Severe Maternal Morbidity (SMM) includes potentially life-threatening conditions or complications during pregnancy, labor and delivery, and postpartum. SMM can be considered near-misses for maternal mortality and can have significant consequences for women's health.[1,2] The Centers for Disease Control and Prevention (**CDC**), the American College of Obstetricians and Gynecologists (**ACOG**) and the Society for Maternal-Fetal Medicine (**SMFM**) **recommend that birthing facilities routinely identify and review SMM events.**[1-3]

The review of SMM events at the facility level allows for:
- Characterization of causes and factors that led to morbidity
- Determination of whether the event was preventable

By identifying preventable or potentially preventable SMM events and associated factors, **facilities learn what worked and did not work in the process of care**, enabling them to recommend and implement practice changes or quality improvement initiatives to prevent future SMM and other adverse maternal outcomes from occurring.

In July 2020, the Maryland Maternal Health Innovation Program (MDMOM) initiated a **pilot SMM Surveillance and Review program working with 6 of the 32 birthing hospitals in Maryland:** Howard County General Hospital, Johns Hopkins Hospital, Luminis Health Anne Arundel Medical Center, Medstar St. Mary's Hospital, Mercy Medical Center, and Sinai Hospital of Baltimore. The program aimed to **ascertain causes of and factors contributing to SMM** and identify ways to **prevent future SMM** from occurring in Maryland hospitals. The pilot program was supported by Maryland House Bill 837/2020.

All SMM events in pregnant and up to 42-day postpartum patients admitted at participating hospitals were identified and reviewed using the following **case definition** (Figure 1):
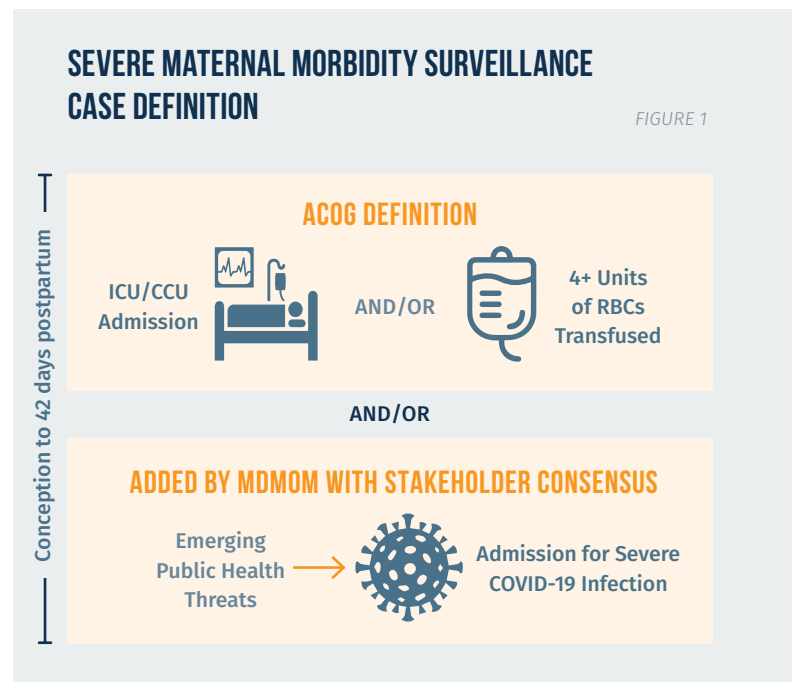 **a.** Admission to an intensive/critical care unit (ICU/CCU) **and/or**
  b. Transfusion of 4 or more units of red blood cells (RBC) **and/or**
  c. Hospitalization for management of emerging public health threats (e.g., COVID-19 infection)

Trained clinical abstractors reviewed all available maternal and newborn medical records for each SMM event using a **standardized, de-identified review form** (Table 1).

Hospital-based review committees meet regularly to review and discuss SMM events and **made recommendations** for preventing similar events from occurring.

This report presents **key findings from the pilot SMM Surveillance and Review program** conducted between August 1, 2020 and July 31, 2021. Analyses of preventable factors, practices done well, and recommendations are organized by domains in the "5Rs" framework, which is widely used in maternal mortality and morbidity reviews and includes:
- Readiness
- Recognition and Prevention
- Response
- Reporting and System Learning
- Respectful Care

SEVERE MATERNAL MORBIDITY SURVEILLANCE CASE DEFINITION

FIGURE 1

Conception to 42 days postpartum

ACOG DEFINITION

ICU/CCU Admission **AND/OR** 4+ Units of RBCs Transfused

AND/OR

ADDED BY MDMOM WITH STAKEHOLDER CONSENSUS

Emerging Public Health Threats → Admission for Severe COVID-19 Infection

[1]American College of Obstetricians and Gynecologists and the Society for Maternal-Fetal Medicine, Kilpatrick SJ, Ecker IL. Severe maternal morbidity: screening and review. Am. J. Obstet Gynecol. 2016;215:817-22. [2]Kilpatrick SJ, Berg C, Bernstein P, Bingham D, Delgado A, Callaghan WM, Harris K, Lanni S, Mahoney J, Main E, Nacht A, Schellpfeffer M, Westover T, Harper M. Standardized severe maternal morbidity review: rationale and process. Obstst Gynecol. 2014;124(2Pt1):361-366. [3]Callaghan WM, Grobman WA, Kilpratick SJ. Main EK, D'Alton M. Facility based identification of women with severe maternal morbidity: It is time to start. Obstst Gynecol, 2014; 123(5):978-981.

