SEVERE MATERNAL MORBIDITY

SURVEILLANCE & REVIEW PROGRAM FINDINGS AND RECOMMENDATIONS

DECEMBER 2025

Developed by the Maryland Maternal Health Innovation Program

MDMOM

APPENDIX A

DATA ABSTRACTION FORM

SMM TYPE

ICU/CCU Admit? ☐ No ☐ Yes

≥4 Units Blood Transfused? ☐ No ☐ Yes

Patient Died in the Hospital? ☐ No ☐ Yes

Timing of Maternal Morbidity:
☐ Antepartum
☐ Intrapartum
☐ Postpartum (within 8 hours)
☐ Postpartum (8 to 72 hours)
☐ Postpartum (after 72 hours)

SMM Case Number:
(Year – Quarter – Hospital ID – Sequence #)
__ __-__ __-__ __-__ __ __

SMM Event Date:
(mm/dd/yyyy)

Hospital Name:

Abstractor:

Abstraction Date:
(mm/dd/yyyy)

SMM Event Occurred During Delivery Hospitalization?
☐ No ☐ Yes
☐ Unknown

Maternal Transport:
☐ No transfer
☐ For delivery
☐ For ICU care
☐ Other: _____
☐ Unknown
Transfer From: (Hospital name)
Transfer To: (Hospital name)

ABSTRACTION

PATIENT CHARACTERISTICS

Admission Date: (mm /yyyy)

Length of Stay: ____days

Gestational Age at Admission:
____weeks / ____days

Maternal Age at Admission:

Weight/Height: (pre-pregnancy/1st trimester)
_____ lbs/kgs.; _____inches/cms
☐ Unknown wt. ☐ Unknown ht.

BMI*: (pre-pregnancy/1st trimester) *if weight/height unknown
☐ Underweight ☐ Normal weight
☐ Overweight ☐ Obese ☐ Unknown

Highest Education Completed:
☐ 12th grade or less, no diploma
☐ High school grad or GED completed
☐ Some college credit but no degree
☐ Associate or Bachelor degree
☐ Master's degree
☐ Doctorate or professional degree
☐ Unknown

Race: (select all that apply)
☐ Black/African American
☐ White
☐ Asian/Pacific Islander
☐ Native American/Alaskan Native
☐ Other: _____
☐ Unknown

Hispanic/Latina:
☐ No ☐ Yes ☐ Unknown

Primary Payer Source:
☐ Medicaid / Medicare
☐ Military
☐ Private Insurance
☐ Self-Pay/None
☐ Unknown

Born in the US?
☐ No ☐ Yes ☐ Unknown

Primary Language:
☐ English ☐ Spanish
☐ Other:_____ ☐ Unknown

OBSTETRICAL HISTORY (at time of hospital admission)

Gravida _____
Para _____
Preterm _____
Induced Abortion _____
Spontaneous Abortion _____
Living _____

Complications in Previous Pregnancies? ☐ Not applicable (no prior pregnancies)
☐ No ☐ Yes ☐ Unknown *If Yes, select all that apply:*

☐ Cesarean delivery *if yes* ⟶ # of Cesarean Deliveries: ____ ☐ Unknown
☐ Embolism ☐ Gestational diabetes
☐ Hypertensive disorders of pregnancy (specify type)
☐ Placental complications (specify type) ☐ Postpartum hemorrhage
☐ Pregnancy loss (stillbirth/fetal death) ☐ Preterm birth ☐ Other _____

PREVIOUS MEDICAL HISTORY

Pre-existing Medical Conditions?

☐ No ☐ Yes ☐ Unknown *If Yes, select all that apply:*

☐ Asthma ☐ Cardiovascular condition (acquired) ☐ Cardiovascular condition (congenital)

☐ Chronic hypertension ☐ Chronic renal disease ☐ HIV

☐ Mental health disorders, *if yes* ⟶ Specify types of mental health disorders:_____

☐ Substance use, *if yes* ⟶ Specify types of substances:_____ ☐ Other: _____

PRENATAL CARE

Prenatal Care Received? ☐ No ☐ Yes ☐ Unknown

If Yes, specify:

Trimester of First Prenatal Care: ☐ First ☐ Second ☐ Third ☐ Unknown

Assisted Reproductive Technology?

☐ No ☐ Yes ☐ Unknown

If Yes, specify:

☐ IVF/ICSI ☐ Other: _____

Index Pregnancy/Birth Problems or Conditions? ☐ No ☐ Yes ☐ Unknown

If Yes, select all that apply:

☐ Gestational diabetes ☐ Hypertensive disorders of pregnancy (specify tyoe)

☐ Placental complications (specify tyoe) ☐ Pregnancy loss (stillbirth/fetal death) ☐ Other: _____

Mental Health Disorder during Index Pregnancy?

☐ No ☐ Yes ☐ Unknown

If Yes, specify: (select all that apply)

☐ Anxiety ☐ Depression

☐ Postpartum depression ☐ Eating disorder

☐ Other: _____ ☐ Unknown

Substance Use during Index Pregnancy?

☐ No ☐ Yes ☐ Unknown *If Yes, specify substance(s)*:

☐ Alcohol ☐ Tobacco ☐ Marijuana ☐ Cocaine

☐ Opioids ☐ Methamphetamines

☐ Prescription drugs (not as intended) ☐ Opioid agonist therapy

☐ Other: _____

Pre-SMM Event Hospitalizations and/or ER Visits?

☐ No ☐ Yes ☐ Unknown *If Yes, for the most recent visit:*

Admission Date: (mm/dd/yyyy) **Discharge Date:** (mm/dd/yyyy) **Length of Stay:** (days)

Gestational Age: (weeks/days) **Reason:**_____

Influenza Vaccination during Year?

☐ No ☐ Yes ☐ Unknown

PREGNANCY STATUS DURING HOSPITALIZATION IN WHICH SMM DOCUMENTED

Pregnancy Type: ☐ Singleton ☐ Twin ☐ Triplets ☐ Multiple (4+)

If 3+, fill out additional delivery information per newborn/fetus in the text box:

Newborn/Fetus A/B Pregnancy Status at end of hospitalization: *(select one)*

☐ **Delivered**

Sex: ☐ Male ☐ Female ☐ Undifferentiated

Birthweight: (grams) _____

Gestational Age: (weeks/days) _____

Fetal/Newborn Status:

☐ Live Birth ☐ Fetal Death (>20 weeks GA)

Neonatal death: ☐ No ☐ Yes ☐ Unknown

NICU admit: ☐ No ☐ Yes ☐ Unknown

☐ **Other Outcome**

☐ Ectopic ☐ Molar pregnancy

☐ Fetal death (not delivered)

☐ Abortion (<20 weeks GA):

☐ Spontaneous

☐ Induced

Gestational Age: (weeks/days) _____

☐ **Not Delivered**

☐ **Unknown**

DELIVERY INFORMATION (*Complete ONLY if Pregnancy Status was "Delivered")* ☐ Not applicable

Delivery Precipitated by SMM event?
☐ No ☐ Yes ☐ Unknown

Labor:
☐ No labor
☐ Spontaneous ☐ Augmented
☐ Induced
☐ Trial of Labor After Cesarean
☐ Other: _____ ☐ Unknown

Mode of Delivery:
☐ Spontaneous vaginal
☐ Assisted vaginal:
  ☐ Vacuum
  ☐ Forceps
☐ Cesarean
☐ Other: _____
☐ Unknown

Type of Anesthesia:
☐ None
☐ Local
☐ Epidural
☐ Spinal
☐ Combined Spinal-Epidural
☐ General
☐ Other: _____
☐ Unknown

Primary Maternity Care Provider at Delivery:
☐ General Obstetrician
☐ Maternal Fetal Medicine Specialist
☐ Family Medicine Physician
☐ Nurse Practitioner
☐ Certified Nurse/Licensed Midwife
☐ Resident
☐ Other: _____
☐ Unknown

Complete ONLY if Mode of Delivery was Cesarean:

Type of Cesarean Section:
☐ Scheduled
☐ Emergency: (specify details below)
☐ Unknown

Cesarean Section Precipitated by SMM Event?
☐ No ☐ Yes ☐ Unknown

Primary Indication for Cesarean:
☐ Repeat
☐ Dystocia / Failure to Progress
☐ Malposition
☐ Placenta previa
☐ Placenta accreta/increta/percreta
☐ Other fetal indication: _____
☐ Other maternal condition: _____
☐ Unknown

ABNORMAL BLOOD LOSS AND TRANSFUSION

Abnormal Blood Loss during Delivery? ☐ No ☐ Yes ☐ Unknown → ***If Yes, complete below details:***

Total Quantified mL of Blood Loss (QBL):
☐ Measured (mL)_____ ☐ Estimated (mL)_____ ☐ Unknown

Massive Transfusion Protocol Called?
☐ No ☐ Yes ☐ Unknown

Blood Transfusion during Delivery Hospitalization?
☐ No ☐ Yes ☐ Unknown
If Yes, specify:
Blood Transfusion due to: (select all that apply)
☐ Blood loss ☐ Anemia ☐ Other:_____
Total Blood Products Transfused: (mL/Units)_____
Type of Blood Products Transfused: (select all that apply)
☐ Packed RBC ☐ Platelets
☐ Fresh frozen plasma (FFP) ☐ Whole blood
☐ Cryoprecipitate

Other Interventions for Management of Blood Loss:
☐ None
☐ Medication(s):
  ☐ Uterotonic: _____
  ☐ Other: _____
☐ Other: _____
☐ Unknown

ICU/CCU ADMISSION

ICU Admission Planned?
☐ No ☐ Yes ☐ Unknown

Admission Date: (mm/yyyy) _____
Discharge Date: (mm/dd/yyyy) _____
Length of Stay: (days)_____

Reasons:

☐ Diabetic ketoacidosis ☐ Embolism
☐ Postpartum hemorrhage ☐ Preeclampsia/eclampsia
☐ Respiratory distress ☐ Seizure ☐ Sepsis
☐ Uterine rupture ☐ Other: _____

Interventions: (specify)

OTHER SURGERY

Any Type of Surgery during the Index Hospitalization?

☐ No ☐ Yes, elective ☐ Yes, emergency ☐ Unknown

If Yes, specify:

Type of Surgery: (specify) **Reason(s):** (specify)

COVID-19 INFORMATION

Positive maternal COVID-19 diagnosis during hospitalization?

