Recent Trends in Severe Maternal Morbidity (SMM) UPMC Harrisburg PA, 2016-2020

**Catherine Baye Easton[1]*,
Kendyl Schreiber[2],
Yijin Wert[1], Holly Thomas[1],
Brian Cohen[1],
Abigail Lukasik[1] and
Courtney Potteiger[1]**

1 Department of Obstetrics and Gynecology, UPMC Harrisburg PA, United States

2 Drexel University College of Medicine, Philadelphia PA, United States

*Corresponding author:
Catherine Baye Easton

✉ bayekate2@yahoo.com

Department of Obstetrics and Gynecology
UPMC, Harrisburg, PA, United States

Abstract

Objectives: This study describes the current burden, trends and identifies the leading causes of Severe Maternal Morbidity (SMM) at UPMC Harrisburg Hospital. Additionally, the study provides recommendations for high priority, system-wide areas of improvement to advance the provision of maternal care.

Methods: This retrospective, population-based study analyzed SMM indicators as delineated by CDC guidelines and identified corresponding obstetric diagnosis and procedure codes from electronic medical records. The study population includes women with pregnancy and/or delivery-related hospitalizations within 42 days after delivery. The data was categorized by SMM indicator, maternal age, race/ethnicity, delivery mode, BMI, and transfusion.

Results: From October 2016 to October 2020, 479 patients experienced at least one SMM indicator. Blood transfusions were the most common (80%), followed by sepsis (3%), and HELLP and/or eclampsia (3%). There was a statistically significant difference in average maternal age between SMM patients with and without transfusions (28.7 *vs.* 30.8, p=0.0073). The study suggests that a higher BMI (≥ 30) is associated to 50% of the non-transfusion related morbidities. However, delivery mode is not a contributing factor.

Conclusion: Additional efforts are needed in this sector of public health given the increasing trends in maternal morbidity. Providing point-of-contact identification is critical to preventing maternal morbidity by SMM and requires adaptations to the present medical care system. Establishing a dedicated EMR database as the preferred medical record system for reporting and tracking SMM cases can streamline the process and help identify trending issues. Modifications to the database to allow simpler reporting of SMM indicators and patient trend analysis would benefit maternal care. There are multiple opportunities at the hospital level for reform and advancement to reduce the increasing rate of SMM.

Keywords: Severe maternal morbidity; Maternal health; Blood transfusions; ICD-10 codes

Abbreviations: ACOG: American College of Obstetricians and Gynecologists, ARDS: Acute Respiratory Distress Syndrome, BMI: Body Mass Index, CDC: Centers for Disease Control and Prevention, D and C: Dilation and Curettage, EMR: Electronic Medical Records, HELLP: Hemolysis Elevated liver Enzymes and Low Platelet Count Syndrome, HTN: Hypertension, ICD: International Classification of Diseases, OASIS: Obstetric Anal Sphincter Injuries, PPH-Postpartum Hemorrhage, pRBCs: Packed Red Blood Cells, QBL: Quantitative Blood Loss, SIRS: Systemic Inflammatory Response Syndrome, SMFM: Society for Maternal-Fetal Medicine, SMM: Severe Maternal Morbidity, TXA: Tranexamic Acid, UPMC: University of Pittsburgh Medical Center, VBAC: Vaginal Birth after Cesarean Delivery

Introduction

Severe Maternal Morbidity (SMM) remains a continuing threat against maternal health in the United States. While defined as any condition or diagnosis that could indicate a potentially life-threatening maternal complication, SMM encompasses various conditions including but not limited to cardiomyopathy, hemorrhage, organ failure, pregnancy-induced hypertension, seizure, pulmonary embolism, amniotic fluid embolism, sepsis and uterine rupture. This also includes unexpected outcomes of labor and delivery that result in significant short and/or long-term consequences to a woman's health [1]. In the absence of prompt identification and treatment, these conditions can lead to maternal death [2,3].