SEVERE MATERNAL MORBIDITY ABSTRACTION FORM AND REVIEW PROCESS

TABLE 1

SMM TYPE	ABSTRACTION	CASE NARRATIVE AND TIMELINE	CASE REVIEW ASSESSMENT	FINAL REVIEW COMMITTEE ANALYSIS
• SMM case definition • Timing of morbidity	• Patient sociodemographic characteristics and medical history • Prenatal care • Delivery information and blood loss • ICU/CCU admission • Follow-up after SMM event • COVID-19 infection	• Narrative synopsis • Timeline of key events	• Underlying causes of morbidity • Sequence of clinical causes of morbidity	• Opportunities to alter outcome • Practices that were done well • Overall recommendations for improvement
Completed by the Data Abstractor(s) in advance of the Hospital Review Committee meeting			Completed during the Hospital Review Committee meeting	
Data Abstractor(s) revise the information entered in the database as a result of Hospital Review Committee meeting				

SEVERE MATERNAL MORBIDITY EVENTS IDENTIFIED AND REVIEWED DURING THE PILOT PHASE

- 119 SMM events were identified and abstracted in the six pilot hospitals
- 51.2% of SMM events involved ICU/CCU admission, 46.2% involved blood transfusion of 4+ units of RBCs, and 32.7% involved hospitalization for management of severe COVID-19 infection (Table 2)
- The average number of units of RBCs transfused in events requiring transfusion was 10.1, ranging from 3* to 46 units (*the case with 3 units transfused qualified as an SMM event due to ICU admission*)
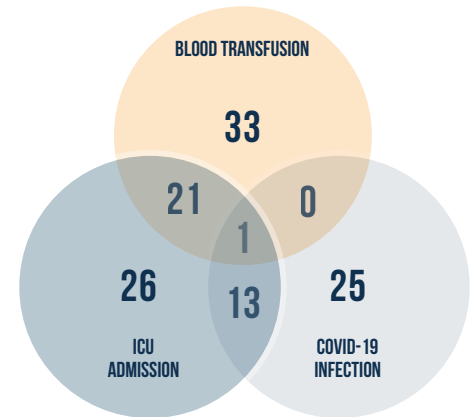- About 3 in 10 SMM events met more than one definition criteria (Figure 2)

KEY SOCIO-DEMOGRAPHIC CHARACTERISTICS OF PATIENTS WITH SEVERE MATERNAL MORBIDITY

- More than half of SMM events occurred in patients 25-34 years of age and fewer than a third in patients >35 years (Figure 3)
- 54.6% of patients with SMM events had private insurance, 37.0% were covered by Medicaid, and 8.4% had no insurance or self-paid for their hospitalization
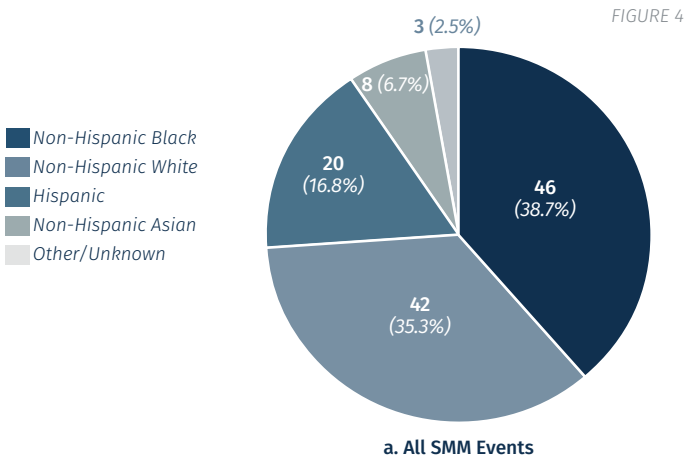
SEVERE MATERNAL MORBIDITY EVENT TYPES

TABLE 2

EVENT TYPE	N	%
ICU Admission	61	51.2
Blood Transfusion	55	46.2
COVID-19 Infection	39	32.7

OVERLAP IN CASE DEFINITION CRITERIA

FIGURE 2

BLOOD TRANSFUSION 33
21
0
1
26
13
25
ICU ADMISSION
COVID-19 INFECTION

Note: Data shown in Figure 2 are absolute numbers.