☐ No ☐ Yes ☐ Unknown

Timing of COVID-19 Diagnosis:

☐ Antepartum: (specify Gestational Age)

GA ____weeks / ____days

☐ Intrapartum

☐ Postpartum: ☐ within 8 hours ☐ 8 to 72 hours ☐ After 72 hours

Indicate presenting symptoms and date of onset in the table below: ☐ **No presenting symptoms**

Symptom	Yes	Symptom	Yes	Symptom	Yes
Fever	☐	Dizziness/fainting	☐	Runny nose	☐
Cough	☐	Tiredness/fatigue	☐	Sore throat	☐
Shortness of breath	☐	Body aches	☐	Nausea/Vomiting	☐
Loss of smell/taste	☐	Headache	☐	Flu-like symptoms	☐
Other (specify)	☐	**Date of First Symptom Onset:** (mm/dd/yyyy)			

Confirmed Pneumonia on Imaging? ☐ No ☐ Yes ☐ Unknown

Anti-viral Drugs Used? ☐ No ☐ Yes: (specify drug(s)) _____ ☐ Unknown

Other drugs (e.g., steroids, antibiotics) used During Pregnancy? ☐ No ☐ Yes: (specify drug) _____ ☐ Unknown

Steroids Given to Enhance Fetal Lung Maturation? ☐ No ☐ Yes ☐ Unknown

Extracorporeal Membrane Oxygenation (ECMO) Used? ☐ No ☐ Yes ☐ Unknown

If Yes, specify:

Date ECMO Commenced: (mm/dd/yyyy)_____ Name of ECMO Facility: _____

Delivery During ECMO Treatment? ☐ No ☐ Yes: (specify reason)_____ ☐ Unknown

NEONATAL COVID-19 OUTCOME ☐ Not applicable (infant not delivered)

Newborn A Diagnosed with COVID-19 Infection?

☐ No ☐ Yes ☐ Unknown

Newborn B Diagnosed with COVID-19 Infection?

☐ No ☐ Yes ☐ Unknown

☐ Not applicable (singleton birth)

PATIENT BLOOD PRESSURE MONITORING

Patient received blood pressure cuff for at home monitoring

☐ No ☐ Yes ☐ Unknown *If Yes:* ☐ Prior to index hospitalization ☐ Upon discharge from index hospitalization

ABSTRACTION: CASE NARRATIVE AND TIMELINE

Include a narrative synopsis focused on the specific SMM that occurred. It should be concise and pertinent to the particular SMM and include appropriate timeline in chronologic format and identifying key moments that impacted care. **Use the Case Narrative and Timeline Template to guide your narrative and ensure that you are capturing critical information.**

CASE REVIEW ASSESSMENT (DO NOT COMPLETE PRIOR TO REVIEW)

Review Date: (mm/dd/yyyy)

SMM Case Number: (Year – Quarter – Hospital ID – Sequence #)
__ __ - __ __ - __ __ - __ __ __

Primary Cause of Morbidity: (select ONLY one)

- ☐ Anesthesia complications
- ☐ Cancer
- ☐ Cardiomyopathy
  - ☐ Hypertrophic cardiomyopathy
  - ☐ Postpartum/peripartum cardiomyopathy
  - ☐ Other
- ☐ Cardiovascular conditions
  - ☐ Conduction defects/arrhythmias
  - ☐ Coronary artery disease
  - ☐ Pulmonary hypertension
  - ☐ Hypertensive cardiovascular disease
  - ☐ Valvular heart disease
  - ☐ Vascular aneurysm/dissection (non-cerebral)
  - ☐ Vascular malformations
  - ☐ Other
- ☐ Collagen vascular/autoimmune disorders
  - ☐ Systemic lupus erythematosus
  - ☐ Other
- ☐ Embolism
  - ☐ Amniotic fluid embolism
  - ☐ Thrombotic
  - ☐ Other
- ☐ Gastrointestinal disorders
- ☐ Hematologic
  - ☐ Sickle cell anemia
  - ☐ Other
- ☐ Hypertensive Disorders of Pregnancy
  - ☐ Preeclampsia
  - ☐ Eclampsia
  - ☐ HELLP Syndrome
  - ☐ Chronic hypertension with superimposed preeclampsia
- ☐ Infection
  - ☐ Antepartum infection
  - ☐ Covid-19
  - ☐ Postpartum genital tract
  - ☐ Non-pelvic infection
  - ☐ Sepsis/septic shock
  - ☐ Other
- ☐ Injury
  - ☐ Drug use
  - ☐ Motor vehicle accident
  - ☐ Other
- ☐ Metabolic/endocrine Conditions
- ☐ Neurologic Conditions
  - ☐ Epilepsy/seizure disorder
  - ☐ Other
- ☐ Obstetric Hemorrhage
  - ☐ Rupture/laceration/intra-abdominal bleeding
  - ☐ Ruptured ectopic pregnancy
  - ☐ Placental abruption
  - ☐ Placenta previa
  - ☐ Placenta accreta/increate/percreta
  - ☐ Uterine atony/postpartum hemorrhage
  - ☐ Other
- ☐ Mental Health Conditions
  - ☐ Postpartum depression
  - ☐ Other
- ☐ Pulmonary Conditions
  - ☐ Asthma
  - ☐ Chronic lung disease
  - ☐ Other
- ☐ Renal Disease
- ☐ Other (specify)
- ☐ Unknown

Other Associated or Contributing Morbidities: (select ALL that apply from the above list) ☐ No contributing morbidity

FINAL REVIEW COMMITTEE ANALYSIS

Opportunity to alter the SMM outcome?

- ***Yes:*** *there were one or more condition(s)/situation(s) during the antepartum, intrapartum, and/or postpartum periods, which contributed to the SMM event. If these conditions/situations were changed, there is potential that the SMM event could have been prevented and/or not been as severe. Select 'Yes' even if you are not certain but you think there may have been an opportunity to alter and/or prevent the outcome.*
- ***No:*** *The SMM could not be avoided during the antepartum, intrapartum, and/or postpartum periods. There was no factor that could have altered the outcome.*

☐ Yes ☐ No ***If Yes, complete below:*** →

Should the Massive Transfusion Protocol have been Activated?

☐ No ☐ Yes ☐ Unknown

Types of factors that offer opportunity to alter the outcome: (Review page 7 of the SMM Form Guide and select all that apply)

Examples of factors to consider

Provider Factors

1. Assessment/point of entry to care
2. Diagnosis/recognition of high-risk
3. Refer to expert
4. Treatment
5. Management hierarchy
6. Provider education
7. Documentation
8. Discharge

System Factors

1. Coordination issue
2. Policies & procedures
3. Delay/timeliness
4. Barriers to care

Patient Factors

1. Previous obstetric conditions
2. Non-obstetric medical conditions that occurred before or during the index pregnancy
3. Complications related to index pregnancy
4. Mental health disorder
5. Substance use disorder
6. Significant stressors
7. Barriers to seeking, obtaining, and maintaining Healthcare

Antepartum	**Intrapartum**	**Postpartum**
☐ Provider _____	☐ Provider _____	☐ Provider _____
☐ System _____	☐ System _____	☐ System _____
☐ Patient _____	☐ Patient _____	☐ Patient _____

Identify up to 3 practices that were done well and should be reinforced:

Comment and include information on those practices that were done well and should be reinforced in the hospital where the SMM event occurred. This should be driven by the findings from the preventability assessment and based on the key findings from the provider, system, and patient factor analyses.

Identify up to 3 *specific* recommendations for *care improvements* as related to this SMM case review:

Comment and list recommendations for system, practice, or provider improvement (such as policies and protocols) based on the findings from the preventability assessment and the key findings from the provider, system, and patient factor analyses.

Other comments:

APPENDIX B

PREVENTABILITY ASSESSMENT GUIDE

Use this checklist to determine SMM preventability in the Final Review Committee meeting.

The factors listed below are examples and are not intended to be an exhaustive list. See other side (page 2) for definitions and examples of potential factors. A complete version of this document is available as an appendix in the SMM Data Abstraction Guide (Guide for Assessing Case Preventability).

PREVENTABILITY DEFINITION
An SMM event is considered preventable if there were one or more factors during the antepartum, intrapartum, and/or postpartum periods which, if changed, might have <u>prevented the SMM event or lessened its severity</u>. These factors can be related to the provider, system, and/or patient. *Include any factors about which you are not certain, but which <u>might</u> have offered an opportunity to alter or prevent the outcome*

Provider Factors	Antepartum	Intrapartum	Postpartum	Notes
Delay or denial of assessment or preventative care	☐	☐	☐	
Delay or non-diagnosis of high-risk pregnancy status	☐	☐	☐	
Delay or non-referral to expert	☐	☐	☐	
Delayed, inappropriate, or absent treatment	☐	☐	☐	
Lack of provider/practitioner supervision or consultation	☐	☐	☐	
Lack of provider education/training	☐	☐	☐	
Inadequate documentation	☐	☐	☐	
Inappropriate discharge, counseling, or follow-up	☐	☐	☐	
Other:	☐	☐	☐	

System Factors	Antepartum	Intrapartum	Postpartum	Notes
Communication issue (e.g. between care providers, departments, different hospitals)	☐	☐	☐	
Policies and procedures not in place or not followed (e.g. regarding preparedness for OB emergency)	☐	☐	☐	
Delay in appropriate assessment or treatment (e.g. transport, blood transfusion)	☐	☐	☐	
Healthcare services unavailable or inaccessible	☐	☐	☐	
Other:	☐	☐	☐	

Patient Factors	Antepartum	Intrapartum	Postpartum	Notes
Pre-pregnancy preexisting conditions	☐	☐	☐	
Previous obstetric conditions (from past pregnancies)	☐	☐	☐	
Non-obstetric medical complications that occurred during index pregnancy	☐	☐	☐	
Complications related to index pregnancy	☐	☐	☐	
Mental health disorder	☐	☐	☐	
Substance use disorder	☐	☐	☐	
Significant social stressors (e.g. lack of adequate housing, experience of intimate partner violence)	☐	☐	☐	
Barriers to seeking, obtaining, and/or maintaining healthcare	☐	☐	☐	
Other:	☐	☐	☐	

Definitions and Examples for Factors that Could have Altered the Outcome

Provider Factors

1. **Delay or denial of assessment or preventative care:** Denied access to care or appointment, not to offered preventative treatment, delay in assessment / evaluation of patient, or incomplete medical history taken.
2. **Delay or non-diagnosis of high-risk:** Inappropriate diagnosis, delay (happened but late), or failure (did not happen) in any of the following: diagnosis/recognition of high-risk status, ordering or checking lab tests, recognition of abnormal vitals, or recognition of surgical complications.
3. **Delay or non-referral to expert:** Delay or failure to refer to expert or specialist care.
4. **Delayed, inappropriate, or absent treatment:** Delays in treatment, inappropriate treatment, or failure to treat. Also includes inadequate staffing, equipment, and other resources and equipment failures.
5. **Lack of supervision or consultation:** Includes issues related to management hierarchy including failure to check junior staff's work or failure to consult more senior staff.
6. **Lack of provider education/training or knowledge.**
7. **Inadequate documentation:** Poor charting, failure to chart, poor legibility, or inability to generate complete and accurate timeline of events.
8. **Inappropriate discharge, counseling, or follow-up:** inappropriate discharge, failure to counsel patient, or failure to follow up.

Systems Factors

1. **Communication issue**: Between any of the following: maternity care providers, other health practitioners (e.g. RNs, anesthetists, other specialty clinicians) and maternity care providers, other health practitioners, departments in the same hospital, different hospitals, maternity care providers and patient, or other health practitioners and patient. Also includes language difficulties and unclear chain of responsibility.
2. **Policies and procedures:** regarding case-relevant lab results, medication, blood transfusion; oversight (residents, nurses); scheduling and assessment; preparedness for obstetric emergency; patient education; hemorrhage/massive transfusion; active management of labor. Specify if policy was not followed or policy not in place.
3. **Delay / timeliness**: transport, laboratory, transfusion, etc.
4. **Healthcare services unavailable or inaccessible**: barriers to care including services not available, services not accessible, communication/translation barriers, etc.