A recent CDC report showed that SMM has been steadily increasing in recent years and affected more than 50,000 women in the United States in 2014 [4-6]. According to the CDC Pregnancy Mortality Surveillance System, pregnancy-related deaths per 100,000 births have steadily increased from 7.2 deaths in 1987 to 17.3 deaths in 2017 [7]. These numbers may be understated as there is still not a complete consensus on the defined conditions which are associated with SMM [1]. Additionally, there is not a standardized set of diagnostic codes to facilitate accurate SMM surveillance. It is difficult to precisely define the reasons for this drastic increase in pregnancy-related deaths. There are indications that should be considered; this includes more consistent identification and recording of these deaths as technology and hospital coding practices have improved [8].

With declining maternal mortality in high income countries, the concept of SMM has become more relevant in small geographic regions and is utilized as an indicator of the quality of maternal health [5,6,9]. The impact of SMM cannot be stressed enough as maternal morbidity is traumatic and affects the woman's physical and mental health, her family, and friends, as well as the overall community. For example, women who experience SMM may be at increased risk of post-traumatic stress disorder symptoms during the 6-8 weeks (about 2 months) after delivery [10].

Moreover, subsequent hospitalizations during the year after delivery are higher for women who experience SMM, even when those with preexisting chronic conditions are excluded [11]. Women with SMM may have an increased likelihood for emergency department visits up to 90 days after delivery [12]. For example, women with hypertensive disorders of pregnancy had higher hospitalization readmission rates for cardiovascular disease [13]. Healthcare systems are impacted by SMM as well. One study found that hospital cost in 2011-2012 for patients with SMM was 2.1 times higher than in patients without SMM [14]. Subsequent studies reported a doubling of costs associated with delivery in patients with SMM [15-17].

The concept of using SMM as a basis for quality and system-wide recommendations follows the sequence of events from a normal healthy pregnant population to pregnancy-related mortality as shown in **Figure 1** [18]. Improving the health of the pregnant population by identifying and acting upon the middle tier issues prevents the bottom tier which is death in the pregnant population.

Methods

Population

This study was conducted to analyze the trends and patterns in severe maternal morbidity in patients at UPMC Harrisburg Hospital during the four-year period of October 1, 2016, to October 1, 2020. The UPMC Harrisburg Hospital has an average of 4,900 deliveries each year of which approximately 30% are Cesarean deliveries, 70% are vaginal deliveries 9 including operative vaginal deliveries and VBAC. The subjects considered in the study were women with pregnancy and/or delivery-related hospitalizations including 42 days after delivery and identified as having experienced an SMM event using the CDC updated list of 21 indicators and the International Classification of Diseases (ICD-
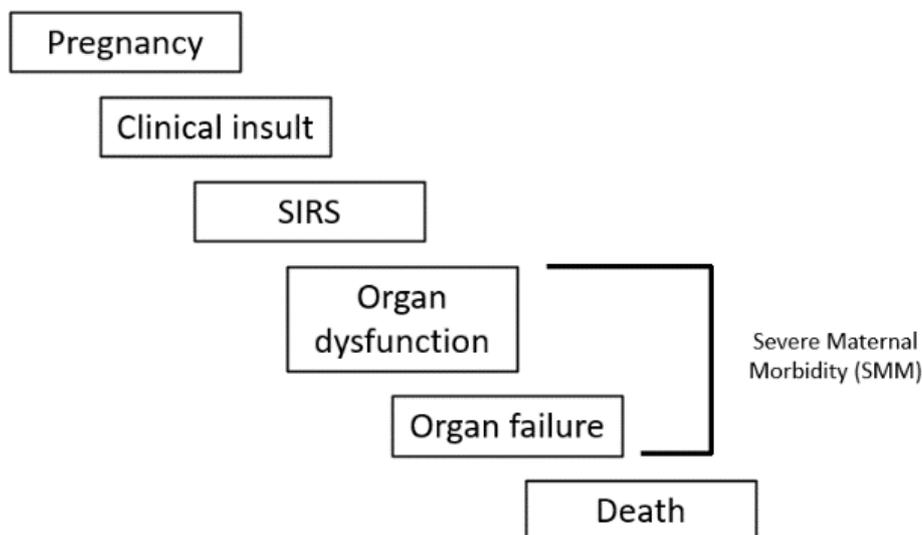
Figure 1 Diagram of the progression of events in pregnancy leading to SMM and death.

