 584.8, 584.9, 669.3x	N17.x, O90.4
Acute Respiratory Distress Syndrome	DX	518.5x, 518.81, 518.82, 518.84, 799.1	J80, J95.1, J95.2, J95.3, J95.82x, J96.0x, J96.2x, J96.9x, R06.03, R09.2
Amniotic Fluid Embolism	DX	673.1x	O88.112, O88.113, O88.119, O88.12, O88.13
Cardiac Arrest / Ventricular Fibrillation	DX	427.41, 427.42, 427.5	I46.x, I49.0x
Conversion of Cardiac Rhythm	PR	99.6x	5A12012, 5A2204Z
Disseminated Intravascular Coagulation	DX	286.6, 286.9, 641.3x, 666.3x	D65, D68.8, D68.9, O45.002, O45.003, O45.009, O45.012, O45.013, O45.019, O45.022, O45.023, O45.029, O45.092, O45.093, O45.099, O46.002, O46.003, O46.009, O46.012, O46.013, O46.019, O46.022, O46.023, O46.029, O46.092, O46.093, O46.099, O67.0, O72.3
Blood Transfusion*	PR	99.0x	30230H0, 30230K0, 30230L0, 30230M0, 30230N0, 30230P0, 30230R0, 30230T0, 30230H1, 30230K1, 30230L1, 30230M1, 30230N1, 30230P1, 30230R1, 30230T1, 30233H0, 30233K0, 30233L0, 30233M0, 30233N0, 30233P0, 30233R0, 30233T0, 30233H1, 30233K1, 30233L1, 30233M1, 30233N1, 30233P1, 30233R1, 30233T1, 30240H0, 30240K0, 30240L0, 30240M0, 30240N0, 30240P0, 30240R0, 30240T0, 30240H1, 30240K1, 30240L1, 30240M1, 30240N1, 30240P1, 30240R1, 30240T1, 30243H0, 30243K0, 30243L0, 30243M0, 30243N0, 30243P0, 30243R0, 30243T0, 30243H1, 30243K1, 30243L1, 30243M1, 30243N1, 30243P1, 30243R1, 30243T1
Eclampsia	DX	642.6x	O15. X
Heart Failure / Arrest During Surgery or Procedure	DX	997.1	I97.120, I97.121, I97.130, I97.131, I97.710, I97.711
Puerperal Cerebrovascular Disorders	DX	046.3, 348.39, 362.34, 430.xx, 431.xx, 432.xx, 433.xx, 434.xx, 435.xx, 436.xx, 437.xx, 671.5x, 674.0x, 997.02	A81.2, G45.x, G46.x, G93.49, H34.0x, I60.xx, I61.xx, I62.xx, I63.00, I63.01x, I63.1xx, I63.2xx, I63.3xx, I63.4xx, I63.5xx, I63.6, I63.8x, I63.9, I65.xx, I66.xx, I67.xx, I68.xx, O22.50, O22.52, O22.53, I97.810, I97.811, I97.820, I97.821, O87.3
Pulmonary Edema / Acute Heart Failure	DX	428.0, 428.1, 428.20, 428.21, 428.23, 428.30, 428.31, 428.33,	I50.1, I50.20, I50.21, I50.23, I50.30, I50.31, I50.33, I50.40, I50.41, I50.43,

		428.40, 428.41, 428.43, 428.9, 518.4	I50.810, I50.811, I50.813, I50.814, I50.82, I50.83, I50.84, I50.89, I50.9, J81.0
Severe Anesthesia Complications	DX	668.0x, 668.1x, 668.2x, 995.4, 995.86	O29.112-O29.119, O29.122-O29.129, O29.192-O29.199, O29.212-O29.219, O29.292-O29.299, O74.0, O74.1, O74.2, O74.3, O89.0x, O89.1, O89.2, T88.2XXA, T88.3XXA
Sepsis	DX	038.xx, 449, 785.52, 995.91, 995.92, 998.02, 670.2x (after October 1, 2009)	A32.7, A40.x, A41.x, I76, O85, O86.04, R65.20, R65.21, T81.12XA, T81.44XA
Shock	DX	669.1x, 785.50, 785.51, 785.59, 995.0, 998.0*, 998.00, 998.01, 998.09 *998.0 is not a valid code but was used prior to 2012	O75.1, R57.x, T78.2XXA, T81.10XA, T81.11XA, T81.19XA, T88.6XXA
Sickle Cell Disease with Crisis	DX	282.42, 282.62, 282.64, 282.69, 289.52	D57.00, D57.01, D57.02, D57.211, D57.212, D57.219, D57.411, D57.412, D57.419, D57.811, D57.812, D57.819
Air and Thrombotic Embolism	DX	415.0, 415.1x, 673.0x, 673.2x, 673.3x, 673.8x	I26.x, O88.012-O88.03, O88.212-O88.23, O88.312-O88.33, O88.812-O88.83, T80.0XXA
Hysterectomy	PR	68.39, 68.49, 68.59, 68.69, 68.79, 68.9 (also include 68.3, 68.4, 68.5, 68.6, 68.7; non-specific codes used frequently)	OUT90ZL, OUT90ZZ, OUT97ZL, OUT97ZZ
Temporary Tracheostomy	PR	31.1	0B110F4, 0B113F4, 0B114F4
Ventilation	PR	96.70, 96.71, 96.72	5A1935Z, 5A1945Z, 5A1955Z

*Excluded but could be examined separately.