Patient Factors

1. **Pre-pregnancy: preexisting conditions:** E.g., hypertension, diabetes, cancer, etc.
2. **Previous obstetric conditions (from past pregnancies)**
3. **Non-obstetric medical complications that occurred during index pregnancy:** E.g., infection, physical injury, cancer, etc.
4. **Complications related to index pregnancy**: E.g., gestational diabetes, preeclampsia, etc.
5. **Mental health disorder:** Depression, anxiety, etc.
6. **Substance use disorder:** Alcohol, tobacco, illicit drugs, etc. Also, if failed to use a seat belt.
7. **Significant social stressors:** domestic/intimate partner violence, safety concerns, lack of access to food/housing/financial resources/emotional support, etc.
8. **Barriers to seeking, obtaining, and maintaining healthcare or to healthcare access:** inadequate prenatal care, non-compliance with treatment, cultural beliefs/belief systems, health insurance, lack of transportation, etc.

APPENDIX C

DATA BRIEFS

SEVERE MATERNAL MORBIDITY
SURVEILLANCE AND REVIEW PILOT PROGRAM

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)

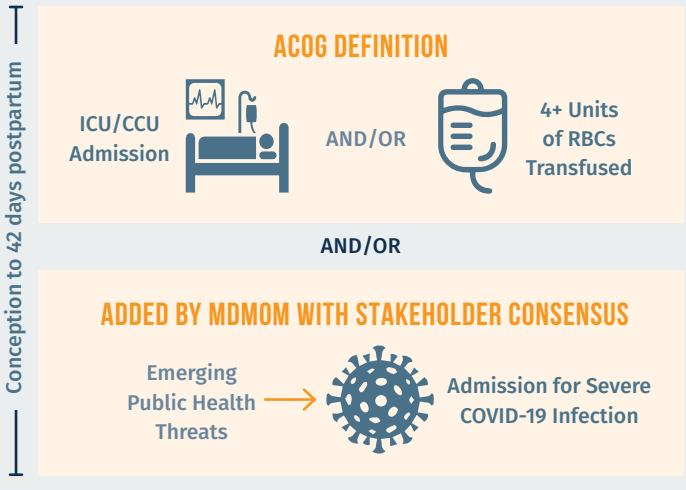
Trained clinical abstractors reviewed all available maternal and newborn medical records for each SMM event using a **standardized, de-identified review form** (Table 1).

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



[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)

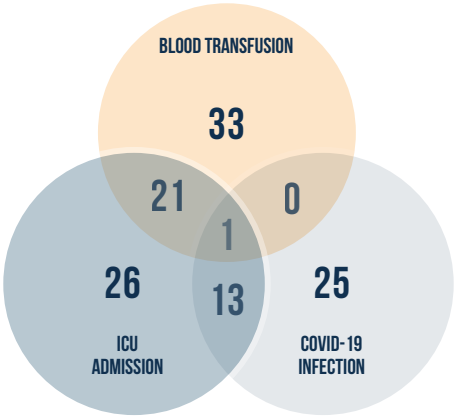
SEVERE MATERNAL MORBIDITY EVENT TYPES

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



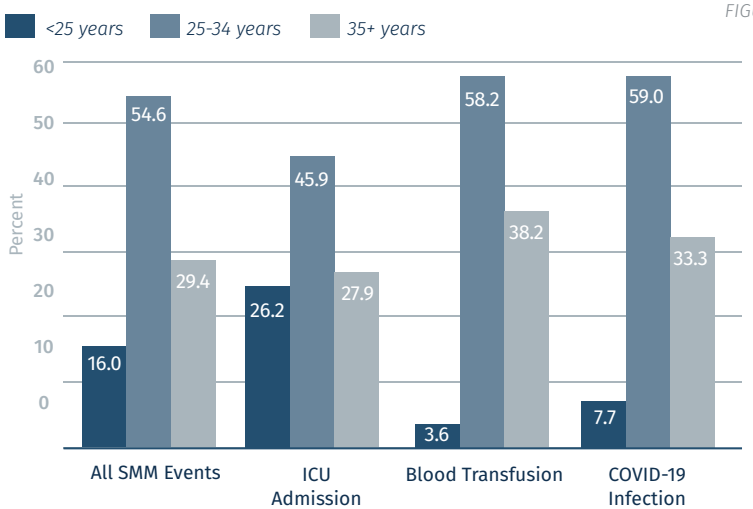
Note: Data shown in Figure 2 are absolute numbers.

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

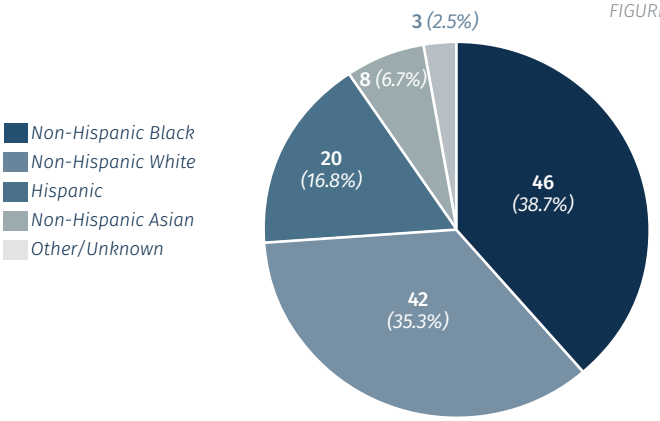
SEVERE MATERNAL MORBIDITY BY MATERNAL AGE

FIGURE 3



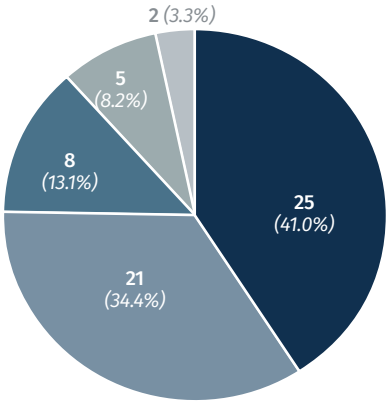
SEVERE MATERNAL MORBIDITY BY RACE/ETHNICITY

FIGURE 4

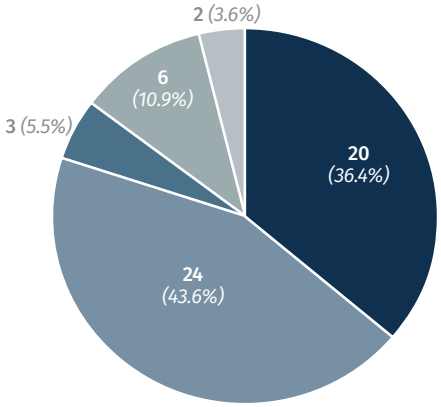


a. All SMM Events

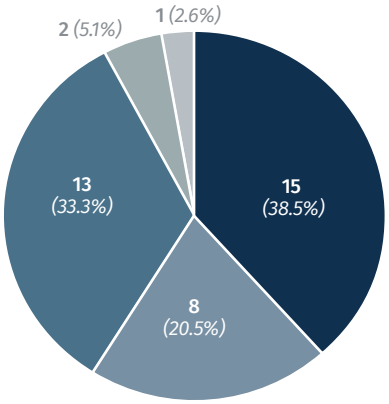
- More than a third of SMM events were experienced by each of non-Hispanic Black (38.7%) and non-Hispanic White (35.3%) patient groups, by 16.8% of Hispanic and 6.7% of non-Hispanic Asian patients (Figure 4a)
- Non-Hispanic Black women comprised the largest group of patients requiring ICU admission (41.0%) 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



c. Blood Transfusion

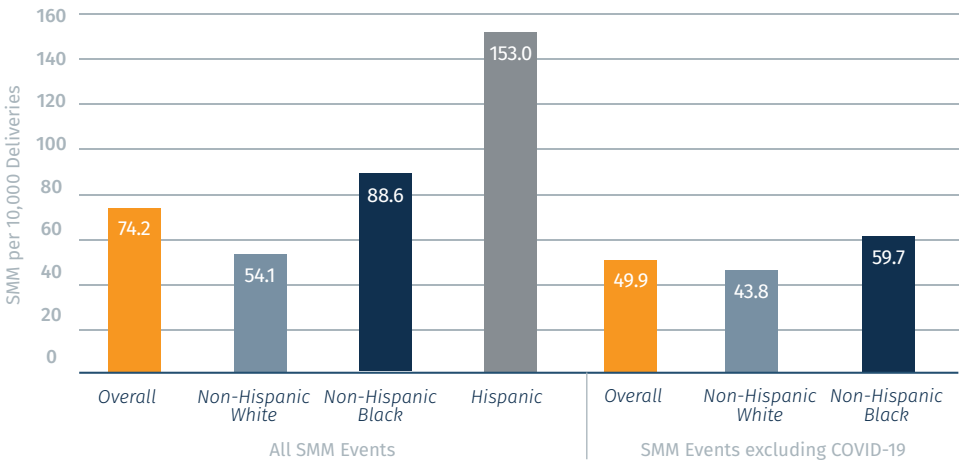


d. COVID-19 Infection

- 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



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

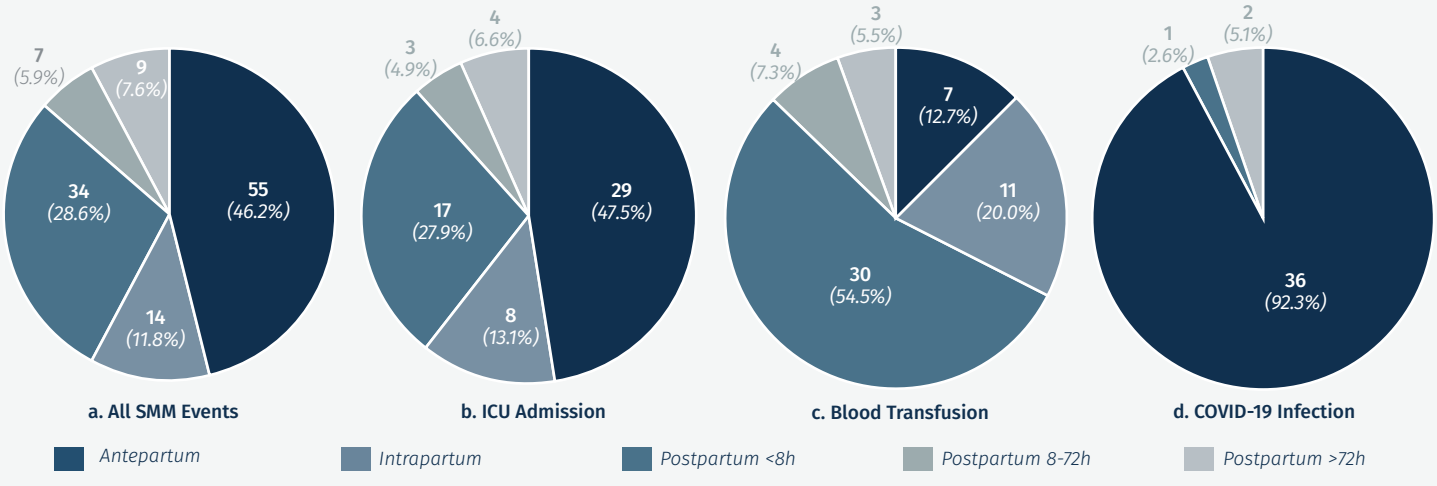
PATIENT CHARACTERISTICS		
Significant medical history	86.6%	103 of 119
Obesity	42.7%	32 of 75
Mental health disorder	25.6%	30 of 117
Cardiovascular condition	16.8%	20 of 119
Asthma	14.3%	17 of 119
Substance use	14.3%	17 of 119
Diabetes	7.6%	9 of 119
Complications in prior pregnancy	51.1%	47 of 92
Pregnancy 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