9 and ICD-10) diagnosis and procedure codes from administrative hospital discharge data **Table 1.** were used [19,20]. Due to the rare prevalence, some indicators (for example, issues pertaining to the vascular system) were grouped together. The unit of analysis was the identified SMM indicator, not the individual.

Data Sources

The study population's information was obtained from Electronic Medical Records (EMRs) acquired from the hospital's EPIC database (Epic Systems Corporation, Verona, WI). All data and records generated through the study were kept confidential and in alignment with UPMC institutional research policies. Furthermore, the study was reviewed and approved by the UPMC Institutional Review Board (IRB). It was conducted in accordance with UPMC human subjects' research requirements as well as applicable federal regulations. As this was a retrospective analysis of health records. No contact occurred with the women whose information was included in the study.

Analysis

The severe maternal morbidity rate was calculated as the number of women identified with an SMM indicator per 1,000 delivery hospitalizations. The leading SMM indicators were reported as a rate per 10,000 delivery hospitalizations. Demographic metrics for the descriptive analysis included age, race/ethnicity, Body Mass Index (BMI), and delivery mode (C-section or vaginal delivery). These data and distributions were then compared with the occurrence of SMM with and without blood transfusions. Chi-square tests were used to detect statistical significance for the categorical variables and a student t-test was used for the continuous variable. A p-value of less than 0.05 was considered for statistical significance. All the analyses were performed using in SAS® software, version 9.4 (SAS Institute, Cary, NC).

Results

From October 1, 2016, to September 30, 2020, a total of 479 SMM cases were reported at UPMC Harrisburg Hospital. The distribution of identified SMM indicators is tabulated in **Table 2.** Blood transfusions were the most common indicator of SMM and contributed to 80% (n=382) of all SMM cases, followed by sepsis 3% (n=12) and hemolysis, elevated liver enzymes, and low platelet count syndrome (HELLP) and/or eclampsia 3% (n=15).

HELLP: Hemolysis Elevated Liver Enzymes, and Low Platelet Count Syndrome, ARDS: Acute Respiratory Distress Syndrome.

When assessed per 10,000 delivery hospitalizations, rate for blood transfusions dramatically outnumbered other indicators at 183.4 patients followed by rates for sepsis and HELLP and/or eclampsia at 7.7 and 7.2 patients, respectively **Figure 2.**

Figure 2: Leading SMM indicators depicted as rate per 10,000 delivery hospitalizations 2016 to 2020.

The overall rate of SMM decreased by 39.4% over the study period, with rates decreasing from 33.3 in 2016 to 20.2 in 2020. This decrease has been driven primarily by the overall rate of blood transfusions decrease from 30.1 to 16.5. Excluding blood transfusions as a factor, the rate of SMM increased over time, from 3.1 to 3.6 **Figure 3.**

The occurrence of SMM was categorized by maternal age. Most patients (60%) were between 25 and 34 years old **Figure 4.** There was a statistically significant difference in average age between SMM patients with blood transfusions and SMM patients without transfusions (28.7 *vs.* 30.8, p=0.0073) **Table 3.**

Taking blood transfusions into account as an SMM indicator, there was a statistically significant difference between SMM patients with blood transfusions and SMM patients without transfusions **Table 3.**

The impact of maternal race and ethnicity on severe maternal morbidity was examined. Of note was 53.4% of SMM patients identified as white or Caucasian **Figure 5.**

In 57% of SMM cases, patients delivered *via* cesarean section. There was no statistically significant difference (p-value= 0.1345) in delivery modes between SMM with and without blood transfusions (**Table 4**). **Table 5** further details the SMM indicators based on delivery mode.

Table 1: Indicators of severe maternal morbidity.