SEVERE MATERNAL MORBIDITY BY MATERNAL AGE

FIGURE 3

Legend: ■ <25 years ■ 25-34 years ■ 35+ years

	<25 years	25-34 years	35+ years
All SMM Events	16.0	54.6	29.4
ICU Admission	26.2	45.9	27.9
Blood Transfusion	3.6	58.2	38.2
COVID-19 Infection	7.7	59.0	33.3
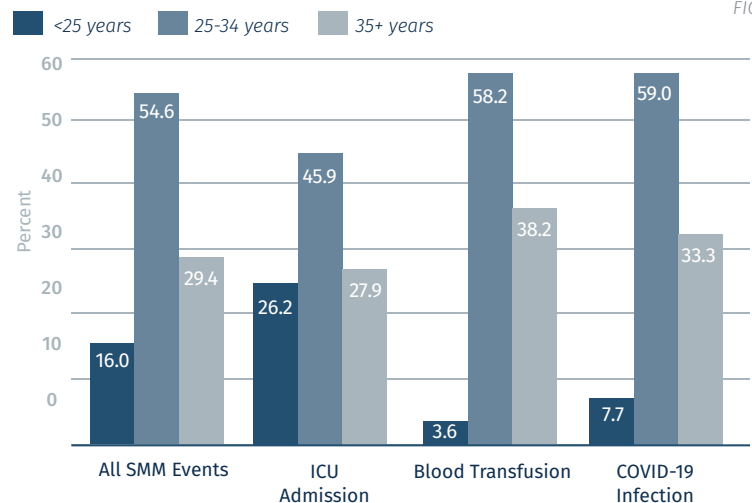
SEVERE MATERNAL MORBIDITY BY RACE/ETHNICITY

FIGURE 4

Legend:
- Non-Hispanic Black
- Non-Hispanic White
- Hispanic
- Non-Hispanic Asian
- Other/Unknown

a. All SMM Events

- 46 (38.7%)
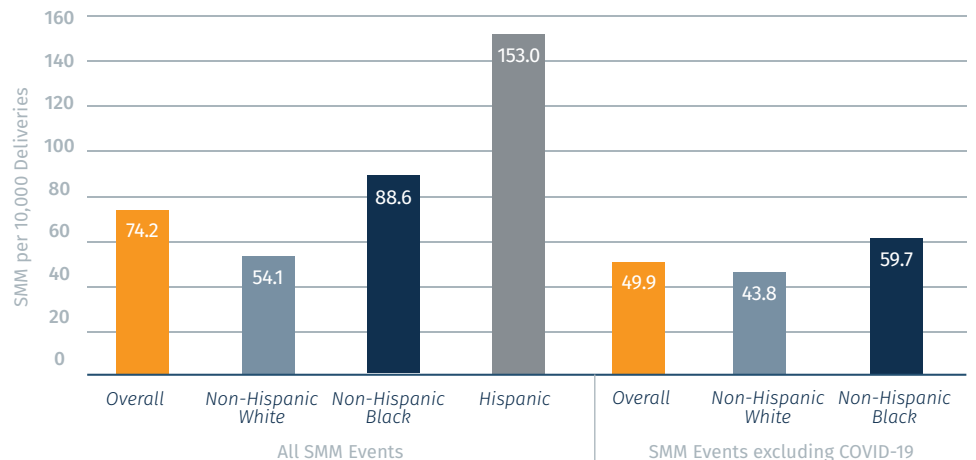- 42 (35.3%)
- 20 (16.8%)
- 8 (6.7%)
- 3 (2.5%)

- More than a third of SMM events were experienced by each of non-Hispanic Black (38.7%) and non-Hispanic White (35.3%) patient groups, by 16.8% of Hispanic and 6.7% of non-Hispanic Asian patients (Figure 4a)
- Non-Hispanic Black women comprised the largest group of patients requiring ICU admission (41.0%) and hospitalization for severe COVID-19 infection (38.5%, Figures 4b and 4d)
- Non-Hispanic White women represented the largest group among blood transfusion events (43.6%, Figure 4c)

b. ICU Admission

- 25 (41.0%)
- 21 (34.4%)
- 8 (13.1%)
- 5 (8.2%)
- 2 (3.3%)

c. Blood Transfusion

- 20 (36.4%)
- 24 (43.6%)
- 3 (5.5%)
- 6 (10.9%)
- 2 (3.6%)

d. COVID-19 Infection

- 15 (38.5%)
- 8 (20.5%)
- 13 (33.3%)
- 2 (5.1%)
- 1 (2.6%)
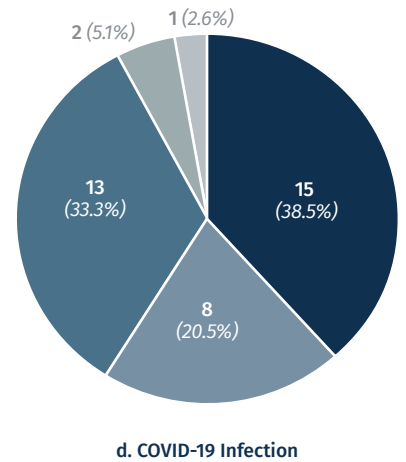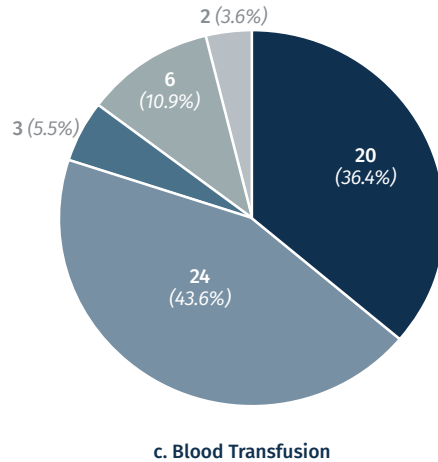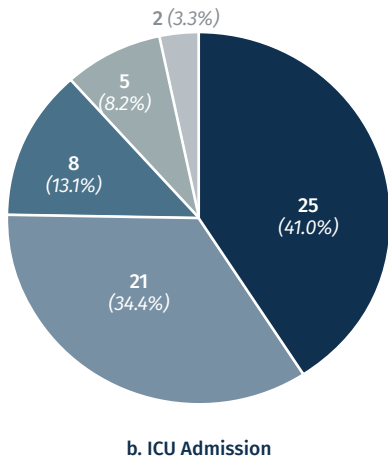
- The SMM rate was highest for Hispanic patients (153.0 per 10,000 deliveries), driven largely by severe COVID-19 infection hospitalizations (Figure 5)
- While lower than for Hispanic patients, the SMM rate among non-Hispanic Black patients (88.6 per 10,000 deliveries) was 64% higher than in non-Hispanic White patients (54.1 per 10,000 deliveries)
- Exclusion of severe COVID-19 infection from the case definition would have reduced the overall SMM rate to about 50 per 10,000 deliveries