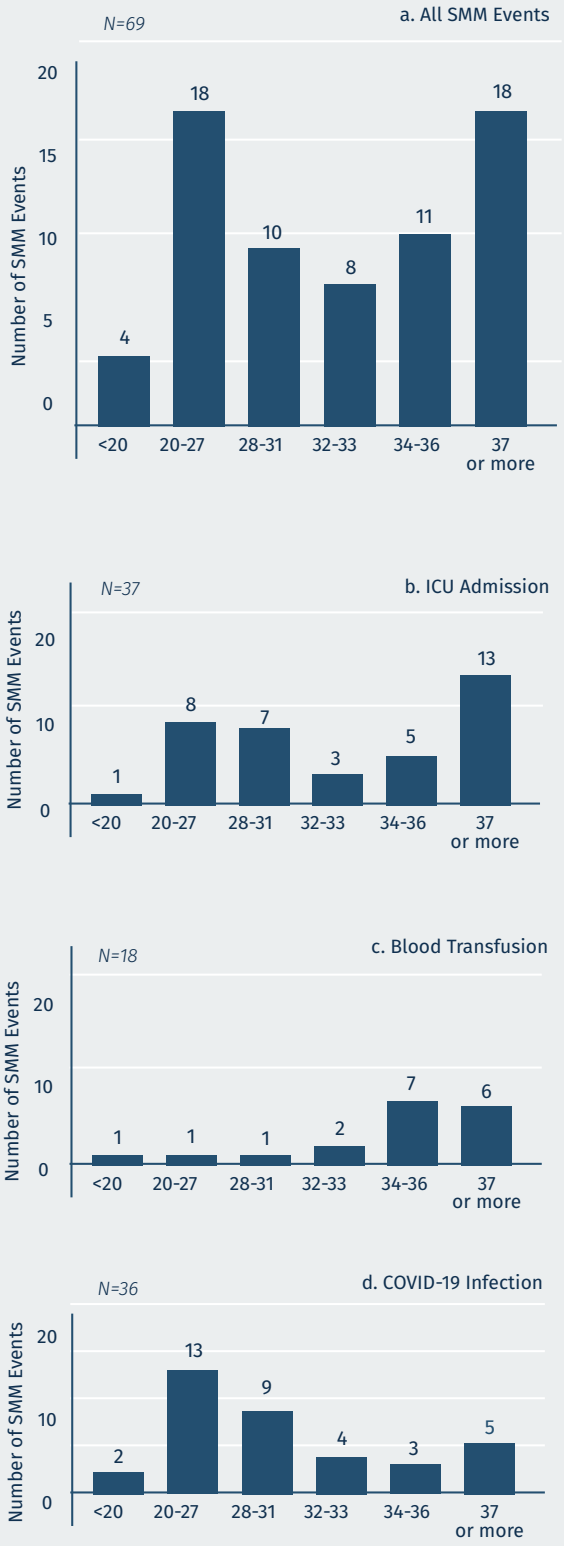
- Nearly half (46.2%) of the SMM events occurred during the antepartum period, 11.8% occurred intrapartum (Figure 6a)
- Among all postpartum SMM events (n=50), 64% occurred on the day of delivery and 16% the day after delivery, with the latest SMM event reported occurred 38 days after delivery
- The 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



GESTATIONAL AGE FOR ANTEPARTUM/INTRAPARTUM SEVERE MATERNAL MORBIDITY EVENTS

FIGURE 7



- 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

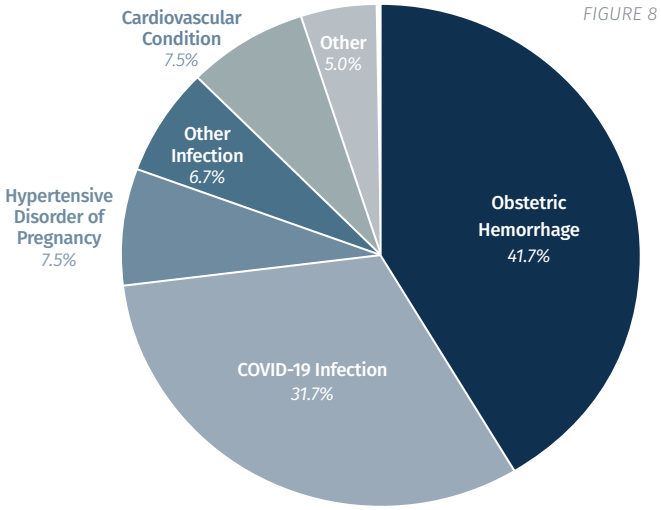
Delivered during the hospitalization with SMM event	68.1%	81 of 119
Vaginal delivery	32.1%	26 of 81
Spontaneous	84.6%	22 of 26
Assisted	15.4%	4 of 26
Cesarean delivery	67.9%	55 of 81
Planned	38.2%	21 of 55
Emergency	60.0%	33 of 55
Live birth	91.4%	74 of 81
Gestational age, mean (range)	37 weeks (24w5d-41w2d)	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 MATERNALMORBIDITY 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%)

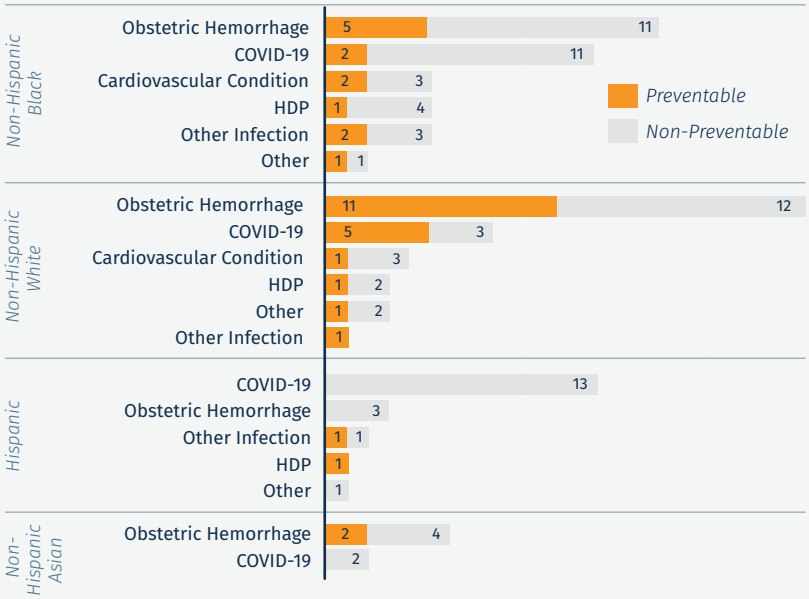
TABLE 5

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

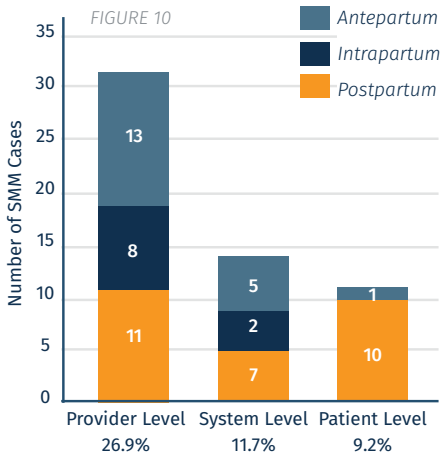


Note: HDP, Hypertensive disorders of pregnancy. Data shown are absolute numbers.

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).

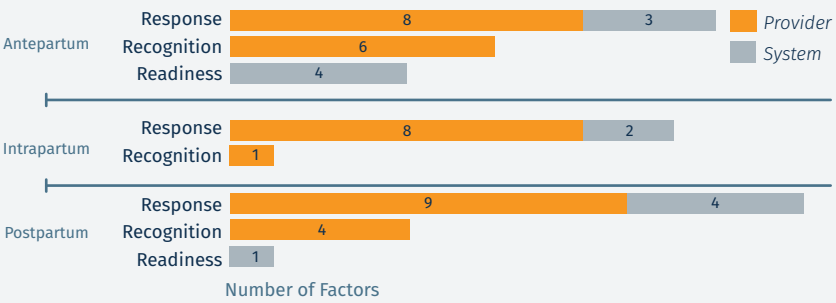
FIGURE 10



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



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.

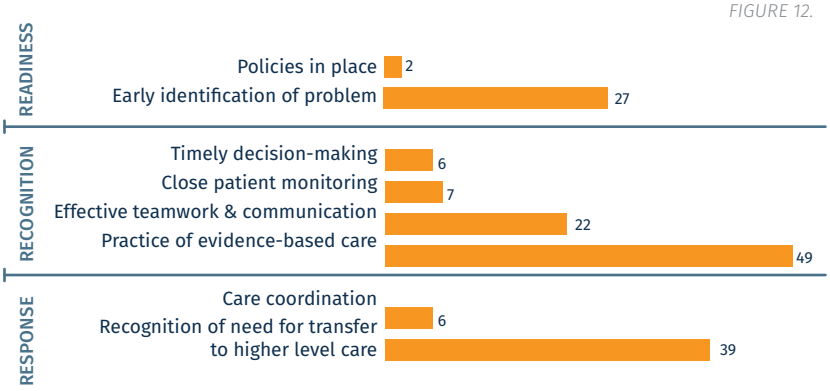
- Provider-level factors included earlier initiation of appropriate treatment, improved care coordination within unit and following chain of command
- System-level factors included higher readiness to address obstetric emergencies, timelier transfer to higher level of care and better care coordination across labor and delivery and ICU units
- Patient-level factor included improved patient-provider communication

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.