CDC Indicators of Severe Maternal Morbidity	
Acute myocardial infarction	Pulmonary edema/acute heart failure
Aneurysm	Severe anesthesia complications
Acute renal failure	Sepsis
Adult Respiratory distress syndrome	Shock
Amniotic fluid embolism	Sickle cell disease (trait) with crisis
Cardiac arrest/ventricular fibrillation	Air and thrombotic embolism
Dysrhythmia or Arrythmia	Blood products transfusion
Disseminated intravascular coagulation	Hysterectomy
Eclampsia	Temporary tracheostomy
Heart Failure/arrest during surgery or procedure	Ventilation
Puerperal cerebrovascular disorders	-

Table 2: Severe maternal morbidity case distribution 2016-2020.

SMM Category	Number of Cases	Percent of Cases
Blood transfusion	382	79.75%
Sepsis	12	3.34%
HELLP and/or eclampsia	15	3.13%
Cardiac complications	14	2.92%
Pulmonary embolism	8	1.67%
Hysterectomy	8	1.67%
Puerperal cerebrovascular disorders	7	1.46%
Aneurysm	7	1.46%
Acute pulmonary edema/ARDS	7	1.46%
Acute renal failure	6	1.25%
Shock	4	0.84%
Amniotic fluid embolism	2	0.42%
Anesthesia complication	2	0.42%
Sickle cell disease with crisis	1	0.21%
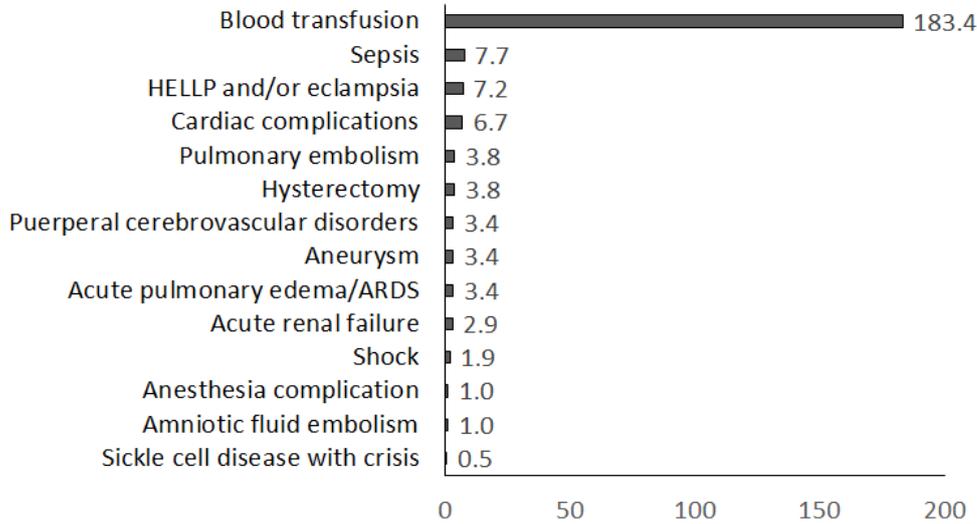
Figure 2 Leading SMM indicators depicted as rate per 10,000 delivery hospitalizations 2016 to 2020.
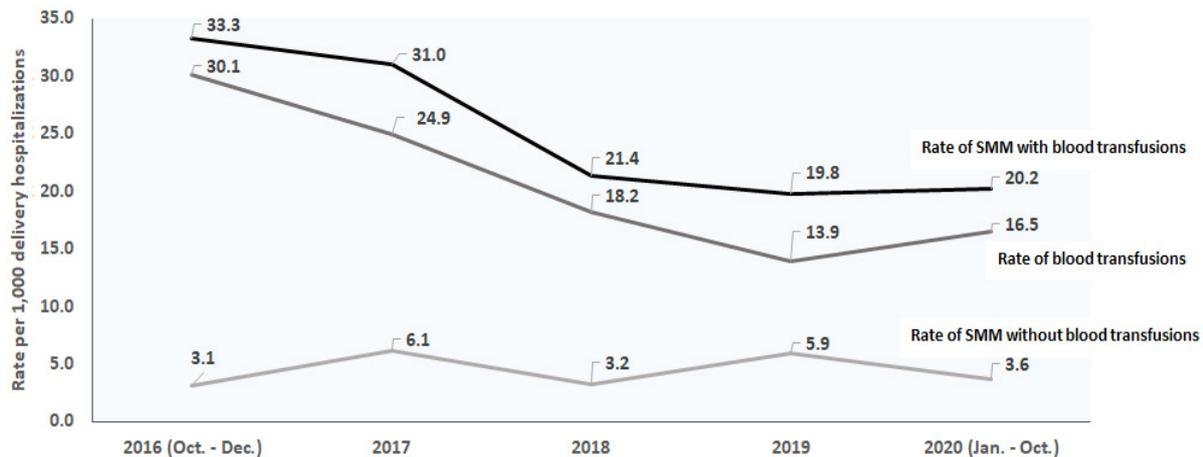
Figure 3 Rates of SMM including blood transfusions, SMM excluding blood transfusions, and blood transfusions alone in 2016-2020.