SEVERE MATERNAL MORBIDITY RATES BY RACE/ETHNICITY

FIGURE 5

SMM per 10,000 Deliveries

All SMM Events
- Overall: 74.2
- Non-Hispanic White: 54.1
- Non-Hispanic Black: 88.6
- Hispanic: 153.0

SMM Events excluding COVID-19
- Overall: 49.9
- Non-Hispanic White: 43.8
- Non-Hispanic Black: 59.7

Note: Denominators are based on 2019 births in pilot hospitals as available from AHRQ's Maryland Statewide Inpatient Database. Rates for other racial/ethnic groups are not shown given small numbers yielding unstable rates.

LENGTH OF HOSPITAL STAY

- The average length of hospital stay for patients with an SMM event was 5.3 days, ranging from 1 to 23 days
- Among SMM events with an ICU admission (n=61), the average length of stay in the ICU was 2.6 days, ranging from 0 to 19 days

MEDICAL & OBSTETRIC HISTORY OF PATIENTS WITH SEVERE MATERNAL MORBIDITY

- The most common pre-existing medical condition prior to the index pregnancy was obesity (42.6%), followed by a mental health disorder (25.6%) and cardiovascular conditions (16.8%, Table 3)
- Among those who reported substance use (n=17), marijuana (58.8%) and tobacco (47.1%) were most frequently reported
- 23.5% of patients with SMM events had no prior births, 31.1% had one prior birth, 24.4% had two prior births, and 21.0% had three or more prior births
- About one in ten patients (11.8%) used assisted reproductive technology to conceive the index pregnancy
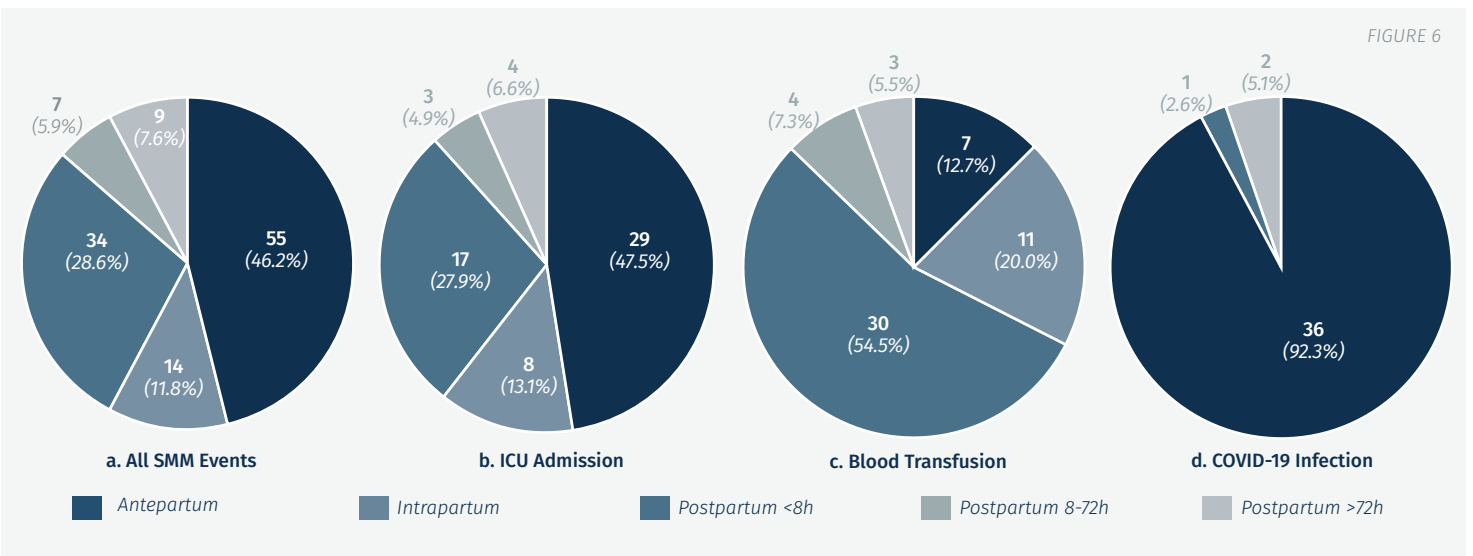
TABLE 3