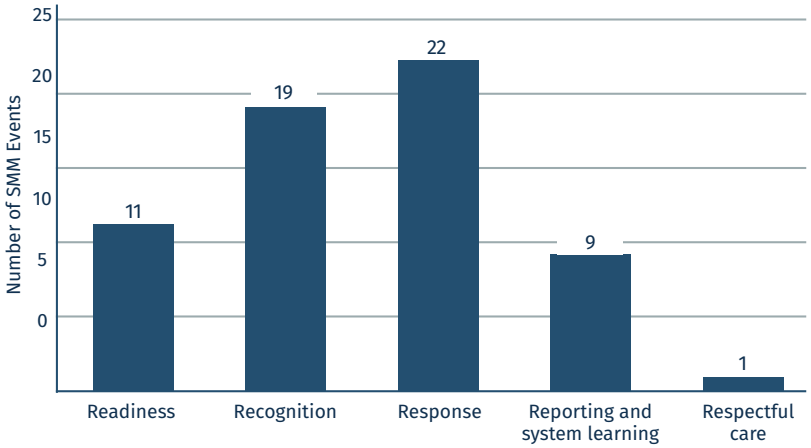


Note: Data shown are absolute numbers.
Fields for capturing this information were open-ended and unprompted; not mentioning these practices for a particular event does not mean they did not occur.

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



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

SEVERE MATERNAL MORBIDITY
SURVEILLANCE & REVIEW PILOT PROGRAM

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 facility-based SMM Surveillance and Review supported by Maryland House Bill 837/2020. The program began as a pilot in 6 of the 32 birthing hospitals in Maryland[4], and now includes 20 hospitals, covering more than 70% of births in the state.

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 blood products and/or

c. Hospitalization for management of emerging public health treats (e.g. severe 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).

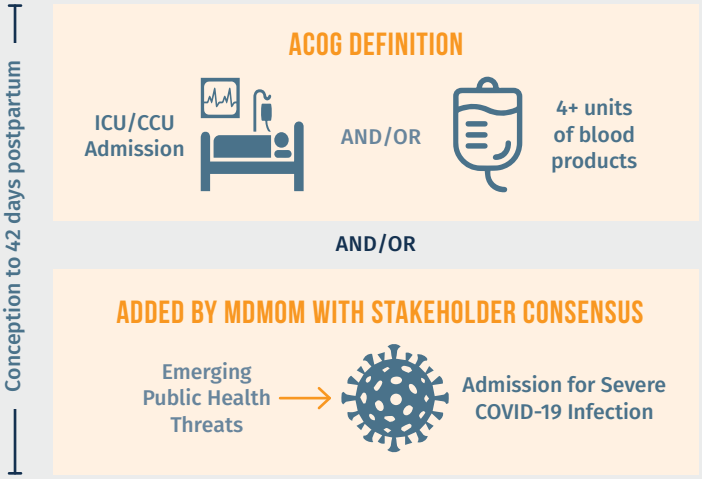
Hospital-based review committees met regularly to review and discuss SMM events and made recommendations for preventing similar events from occurring.

This report presents key findings from the SMM Surveillance and Review program from July 1, 2020 – December 31, 2022 and includes SMM events contributed by 13 hospitals, with varying timeframes of participation. 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



Notes: Adapted from ACOG's definition[2,3] for facility based SMM surveillance and informed by the Illinois SMM surveillance system and the UK Obstetric Surveillance System (UKOSS); Blood transfusion criteria changed over period of analysis. Prior to January 2022, threshold was ≥4 units of packed red blood cells transfused. Starting January 1, 2022, criteria included ≥4 units of any blood product. COVID-19 criteria changed over period of analysis. Prior to December 2021, criteria included all pregnant and postpartum patients admitted with COVID-19 infection. Starting December 1, 2021, criteria included pregnant and postpartum patients admitted with a COVID-19 infection and with a length of stay >1 day and treatment for 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. [4]Wolfson C, Qian J, Chin P, et al. Findings From Severe Maternal Morbidity Surveillance and Review in Maryland. JAMA Netw Open. 2022;5(11):e2244077. doi:10.1001/jamanetworkopen.2022.44077.

SEVERE MATERNAL MORBIDITY ABSTRACTION FORM MODULES

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 • Surgery and other follow-up after SMM event • COVID-19	• 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 improvements
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

- 374 SMM events were identified and abstracted in the 13 participating hospitals
- 59.9% of SMM events involved ICU/CCU admission, 52.1% involved blood transfusion of 4+ units of blood products, and 20.3% involved hospitalization for management of severe COVID-19 infection (Table 2)
- The average number of units of blood products transfused in events requiring transfusion was 9.1, ranging from 1* to 49 units *(*cases with <4 units transfused qualified as an SMM event due to ICU admission)*. The massive transfusion protocol was called in 81 events (38.9% of events requiring blood transfusion)
- About 3 in 10 SMM events met more than one definition criteria (Figure 2)

KEY SOCIO-DEMOGRAPHIC CHARACTERISTICS OF PATIENTS WITH SEVERE MATERNAL MORBIDITY

- Almost half of SMM events occurred in patients 25-34 years of age and just over a third in patients ≥35 years (Figure 3)
- 51.3% of patients with SMM events had private insurance, 42.0% were covered by Medicaid, and 4.6% had no insurance or self-paid for their hospitalization

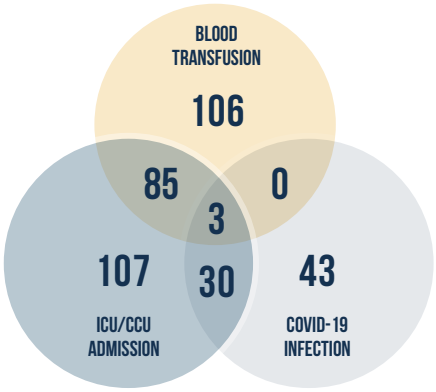
SEVERE MATERNAL MORBIDITY EVENT TYPES

TABLE 2

EVENT TYPE	N	%
ICU/CCU Admission	224	59.9
Blood Transfusion	195	52.1
COVID-19 Infection	76	20.3

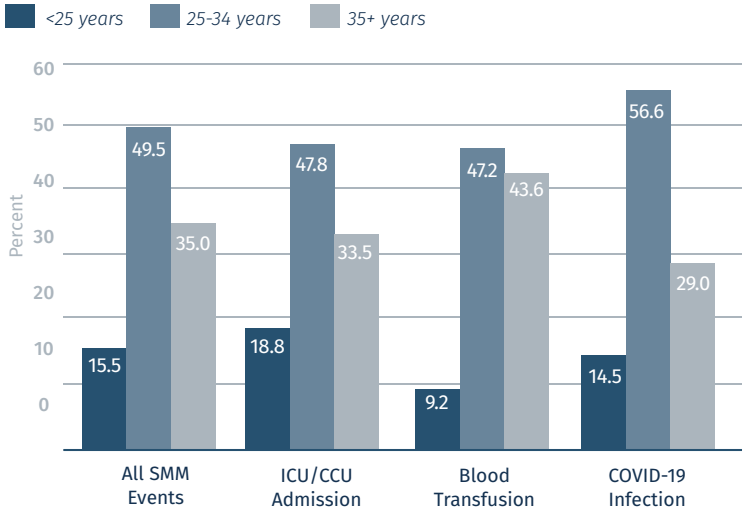
OVERLAP IN CASE DEFINITION CRITERIA

FIGURE 2



SEVERE MATERNAL MORBIDITY BY MATERNAL AGE

FIGURE 3



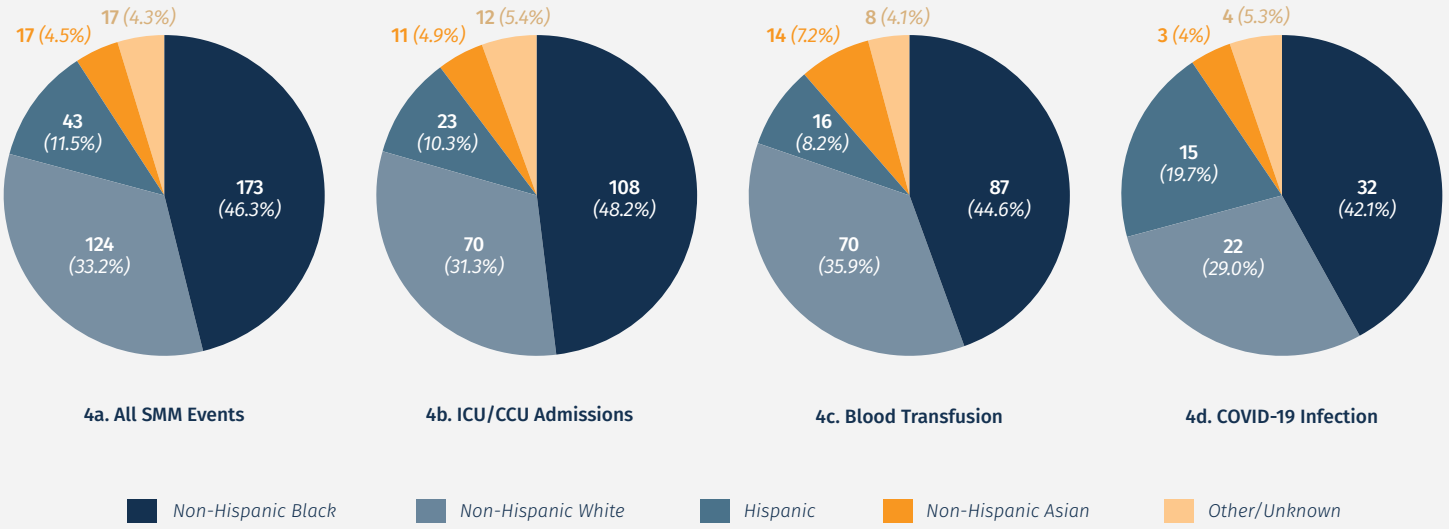
Note: ICU/CCU, intensive or critical care unit; blood transfusion includes patients with ≥4 units transfused.

SEVERE MATERNAL MORBIDITY BY RACE & ETHNICITY

- Almost half (46.3%) of SMM events were experienced by non-Hispanic Black patients, a third by non-Hispanic White (33.2%) patients, 11.5% by Hispanic patients and 4.6% by non-Hispanic Asian patients (Figure 4a)
- Non-Hispanic Black patients comprised the largest group requiring ICU admission (48.2%), blood transfusion (44.6%), and hospitalization for severe COVID-19 infection (42.1%, Figures 4b, 4c, and 4d)

SEVERE MATERNAL MORBIDITY BY RACE & ETHNICITY

FIGURE 4

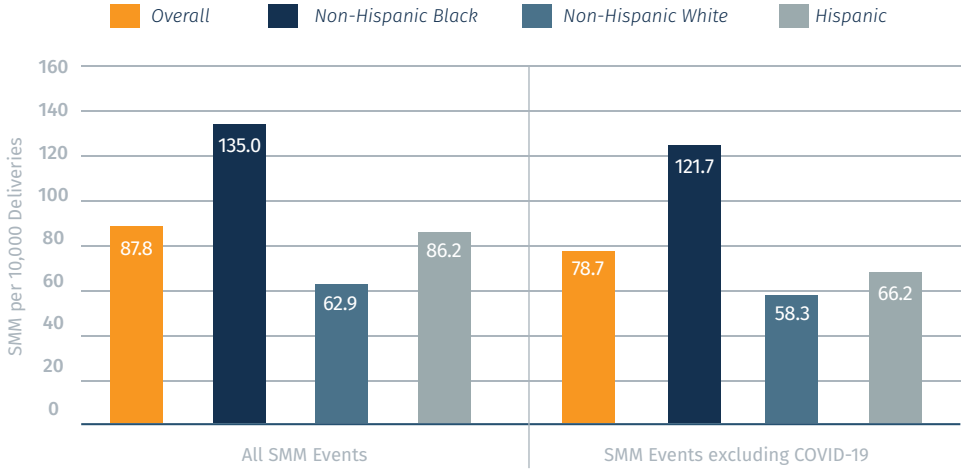


Note: ICU/CCU, intensive or critical care unit; blood transfusion includes patients with ≥4 units transfused.