Examining the SMM case distribution by BMI category, the study suggested that a higher BMI (≥ 25) does contribute to 50% of the non-transfusion related morbidities **Table 6.**

Discussion

Taken together, the present study shows similar trends to those observed in other studies in the United States. However, these observations are likely only a limited proportion of the total burden of pregnancy, labor, and delivery complications faced by women. From October 1, 2016, to October 1, 2020, a total of 479 patients in this study suffered at least one of the indicators of SMM with the top three indicators of SMM being blood transfusion, sepsis, and HELLP and/or eclampsia. Specific measures can be recommended to reduce the number of women experiencing these concerns. Identified as the top SMM indicator, this study dissociated the rate of blood transfusions from the overall rate of SMM to show that while the overall rate of SMM decreased by almost 40% during the study period. This trend was primarily driven by the overall decrease of blood transfusions given; moreover, when the data for blood transfusions is separated out, it shows that total observations of SMM continue to increase. Thus, it remains important to understand the individual aspects of SMM so as not to obscure underlying trends.

This distribution supports the results found in a similar study by Assibey Menshah et al. wherein blood transfusions constituted 66% of all SMM cases as the most common indicator with a rate of 13.8 per 1,000 deliveries in Philadelphia Country [21]. CDC data notes that the top three indicators of SMM are blood transfusions,
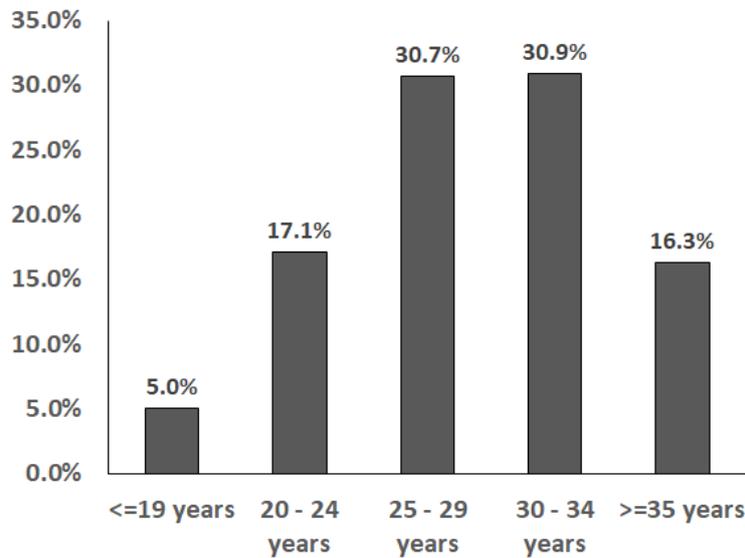
Figure 4 Occurrence of SMM by maternal age 2016-2020; n=479.