PATIENT CHARACTERISTICS		
Significant medical history	86.6%	103 of 119
Obesity	42.7%	32 of 75
Mental health disorder	25.6%	30 of 117
Cardiovascular condition	16.8%	20 of 119
Asthma	14.3%	17 of 119
Substance use	14.3%	17 of 119
Diabetes	7.6%	9 of 119
Complications in prior pregnancy	51.1%	47 of 92
Pregnancy loss	42.4%	39 of 92
Hypertensive disorder of pregnancy	13.0%	12 of 92
Gestational diabetes	4.3%	4 of 92
Complications in current pregnancy	59.5%	66 of 111
Hypertensive disorder of pregnancy	9.9%	11 of 111
Placental abnormality	9.9%	11 of 111
Gestational diabetes	3.6%	4 of 111
Prenatal care	95.7%	112 of 117
Prenatal care initiated in first trimester	80.8%	80 of 99
No prenatal care	4.3%	5 of 117
Number of visits, mean (std dev)	9.1 (4.8)	82 of 117

Note: Reported percentages are based on events with available data for the characteristic shown.

## TIMING OF SEVERE MATERNAL MORBIDITY EVENTS

- Nearly half (46.2%) of the SMM events occurred during the antepartum period, 11.8% occurred intrapartum (Figure 6a)
- Among all postpartum SMM events (n=50), 64% occurred on the day of delivery and 16% the day after delivery, with the latest SMM event reported occurred 38 days after delivery
- The antepartum period was most common for SMM events that involved hospitalization for COVID-19 infection (92.3%) and required ICU admission (47.5%)
- 54.5% of SMM blood transfusion events occurred, as expected, during the first 8 hours after delivery (Figures 6b-d)

FIGURE 6

a. All SMM Events
b. ICU Admission
c. Blood Transfusion
d. COVID-19 Infection

■ *Antepartum*   ■ *Intrapartum*   ■ *Postpartum <8h*   ■ *Postpartum 8-72h*   ■ *Postpartum >72h*

GESTATIONAL AGE FOR ANTEPARTUM/INTRAPARTUM SEVERE MATERNAL MORBIDITY EVENTS

FIGURE 7

N=69

a. All SMM Events

N=37

b. ICU Admission

N=18

c. Blood Transfusion

N=36

d. COVID-19 Infection
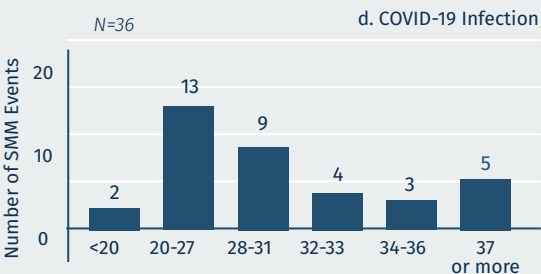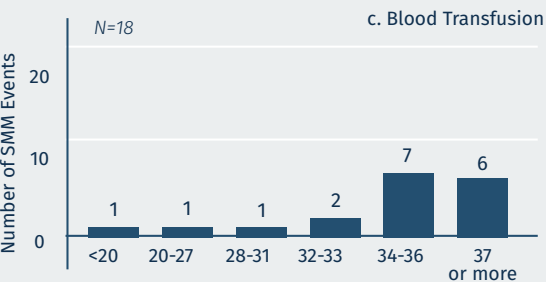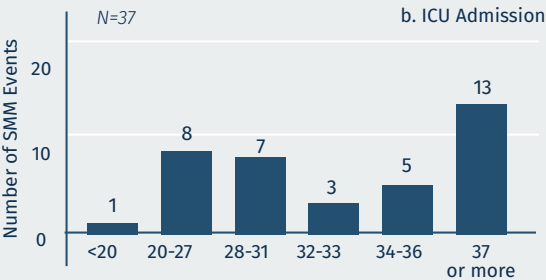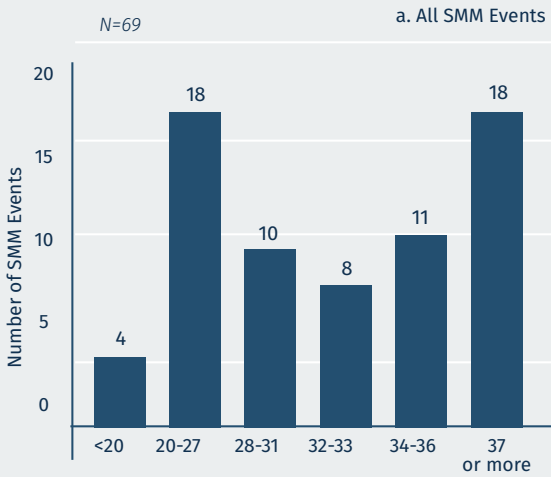
- Of the SMM events that occurred antepartum or intrapartum (n=69), 31.9% occurred before 28 weeks, 42.0% between 28 and 36 weeks, and 26.1% at 37 weeks or more gestation (Figure 7a)
- Over one third (35.1%) of ICU admission events occurred at 37 weeks or more and most blood transfusion events (72.2%) occurred at 34 weeks or later
- Two-thirds of events involving severe COVID-19 infection occurred before 32 weeks of gestation (Figures 7b-d)