- The SMM rate was highest for non-Hispanic Black patients (135.0 per 10,000 deliveries); more than double that of non-Hispanic White patients (62.9 per 10,000 deliveries) (Figure 5)
- While lower than for non-Hispanic Black patients, the SMM rate among Hispanic patients (86.2 per 10,000 deliveries) was 37% higher than in non-Hispanic White patients (62.9 per 10,000 deliveries)
- Exclusion of severe COVID-19 infection from the case definition would have reduced the overall SMM rate from 87.8 to 78.7 per 10,000 deliveries

SEVERE MATERNAL MORBIDITY RATES BY RACE & ETHNICITY

Figure 5



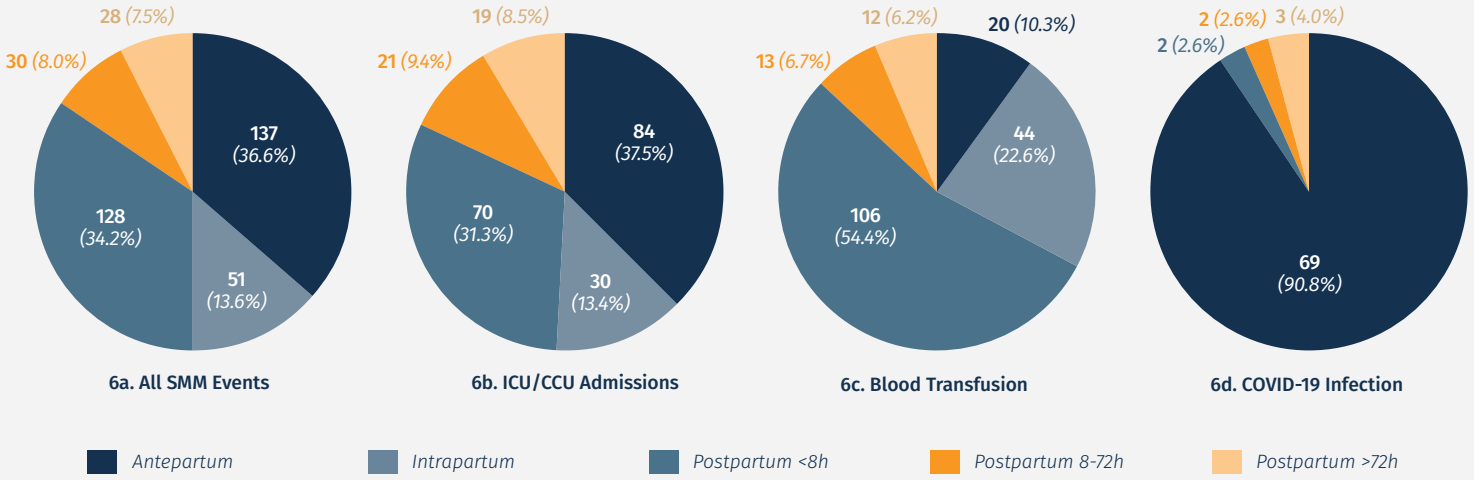
Note: Denominators are based on 2020-2022 births in participating hospitals as available from AHRQ's Maryland Statewide Inpatient Database. Rates for other racial/ethnic groups are not shown given small numbers yielding unstable rates.

TIMING OF SEVERE MATERNAL MORBIDITY EVENTS

- Over one-third (36.6%) of the SMM events occurred during the antepartum period and during the first 8 hours after delivery (34.2%) (Figure 6a)
- The antepartum period was most common time for SMM events that involved hospitalization for COVID-19 infection (90.8%) and those requiring ICU admission (37.5%)
- Among all postpartum SMM events (n=99), 71.7% occurred on the day of delivery and 8.1% the day after delivery; the latest SMM event reported occurred 39 days after delivery
- 54.4% of SMM blood transfusion events occurred, as expected, during the first 8 hours after delivery (Figures 6c)

TIMING OF SEVERE MATERNAL MORBIDITY EVENTS

FIGURE 6



Note: ICU/CCU, intensive or critical care unit; blood transfusion includes patients with ≥4 units transfused.

LENGTH OF HOSPITAL STAY

- The average length of hospital stay for patients with an SMM event was 6.7 days, ranging from 0 to 84 days
- Among patients with SMM and an ICU admission (n=224), the average length of stay in the ICU was 2.9 days, ranging from 0 to 35 days

MEDICAL & OBSTETRIC HISTORY OF PATIENTS WITH SEVERE MATERNAL MORBIDITY

- The most common pre-existing medical condition prior to the index pregnancy was obesity (41.2%), followed by a mental health disorder (31.3%) and chronic hypertension (19.1%) (Table 3)
- Among those who reported substance use (n=70), marijuana (62.9%), tobacco (25.7%), and opioids (14.3%) were most frequently reported
- 27.8% of patients with SMM events had no prior births, 27.8% had one prior birth, 21.4% had two prior births, and 23.0% had three or more prior births
- About one in ten patients (10.4%) used assisted reproductive technology to conceive the index pregnancy

MEDICAL HISTORY AND CARE SEEKING

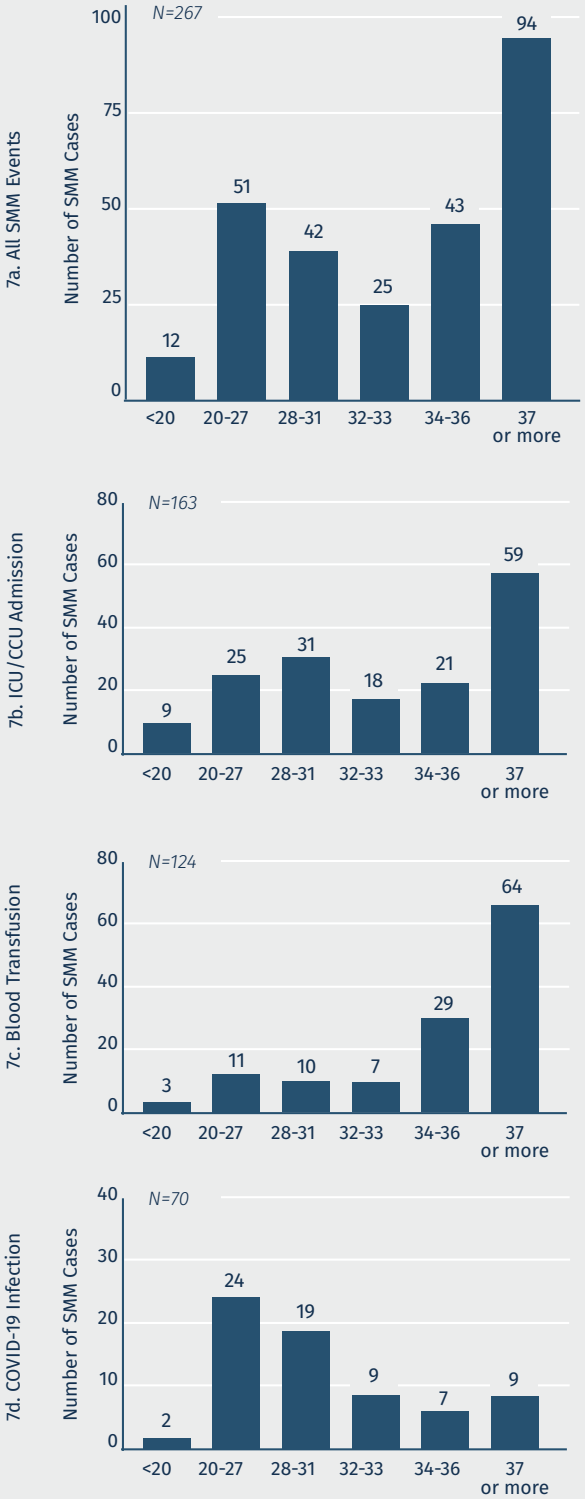
TABLE 3

PATIENT CHARACTERISTICS		
Significant medical history	77.4%	287 of 371
Obesity	41.2%	153 of 371
Mental health disorder	31.3%	116 of 371
Chronic hypertension	19.1%	71 of 371
Asthma	18.6%	69 of 371
Substance use	18.9%	70 of 371
Anemia	14.6%	54 of 371
Diabetes	6.7%	25 of 371
Cardiovascular condition	5.9%	22 of 371
Complications in prior pregnancy	66.3%	165 of 249
Pregnancy loss	36.9%	92 of 249
Cesarean delivery	26.1%	65 of 249
Hypertensive disorder of pregnancy	15.7%	39 of 249
Gestational diabetes	5.6%	14 of 249
Complications in current pregnancy	65.4%	233 of 356
Hypertensive disorder of pregnancy	16.3%	58 of 356
Placental abnormality	14.9%	53 of 356
Gestational diabetes	8.1%	29 of 356
Prenatal care		
Prenatal care initiated in first trimester	76.3%	251 of 329
No prenatal care	3.3%	12 of 367

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

GESTATIONAL AGE (WEEKS) FOR ANTEPARTUM/INTRAPARTUM SEVERE MATERNAL MORBIDITY EVENTS

FIGURE 7



Note: ICU/CCU, intensive or critical care unit; blood transfusion includes patients with ≥4 units transfused.

GESTATIONAL AGE (WEEKS) FOR ANTEPARTUM/ INTRAPARTUM SEVERE MATERNAL MORBIDITY EVENTS

- Of the SMM events that occurred antepartum or intrapartum (n=267), 23.6% occurred before 28 weeks, 41.2% between 28 and 36 weeks, and 35.2% at 37 weeks or more gestation (Figure 7a)
- Over one third (36.2%) of ICU admission events and one half of blood transfusion events (51.6%) occurred at 37 weeks or more (Figures 7b-c)
- More than two-thirds (64.2%) of events involving severe COVID-19 infection occurred before 32 weeks of gestation (Figures 7d)

DELIVERY OUTCOMES AMONG PATIENTS WITH SEVERE MATERNAL MORBIDITY

- A total of 264 (70.6%) SMM events occurred during the delivery hospitalization, of which 25.8% were vaginal and 72.3% were cesarean deliveries (Table 4)
- The majority of deliveries were live births (91.3%), with an average gestational age of 37 weeks
- Nearly half (45.6%) of infants were born preterm, 36.1% were low birthweight, and 47.3% were admitted to the neonatal intensive care unit (NICU)

DELIVERY CHARACTERISTICS OUTCOMES AMONG PATIENTS WITH SEVERE MATERNAL MORBIDITY

TABLE 4

SMM Event Occurred During Delivery Hospitalization[1]	70.6%	264 of 374
Vaginal delivery	25.8%	68 of 264
Spontaneous	92.6%	63 of 68
Assisted	7.4%	5 of 68
Cesarean delivery[2]	72.3%	191 of 264
Planned	35.3%	65 of 184
Emergency	64.7%	119 of 184
Live birth	91.3%	241 of 264
Gestational age, mean (range)	37w2d (20w4d-41w2d)	
Preterm birth	45.6%	110 of 241
Low birthweight	36.1%	87 of 241
NICU admission	47.3%	114 of 241
Stillbirth	9.5%	23 of 241
Gestational age, mean (range)	32w5d (18w6d-40w2d)	

Note: w, weeks, d, days, NICU, Neonatal intensive care unit; Reported denominators are based on events with available data for the relevant characteristic. [1]Five other delivery outcomes include ruptured uterus, hysterectomy, and dilation and curettage; [2]Cesarean delivery type unknown among 7 patients.