Table 3: Occurrence of SMM (including blood transfusions), SMM (excluding blood transfusions), and overall blood transfusions among maternal age categories.
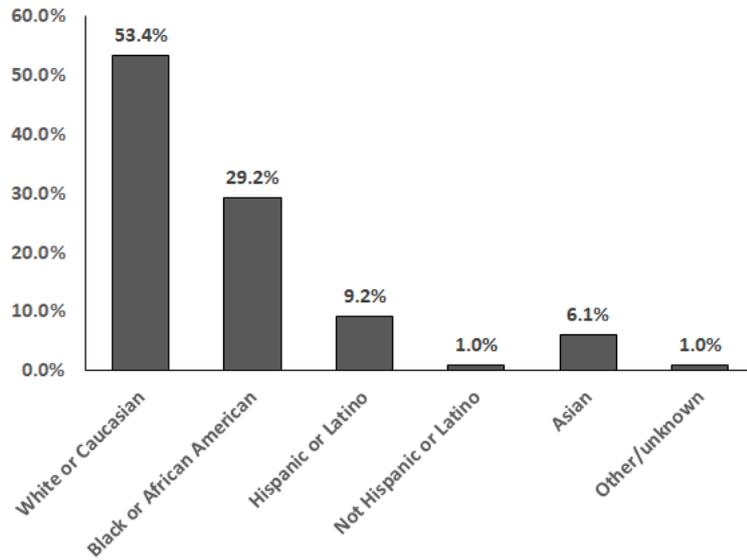
		SMM (including blood transfusions)		SMM (excluding blood transfusions)		Blood Transfusions		p-value
Total number of patients		479		97		382		**0.0011**
Age-Mean (SD), Range		29.1 (5.8)	13-45	30.8 (5.7)	17-44	28.7(5.8)	13-45	0.0073
Age Category	≤19 years	24	5.00%	5	5.20%	19	5.00%	
	20-24 years	82	17.10%	8	8.20%	74	19.40%	
	25-29 years	147	30.70%	23	23.70%	124	32.50%	
	30-34 years	148	30.90%	39	40.20%	109	28.50%	
	≥35 years	78	16.30%	22	22.70%	56	14.70%	

Table 4: Occurrence of SMM by delivery mode 2016-2020.

	SMM (including blood transfusions)		SMM (excluding blood transfusions)		Blood transfusions		p-value
Total number of patients	479		97		382		0.1345
C-section	274	57.20%	62	63.90%	212	55.50%	-
Vaginal delivery	205	42.80%	35	36.10%	170	44.50%	-

Table 5: Occurrence of identified SMM indicators by delivery mode.

SMM Category	C-section		Vaginal Delivery	
Total number of patients	274		205	
Acute pulmonary edema/ARDS	6	2.20%	1	0.50%
Acute renal failure	6	2.20%	0	0.00%
Amniotic fluid embolism	2	0.70%	0	0.00%
Anesthesia complication	1	0.40%	1	0.50%
Aneurysm	2	0.70%	5	2.40%
Cardiac complications	7	2.60%	7	3.40%
HELLP and/or eclampsia	12	4.40%	3	1.50%
Hysterectomy	7	2.60%	1	0.50%
Puerperal cerebrovascular disorders	3	1.10%	4	2.00%
Pulmonary embolism	4	1.50%	4	2.00%
Sepsis	7	2.60%	9	4.40%
Shock	4	1.50%	0	0.00%
Sickle cell disease with crisis	1	0.40%	0	0.00%
Blood transfusion	212	77.40%	270	82.90%

Figure 5 Occurrence of SMM by race/ethnicity 2016-2020; n=479.

Table 6: Occurrence of SMM categorized by BMI.