DELIVERY OUTCOMES AMONG PATIENTS WITH SEVERE MATERNAL MORBIDITY

- Eighty-one (68.1%) SMM events occurred during the delivery hospitalization, of which 31.7% were vaginal and 67.9% cesarean deliveries (Table 4)
- The vast majority of deliveries were live birhts (91.4%), with an average gestational age of 37 weeks
- 33.8% of infants were born preterm, 23.3% were low birthweight, 36.1% were admitted to the neonatal intensive care unit (NICU)

TABLE 4

Delivered during the hospitalization with SMM event	68.1%	81 of 119
Vaginal delivery	32.1%	26 of 81
Spontaneous	84.6%	22 of 26
Assisted	15.4%	4 of 26
Cesarean delivery	67.9%	55 of 81
Planned	38.2%	21 of 55
Emergency	60.0%	33 of 55
Live birth	91.4%	74 of 81
Gestational age, mean (range)	37 weeks (24w5d-41w2d)	74
Preterm birth (<37 weeks' gestation)	33.8%	25 of 74
Low birthweight (<2,500 grams)	23.3%	17 of 73
NICU admission	36.1%	26 of 72
Stillbirth	8.6%	7 of 81
Gestational age, mean (range)	30w4d (24w2d-36w3d)	7

Note: w=weeks; d=days
Reported denominators are based on events with available data for the relevant characteristic shown. One cesarean delivery type was "unknown".

PRIMARY CAUSE OF SEVERE MATERNAL MORBIDITY EVENTS

- The most common primary causes of SMM were obstetric hemorrhage (41.7%), COVID-19 infection (31.7%), hypertensive disorders of pregnancy (7.5%), cardiovascular conditions, including cardiomyopathy (7.5%) and other infections (6.7%, Figure 8)
- Among the 61 events requiring ICU admission, the top 5 primary causes of SMM were obstetric hemorrhage (31.1%), COVID-19 infection (21.3%), hypertensive disorders of pregnancy (14.8%), cardiovascular conditions (13.1%) and other infections (13.1%)
- Common contributing morbidities for all types of SMM events were infections, including COVID-19 infection (13.4%), cardiovascular conditions (9.2%), obstetric hemorrhage (8.4%), hypertensive disorders of pregnancy (6.7%), pulmonary conditions (5.9%) and obesity (5.0%)
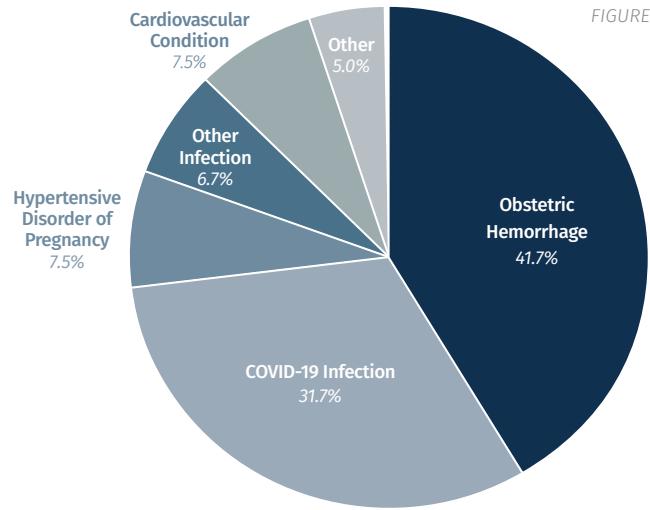
FIGURE 8

Note: "Other" included one event of each of the following conditions: brain tumor, cervical cancer, pulmonary embolism, hematologic, motor vehicle accident, and type-1 diabetes.

32% OF SEVERE MATERNAL MORBIDITY EVENTS WERE POTENTIALLY PREVENTABLE

PREVENTABILITY OF SEVERE MATERNAL MORBIDITY

Cases were considered potentially preventable if changes in provider, system, and/or patient-level factors could have altered the SMM outcome.

- Preventability of SMM events varied by the primary cause of SMM, ranging from 18.4% for COVID-19 infection to 50.0% for other infections (Table 5)
- Nearly half (47.6%) of SMM events among non-Hispanic White women were deemed preventable (Figure 9, *next page*)
- SMM preventability was lower for all other racial-ethnic groups at 28%, 25% and 10% among non-Hispanic Black, Asian and Hispanic patients, respectively
- Obstetric hemorrhage was the most common primary cause of preventable SMM events for non-Hispanic White (54.8%), Black (34.0%) and Asian (75.0%) patients, while COVID-19 infection was the most common primary SMM cause for Hispanic patients (65.0%)

TABLE 5

CAUSE	%	N
Cervical cancer	100.0%	1 of 1
Hematologic[1]	100.0%	1 of 1
Other infection	50.0%	4 of 8
Obstetric hemorrhage	38.0%	19 of 50
Cardiovascular condition	33.3%	3 of 9
Hypertensive disorders of pregnancy	33.3%	3 of 9
COVID-19 infection[2]	18.9%	7 of 37
Brain tumor	0.0%	0 of 1
Embolism[3]	0.0%	0 of 1
Injury[4]	0.0%	0 of 1
Metabolic/endocrine condition[5]	0.0%	0 of 1

Note: [1]Iron-deficiency anemia; [2]Preventability assessment for COVID-19 infection should be interpreted with caution given that the COVID-19 vaccine only became available in the spring of 2021; [3]Pulmonary embolism; [4]Motor vehicle accident; [5]Type 1 diabetes.