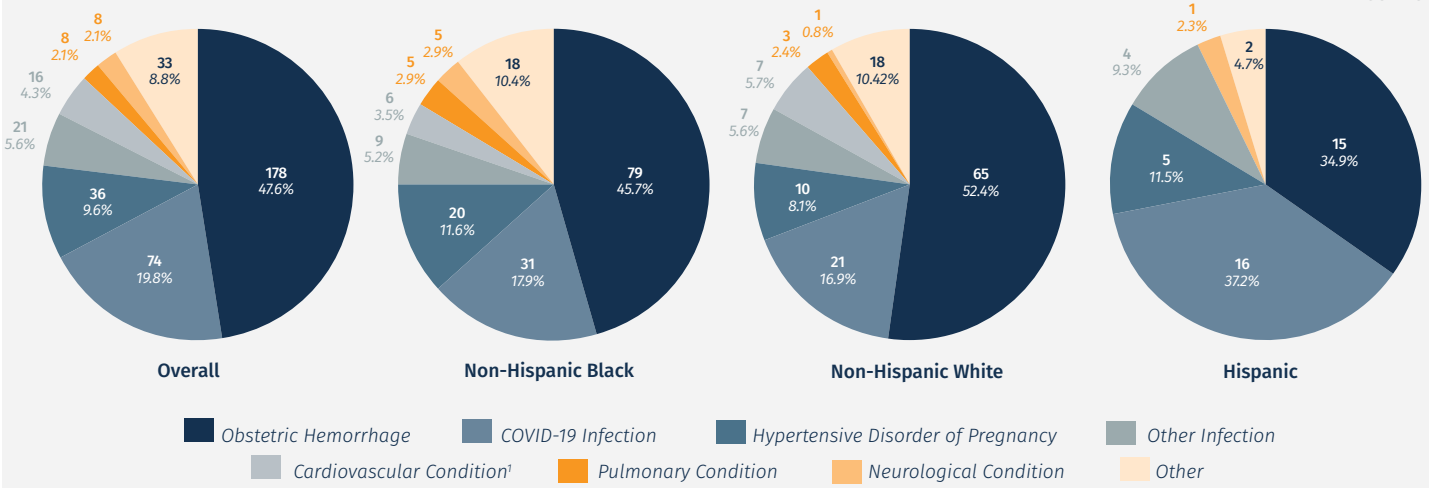
PRIMARY CAUSE OF SEVERE MATERNAL MORBIDITY EVENTS

- The most common primary cause of SMM was obstetric hemorrhage (47.6%), COVID-19 infection (19.8%), hypertensive disorder of pregnancy (9.6%), other infection (5.6%), and cardiovascular condition, including cardiomyopathy (4.3%, Figure 8)
- Among the 224 events requiring ICU admission, the top 5 primary causes of SMM were obstetric hemorrhage (36.2%), COVID-19 infection (15.6%), hypertensive disorder of pregnancy (14.3%), other infection (8.9%), and cardiovascular condition (6.7%)
- Common contributing morbidities for all types of SMM events were hypertensive disorder of pregnancy (12.3%), infection, including COVID-19 (10.4%), obstetric hemorrhage (10.7%), pulmonary condition (7.7%), obesity (6.7%), and cardiovascular condition (5.8%)

32% OF SEVERE MATERNAL MORBIDITY EVENTS WERE **POTENTIALLY PREVENTABLE**

PRIMARY CAUSE OF SEVERE MATERNAL MORBIDITY

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.
¹ Cardiovascular condition includes cardiomyopathy.

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 16.7% for cancer to 66.7% for metabolic/endocrine condition (Table 5)
- Among non-Hispanic Asian, Black, and White patients, approximately two-thirds of SMM events (35.3%, 32.4%, and 33.9%, respectively) were deemed preventable (Figure 9, next page)
- SMM preventability was lower for Hispanic patients at 23.3%
- Obstetric hemorrhage was the most common primary cause of preventable SMM events for non-Hispanic Asian (83.3%), Black (46.4%), and White patients (57.1%), while other infection was the most common preventable primary cause for Hispanic patients (40.0%)

PREVENTABILITY OF SEVERE MATERNAL MORBIDITY

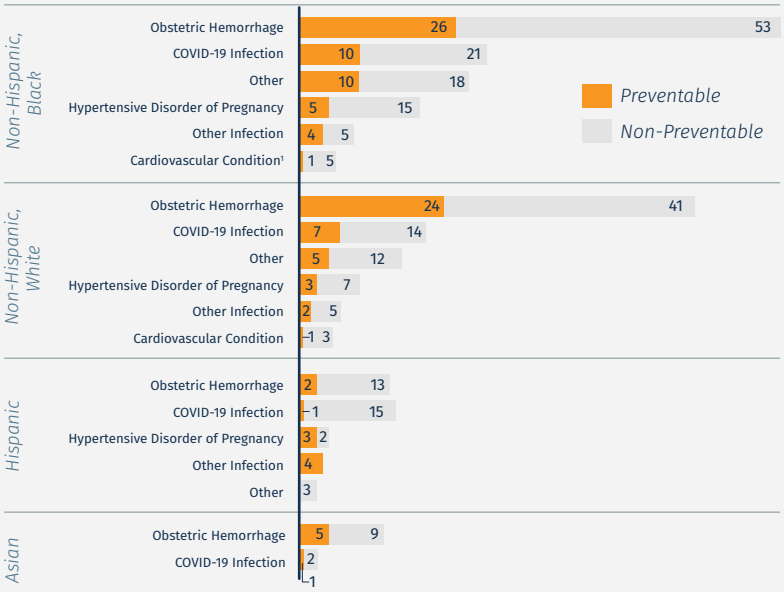
TABLE 5

CAUSE	%	N
Metabolic/endocrine condition	66.7	4 of 6
Other infection	52.4	11 of 21
Hematologic	50.0	3 of 6
Obstetric hemorrhage	32.6	58 of 178
Hypertensive disorder of pregnancy	30.6	11 of 36
COVID-19 infection	27.0	20 of 74
Neurologic condition	25.0	2 of 8
Pulmonary condition	25.0	2 of 8
Other	20.0	3 of 15
Cardiovascular condition[1]	18.8	3 of 16
Cancer	16.7	1 of 5

Note: [1] Cardiovascular condition includes cardiomyopathy.

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

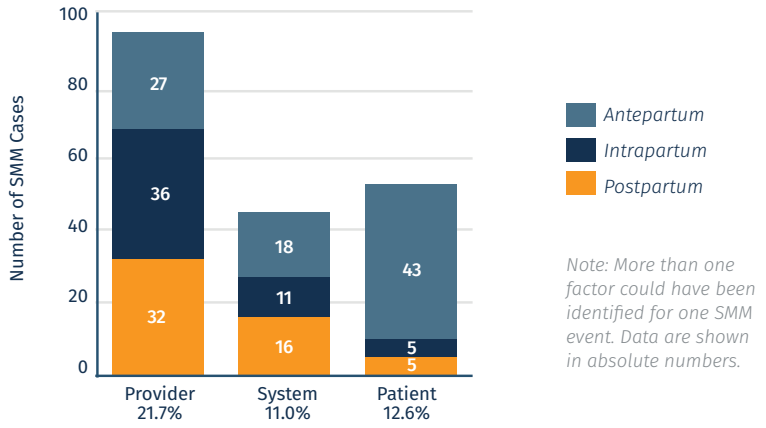
FIGURE 9



Note: Data are shown in absolute numbers; ¹Cardiovascular condition includes cardiomyopathy.

LEVEL, TIMING, AND FACTORS THAT COULD HAVE ALTERED THE SEVERE MATERNAL MORBIDITY OUTCOME

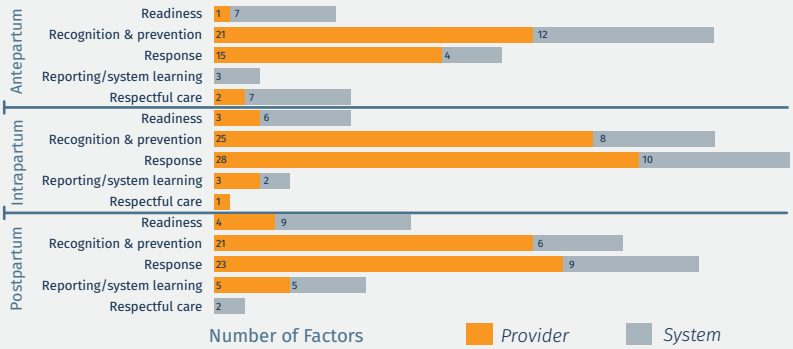
FIGURE 10



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

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

FIGURE 11



Note: Factors could apply to multiple 5Rs domains; Data are shown in 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 95 (21.7%), 45 (11.0%), and 53 (12.6%) SMM events, respectively (Figure 10).

About **17%** of SMM could have been prevented by addressing factors in the **antepartum** period. Most of these factors related to the Recognition, Response, and Respectful Care domains (Figure 11).

- Provider-level factors included enhanced monitoring of high-risk patients and earlier recognition of patient decompensation
- System-level factors included guidelines for outpatient management of high-risk patients
- Patient-level factors included utilization of prenatal care, management of preexisting medical conditions, and COVID-19 vaccination

About **12%** of SMM could have been prevented by addressing factors in the **intrapartum** period. Most of these factors related to the Readiness, Recognition and Response domains (Figure 11).

- Provider-level factors included referral to higher level of care, use of safe surgical technique and improved labor management
- System-level factors included availability of platelets and other resources including point of care testing

About **19%** of SMM could have been prevented by addressing factors in the **postpartum** period. Most of these factors related to the Readiness, Recognition and Response domains (Figure 11).