Total number of patients		SMM (including blood transfusions)		SMM (excluding blood transfusions)		Blood Transfusions		p-value
		479		97		382		0.375
BMI Category	<18.5 Underweight	16	3.30%	5	5.20%	11	2.90%	-
	18.5-24.9 Normal	111	23.20%	17	17.50%	94	24.60%	-
	25.0-29.9 Overweight	132	27.60%	26	26.80%	106	27.70%	-
	30.0-34.5 Obesity (Class I)	102	21.30%	20	20.60%	82	21.50%	-
	35.0-39.9 Obesity (ClassII)	70	14.60%	15	15.50%	55	14.40%	-
	>40 Obesity (Class III)	48	10.00%	14	14.40%	34	8.90%	-

cesarean hysterectomy, and temporary tracheostomy [22]. The CDC reported an overall SMM rate (including blood transfusions) of 14.4, an overall blood transfusion rate of 12.2, and an SMM rate (excluding blood transfusions) of 3.5 in 2014 using data acquired from the National (Nationwide) Inpatient Sample databases [23]. In a study of SMM in Massachusetts, Harvey et al used the Pregnancy to Early Life Longitudinal data system which links birth/fetal death records with hospital discharge records, at noted an average SMM rate of 9.9 per 1,000 deliveries between 2002 to 2011 [24]. Additionally, Assibey Menshah et al. noted a SMM rate of 22.7 per 1,000 deliveries in 2014 in Philadelphia Country [21].

Of the study population, most patients who experienced SMM were between 25 and 34 years old (61.6%). When assessing whether this majority was more susceptible to SMM, the data demonstrated that there was a statistically significant difference in women of this age range that cannot be attributed to blood transfusions alone.

On initial analysis, white or Caucasian women comprised 53.4% of the affected population, followed by black or African American women at 29.2%. However, given that 67% of our patient population are White or Caucasian and 21% are black or African American, our study does seem to align with other studies which have shown higher rates of SMM among non-Hispanic black

women when compared to Caucasian women [25,26]. Given the limited scope of this study, no definitive conclusions can be drawn from this data. Other studies have shown SMM to be more frequent among women who give birth by cesarean section, as cesarean delivery carries more risk of maternal complications [27]. In this study, after dissociating the data for blood transfusions alone, there was no conclusive evidence within this population to show that there was a difference between vaginal and cesarean delivery in terms of SMM. However, obesity is a contributing factor to non-blood transfusion related morbidities. In cases of pregnancy in women with a BMI ≥ 30.0, additional attention, and monitoring should be placed on their health vitals to detect SMM indicators early to mitigate preventable adverse outcomes. Including additional prenatal discussions addressing the risk factors of a higher BMI may further increase patient awareness of gestational weight gain.

The trends observed in blood transfusions could benefit from implementing revised patient blood management practices throughout pregnancy. Patient blood management which aims to improve patient outcome and safety by reducing the number of unnecessary Red Blood Cell (RBC) transfusions and vitalizing patient-specific anemia reserves. Certain areas that could benefit from additional medical supervision include optimizing pre-pregnancy hematocrit and hemoglobin levels and ensuring

adequate blood iron levels during pregnancy. Other studies have documented how pregnancy substantially decreases hemoglobin concentration, and routine blood screenings during pregnancy could be very beneficial to identifying issues prior to crisis [28]. As iron is an essential microelement in maternal health, iron supplementation and intravenous iron infusions during pregnancy may also provide a benefit to women at risk for SMM [29].

Data suggests that obstetric hemorrhage, a leading cause for blood transfusion, accounts for most maternal deaths, but 54% to 93% of these deaths are preventable [30-33]. Thus, improvement in maternal care and departmental practices may reduce these unnecessary deaths. Based on the high rates of transfusions observed, we recommend providing continuing education on the prevention of Postpartum Hemorrhage (PPH), Quantitative Blood Loss (QBL), the use of uterotonics, and timing of PPH identification. Furthermore, early administration of Tranexamic Acid (TXA) and fibrinogen concentrate to manage PPH should be considered as well as focusing on rapid diagnosis and correction of coagulopathy in pregnant patients. In addition to the previous recommendations, intra-operative cell salvage may be considered for its obstetric potential to treat patients safely and effectively with predicted potential for massive obstetric hemorrhage [33,34].