PRIMARY CAUSE AND OPPORTUNITY TO ALTER THE SEVERE MATERNAL MORBIDITY OUTCOME BY RACE AND ETHNICITY

FIGURE 9

Non-Hispanic Black
- Obstetric Hemorrhage: 5 | 11
- COVID-19: 2 | 11
- Cardiovascular Condition: 2 | 3
- HDP: 1 | 4
- Other Infection: 2 | 3
- Other: 1 | 1

  Preventable
  Non-Preventable

Non-Hispanic White
- Obstetric Hemorrhage: 11 | 12
- COVID-19: 5 | 3
- Cardiovascular Condition: 1 | 3
- HDP: 1 | 2
- Other: 1 | 2
- Other Infection: 1

Hispanic
- COVID-19: 13
- Obstetric Hemorrhage: 3
- Other Infection: 1 | 1
- HDP: 1
- Other: 1

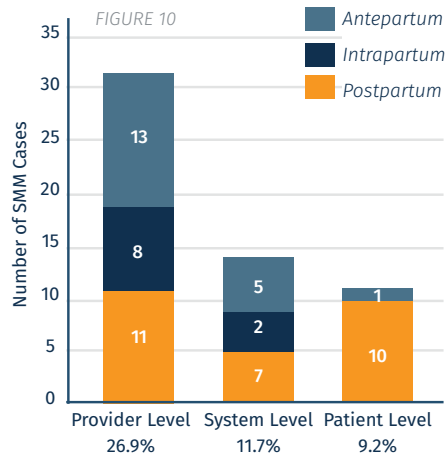**Non-Hispanic Asian**
- Obstetric Hemorrhage: 2 | 4
- COVID-19: 2

Note: HDP, Hypertensive disorders of pregnancy. Data shown are absolute numbers.

LEVEL, TIMING, AND FACTORS THAT COULD HAVE ALTERED THE SEVERE MATERNAL MORBIDITY OUTCOME
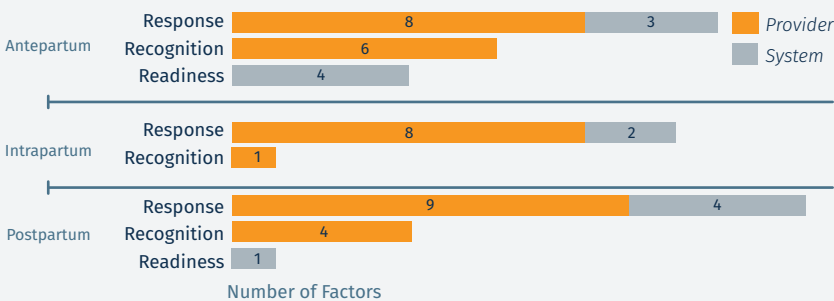
Hospital Review Committees determined that addressing provider, system, and patient-level factors could have altered outcomes in 32 (26.9%), 14 (11.7%), and 11 (9.2%) SMM events, respectively (Figure 10).

FIGURE 10

Antepartum
Intrapartum
Postpartum

Number of SMM Cases

- Provider Level 26.9%: Postpartum 11, Intrapartum 8, Antepartum 13
- System Level 11.7%: Postpartum 7, Intrapartum 2, Antepartum 5
- Patient Level 9.2%: Postpartum 10, Antepartum 1

Note: More than one factor could have been identified for one SMM event. Data shown are absolute numbers.

TYPES OF FACTORS THAT COULD HAVE ALTERED THE SEVERE MATERNAL MORBIDITY OUTCOME

FIGURE 11

Antepartum
- Response: 8 | 3
- Recognition: 6
- Readiness: 4

Intrapartum
- Response: 8 | 2
- Recognition: 1

Postpartum
- Response: 9 | 4
- Recognition: 4
- Readiness: 1

Provider
System

Number of Factors

Note: Factors could apply to multiple "5Rs" framework domians. Data shown are absolute numbers.

About **16%** of SMM events could have been prevented by addressing factors in the **antepartum** period. Most of these factors related to the **Readiness, Recognition and Response** domains (Figure 11).

- Provider-level factors included earlier recognition of maternal decompensation and initiation of appropriate treatment
- System-level factors included enhanced care coordination with laboratory services to ensure timely delivery of test results and adequate staffing on weekends
- Patient-level factors included utilization of prenatal care and management of preexisting medical conditions

About **8%** of SMM events could have been prevented by addressing factors in the **intrapartum** period. Most provider and system factors were related to the **Response** domain.