Source: <https://www.cdc.gov/reproductivehealth/maternalinfanthealth/smm/severe-morbidity-ICD.htm>

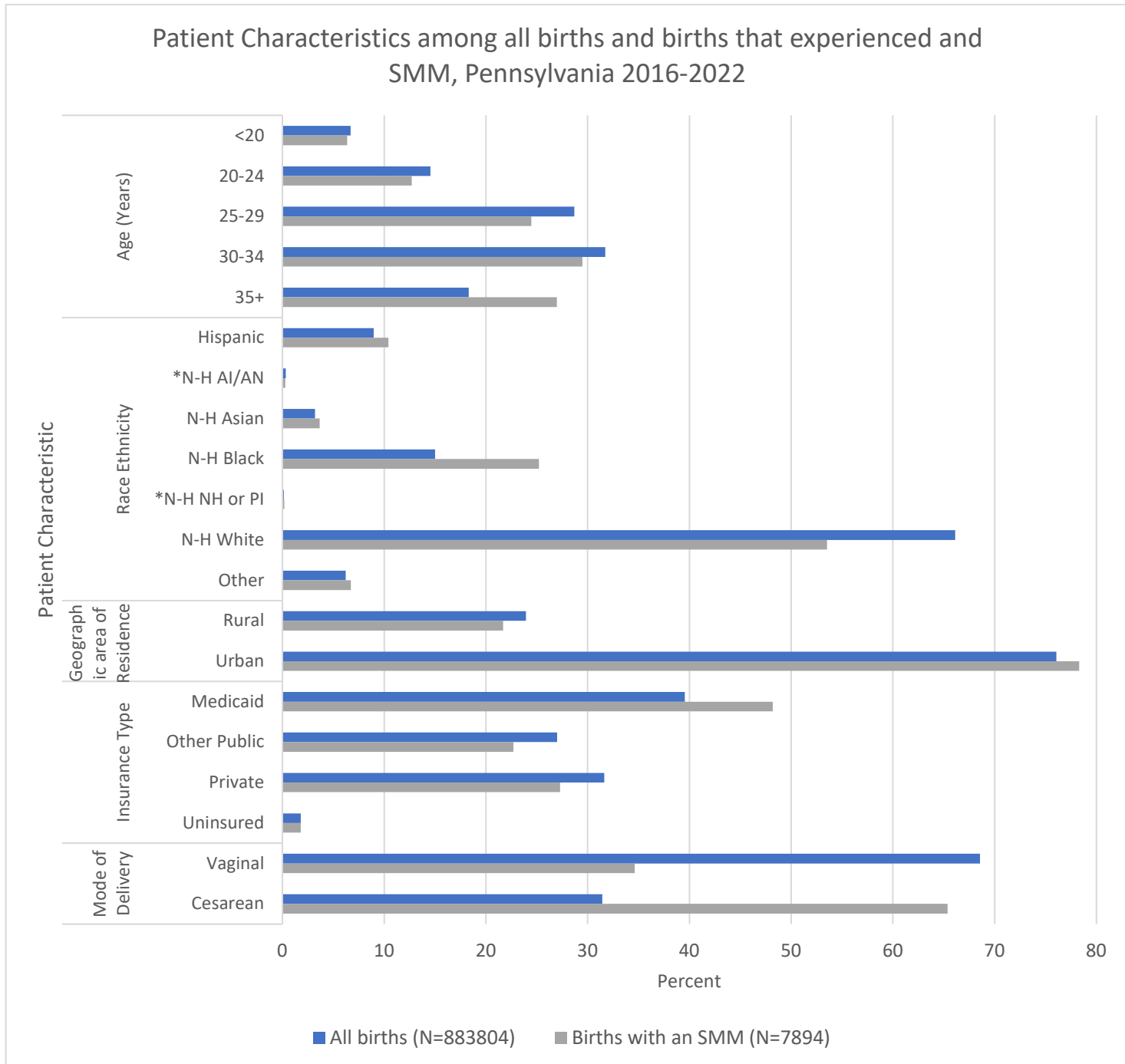
Social Vulnerability Index Components



Source:

https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2020.html

Comparing the proportion of patient characteristics among all births and births that experienced an SMM in Pennsylvania from 2016-2022



* N-H AI/AN: Non-Hispanic American Indian/Alaska Native; *N-H NH or PI: Non-Hispanic Native Hawaiian or Pacific Islander

PHC4 Hospital Region Map