Among the most common indicators, sepsis can be more effectively managed through prompt identification and infection treatment in the peripartum period as research has shown that over 30% of sepsis cases were impacted by delayed recognition [35]. Specifically, preventative measures include more research and institutional standardization of prophylactic antibiotic use following operative deliveries, Obstetric Anal Sphincter Injuries (OASIS), manual removal of the placenta, postpartum Dilation and Curettage (D and C), and PPH [36]. Eclampsia, including HELLP syndrome, also continues to be a leading indicator of SMM, one of which results in many preventable cases. In terms of recommendations to reduce these events, Hypertension (HTN) management is a critical matter requiring immediate management [37]. In particular, prompt evidence-based management of gestational hypertension along with continuing clinical education on severe HTN management protocols can decrease the number of fatal cases. Following delivery, women who have risk factors for pre-eclampsia should be offered short and long-term HTN management options including closer postpartum visits, home blood pressure monitoring and multi-disciplinary team management as needed. Notably, some limitations of this study can be areas for improvement in the medical care system. In general, navigating through and collecting data on the relevant patients in the EPIC electronic medical record database was labor intensive and not conducive to supporting data and trend analysis in patient care. In part, this stemmed from issues extracting the ICD codes from administrative data which is not designed with research in mind; additionally, much of the available patient data could have been improved with more thorough documentation as well as added validity and oversight to the data content. This study demonstrates the increased need to investigate trends relating to maternal health to prevent SMM. In particular, the leading indicators of SMM continue to be blood transfusions, sepsis, and HELLP/eclampsia.

The results of this study further demonstrate the inadequacies present in maternal care which, if addressed, will reduce the many cases of preventable maternal morbidity. The recommendations discussed herein describe a revised agenda focusing on prompt, evidence-based identification, and management of SMM indicators which begins with updated clinical practices and continuing education. Furthermore, establishing EMR databases modified to document SMM indicators/risk factors and increase the ease of data reporting may also provide in-time information for addressing these issues at the hospital level. In addition, improved analysis of patient data will also help identify SMM hospitalizations that occur outside of delivery hospitalizations, including antepartum and postpartum issues as this period may account for additional SMM cases not previously considered.

In summary we recommend several process changes to decrease SMM. We need to accurately define SMM and then standardized criteria to identify women at risk of having a severe maternal morbidity event. Utilizing these criteria, we can then build them into our EMR systems to work for us by flagging our OB providers and by having the ability to capture data for further study. Changing our postpartum follow-up for SMM patients can also benefit and lastly, improving access and coverage to our moms to decrease SMM. Specifically, establishing a dedicated EMR database for reporting and tracking SMM cases can streamline the process and help identify trending issues. Modifications to the database to allow simpler reporting of SMM indicators and patient trend analysis would be beneficial to improving care. Identifying an outcome as a severe maternal morbidity does not suggest blame, nor does it mean that there will always be an opportunity for improvement. Reviewing such cases in detail to determine whether the morbidity may have been avoidable and whether it should prompt changes in systems for care provision is, however, a necessary and crucial step in efforts to ensure quality obstetric care. Patient education and encouragement will continue to be a necessary point of focus for improving SMM trends. This begins with informing women on the necessity to always identify as pregnant or previously pregnant when seeking medical care within the last year. Increasing awareness at the community level of the importance of preconception, prenatal, and postpartum care can make a difference in initiating the necessary conversations in the medical setting.

Insurance and payer policies may also be important to include in future research in terms of trends and rates of SMM; women who are not fully covered by insurance may not seek the critical care needed to prevent SMM events. Thus, campaigning for policy changes to promote greater access to essential maternal care is key to ensuring that at-risk pregnant and postpartum women are connected to and able to afford subspecialty care. Thus, tracking and understanding current patterns of SMM, along with developing and carrying out interventions to improve the quality of maternal care are essential to reducing SMM.

In summary we recommend several process changes to decrease SMM. We need to accurately define SMM and then standardized criteria to identify women at risk of having a severe maternal morbidity event. Utilizing these criteria, we can then build them into our EMR systems to work for us by flagging our OB providers

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