- Provider-level factors included referral to higher level of care, use of safe surgical technique and improved labor management
- System-level factors included timelier treatment and anesthesia consults

About **11%** of SMM events could have been prevented by addressing factors in the **postpartum** period. Most provider and system factors were related to the **Response** domain.
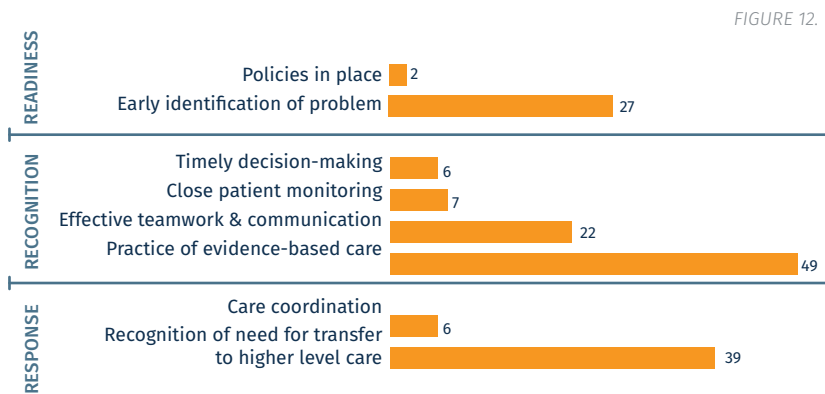
- Provider-level factors included earlier initiation of appropriate treatment, improved care coordination within unit and following chain of command
- System-level factors included higher readiness to address obstetric emergencies, timelier transfer to higher level of care and better care coordination across labor and delivery and ICU units
- Patient-level factor included improved patient-provider communication

7

PRACTICES DONE WELL IN RELATION TO SEVERE MATERNAL MORBIDITY EVENTS

For all SMM events, Hospital Review Committees listed up to three practices that were done well and should be reinforced in their hospitals. Eight themes emerged from the 119 SMM events (Figure 12).
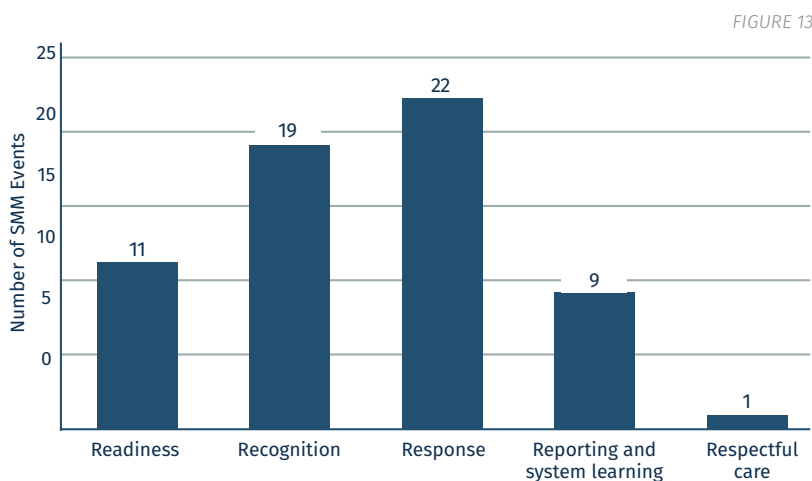
- Most commonly reported 'practices done well included practice of evidence-based care (41.2%), recognition of need for higher level of care (32.8%), and early identification of the problem (22.7%)

FIGURE 12.

READINESS
- Policies in place — 2
- Early identification of problem — 27

RECOGNITION
- Timely decision-making — 6
- Close patient monitoring — 7
- Effective teamwork & communication — 22
- Practice of evidence-based care — 49

RESPONSE
- Care coordination
- Recognition of need for transfer to higher level care — 6 / 39

Note: Data shown are absolute numbers.
Fields for capturing this information were open-ended and unprompted; not mentioning these practices for a particular event does not mean they did not occur.

KEY RECOMMENDATIONS FOR SEVERE MATERNAL MORBIDITY PREVENTION IN MARYLAND HOSPITALS

The most frequent recommendations by Hospital Review Committees were within the Response (22), Recognition (19), and Readiness (11) domains of the "5Rs" framework (Figure 13).

FIGURE 13

Number of SMM Events

Readiness	Recognition	Response	Reporting and system learning	Respectful care
11	19	22	9	1

READINESS
The ability to use an institution's resources, protocols and procedures when needed

- Enhance readiness for hemorrhage management and blood transfusion
- Offer specific training to providers on the management of antepartum anemia and severe hypertension
- Ensure availability of diagnostic services during nighttime hours and weekends

RECOGNITION
Assessment and measurement

- Timely assessment of, screening for and diagnosis of severe complications
- Enhance vital sign monitoring during hospitalization
- Follow-up on abnormal test results

RESPONSE
Treatment and management

- Timely initiation of treatment for patients with severe range blood pressure values and abnormal bleeding
- Implement surgical care per clinical guidance
- Strengthen teamwork and communication within labor and delivery units
- Timely engagement with specialist care
- Coordination of care within and across hospital systems and warm handoff of patient

REPORTING AND SYSTEM LEARNING
Communication, debrief and review

- System learning to better manage hemorrhage and blood transfusion events
- System learning to ensure safe anesthesia and surgical care

RESPECTFUL CARE
Recognizing the patient's right to be educated, informed and supported

- Consider patients' individual circumstances when making discharge recommendations