- Provider-level factors included earlier initiation of appropriate treatment, improved care coordination within unit and enhanced monitoring of high-risk patients
- System-level factors included higher readiness to address obstetric emergencies, better care coordination across labor and delivery, anesthesia, and ICU units, and enhanced training for travel nurses
- Patient-level factors included improved patient-provider communication and compliance with medical recommendations

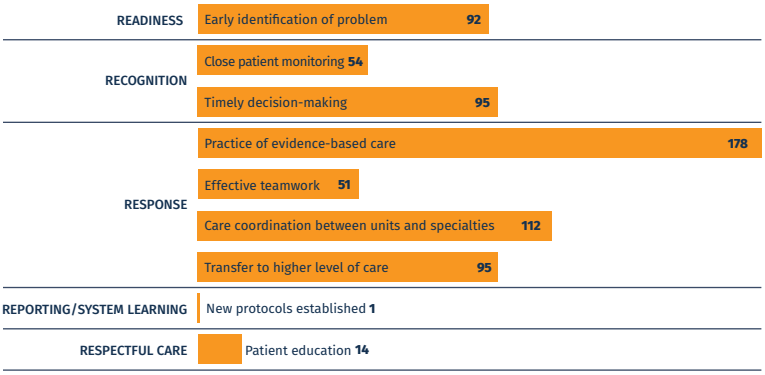
PRACTICES DONE WELL IN RELATION TO SEVERE MATERNAL MORBIDITY EVENTS

For all SMM events, Hospital Review Committees listed up to three practices that were done well and should be reinforced in their hospitals. Nine themes emerged from the 374 SMM events (Figure 12).

- The most commonly reported practices were practice of evidence-based care (mentioned in 178 reviews of SMM events, 47.6%) and care coordination between unites (mentioned in 112 reviews, 29.9%)

PRACTICES DONE WELL IN RELATION TO SEVERE MORBIDITY EVENTS REVIEWED

FIGURE 12



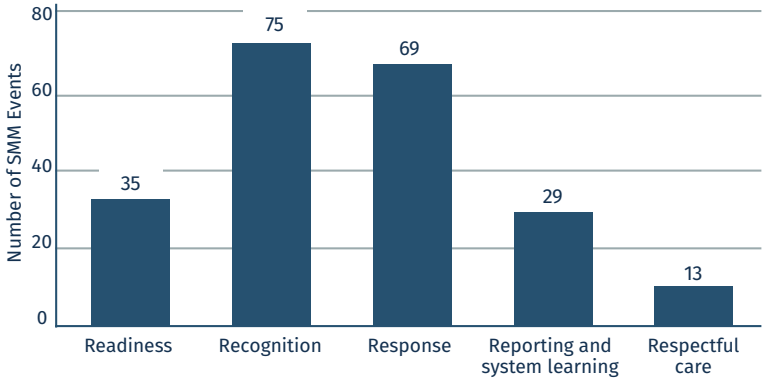
Note: Data are shown in absolute numbers; Fields for capturing this information were open-ended and unprompted; not mentioning these practices for a larger number of events does not mean that it did not occur.

KEY RECOMMENDATIONS FOR SEVERE MATERNAL MORBIDITY PREVENTION IN MARYLAND HOSPITALS

The most frequent recommendations by Hospital Review Committees were within the Recognition (75), Response (69), and Readiness (35) domains of the "5Rs" framework (Figure 13).

RECOMMENDATIONS FOR CARE IMPROVEMENT BY QUALITY IMPROVEMENT DOMAIN IN THE "5RS" FRAMEWORK

FIGURE 13



Note: Data are shown in absolute numbers. Recommendations were made in 194 SMM reviews. Hospital committees could make up to 3 recommendations for each event.

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

- Establish or strengthen Emergency Department protocols for OB emergencies
- Ensure 24/7 availability of assigned clinical staff and services (Anesthesia and OR) to assist with OB emergencies
- Enhance rapid availability of all blood products, especially platelets
- Require that all staff new to the OB unit be educated on emergency OB procedures and location of needed equipment

RECOGNITION *Assessment and measurement*

- Improve the recognition of patients in need of closer monitoring during the antenatal period
- Reinforce staff education in the recognition of clinical markers signaling patients at risk for decompensation intrapartum and in the immediate postpartum period
- Closer inspection and longer observation in the immediate postpartum period for adequate hemostasis and evidence of organ injury
- Discern aberration of clinical values upon patients' presentation

RESPONSE *Treatment and management*

- Reinforce TeamSTEPPS communication strategies with OB care teams
- Establish communication pathways to enhance clinical specialties involvement in the coordination of OB patient care
- Review guidelines for escalating patient care to a higher level with frontline staff
- Provide readily assessable clinical pathways to guide new or inexperienced staff in OB emergencies to reduce care variation

REPORTING AND SYSTEM LEARNING *Communication, debrief and review*

- Encourage the reporting of critical values directly to the clinician as well as in the EHR
- Encourage system learning to better manage hemorrhage and blood transfusion events
- Reinforce established guidelines allowing for open communication among all staff to enhance OB patient care

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

- Provide a listing and contact number of available support and resources at first contact with high-risk patients (e.g. those with medical risk due to pregnancy conditions, comorbidities, substance use; and patients with barriers to care).
- Periodic follow up calls to establish rapport and/or offer support to high-risk patients

Note: OB, obstetric; OR, operating room; EHR, electronic health record.

July 2024

SEVERE MATERNAL MORBIDITY SURVEILLANCE & REVIEW PROGRAM IN MARYLAND

Severe maternal morbidity (SMM) includes potentially life-threatening conditions or complications during pregnancy, labor and delivery, and postpartum. SMM events 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]

Reviewing SMM events at the facility level allows for the:

- Characterization of causes and factors that led to morbidity.
- Determination of whether the event was preventable.

By identifying 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.

In July 2020, the Maryland Maternal Health Innovation Program (MDMOM) initiated facility-based SMM Surveillance and Review supported by Maryland House Bill 837/2020. The program began as a pilot in six of the 32 birthing hospitals in Maryland, and now includes 27 hospitals, covering more than 80% of births in the state.[4]

All SMM events in pregnant and up to 42-day postpartum patients admitted at participating hospitals are identified and reviewed using the following case definition (Figure 1):

1. Admission to an intensive/critical care unit (ICU/CCU); and/or
2. Transfusion of four or more units of blood products.

Trained clinical abstractors review all available maternal and newborn medical records for each SMM event using a standardized electronic, de-identified review form.

Hospital-based review committees meet regularly to review and discuss SMM events, identify primary causes of each SMM event, determine whether each event was preventable, and make recommendations for preventing similar events from occurring.

This report presents key findings from the SMM Surveillance and Review program in 2023 and includes all SMM events contributed by participating hospitals during the reporting period. 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 the following:

Readiness

Recognition and Prevention

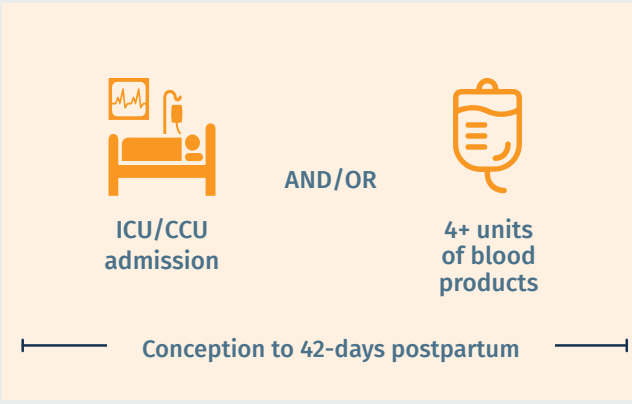
Response

Reporting and System Learning

Respectful Care

SEVERE MATERNAL MORBIDITY SURVEILLANCE CASE DEFINITION

FIGURE 1



Notes: Adapted from ACOG's definition for facility based SMM surveillance and informed by the Illinois SMM surveillance system and the UK Obstetric Surveillance System (UKOSS).[2,3]

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.*

4 *Wolfson C, Qian J, Chin P, et al. Findings From Severe Maternal Morbidity Surveillance and Review in Maryland. JAMA Netw Open. 2022;5(11):e2244077. doi:10.1001/jamanetworkopen.2022.44077.*

FIGURE 2

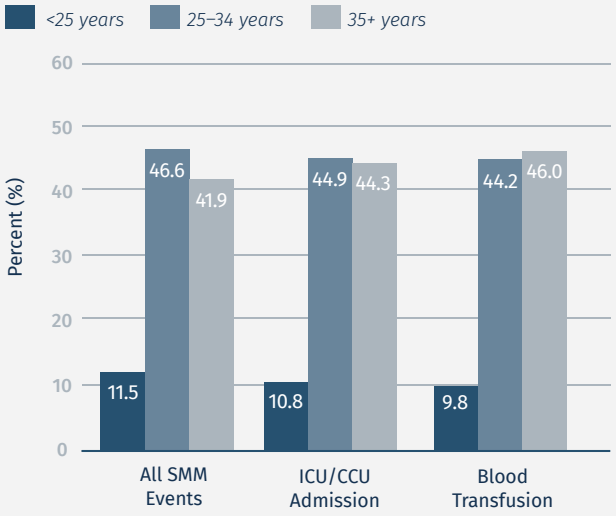
SEVERE MATERNAL MORBIDITY EVENT TYPES

ICU/CCU ADMISSION	BOTH CRITERIA	BLOOD TRANSFUSION ≥ 4 UNITS
41.6%	21.5%	36.9%
(116)	(60)	(103)

279 SMM Events

FIGURE 3

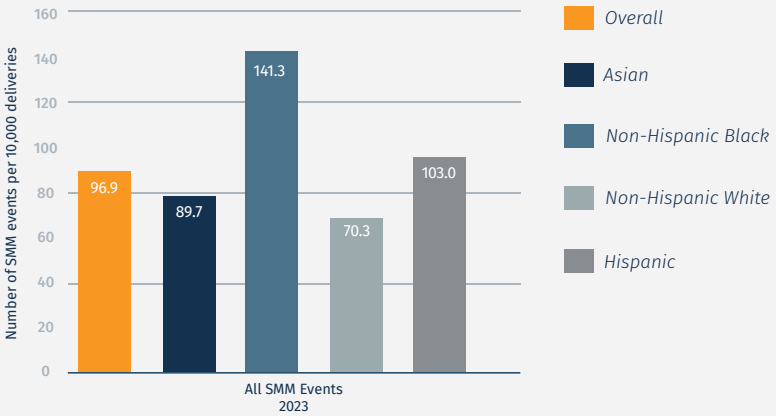
SEVERE MATERNAL MORBIDITY BY MATERNAL AGE



Note: Blood transfusion includes patients with ≥4 units transfused.

Figure 4

SEVERE MATERNAL MORBIDITY RATES BY RACE & ETHNICITY



Note: Denominators are based on 2022 births in participating 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.

SEVERE MATERNAL MORBIDITY EVENTS IDENTIFIED AND REVIEWED

- 279 SMM events were identified and abstracted in 2023.
- 41.6% of SMM events involved ICU/CCU admission only, 36.9% involved blood transfusion of 4+ units of blood products only, and 21.5% involved both (Figure 2).
- The average number of units of blood products transfused in events requiring transfusion was 8.4, ranging from <1 to 92 units (n.b. cases with <4 units transfused qualified as an SMM event due to ICU admission). The massive transfusion protocol was called in relation to 60 SMM events (35.9% of events requiring blood transfusion).

KEY SOCIO-DEMOGRAPHIC CHARACTERISTICS OF PATIENTS WITH SEVERE MATERNAL MORBIDITY

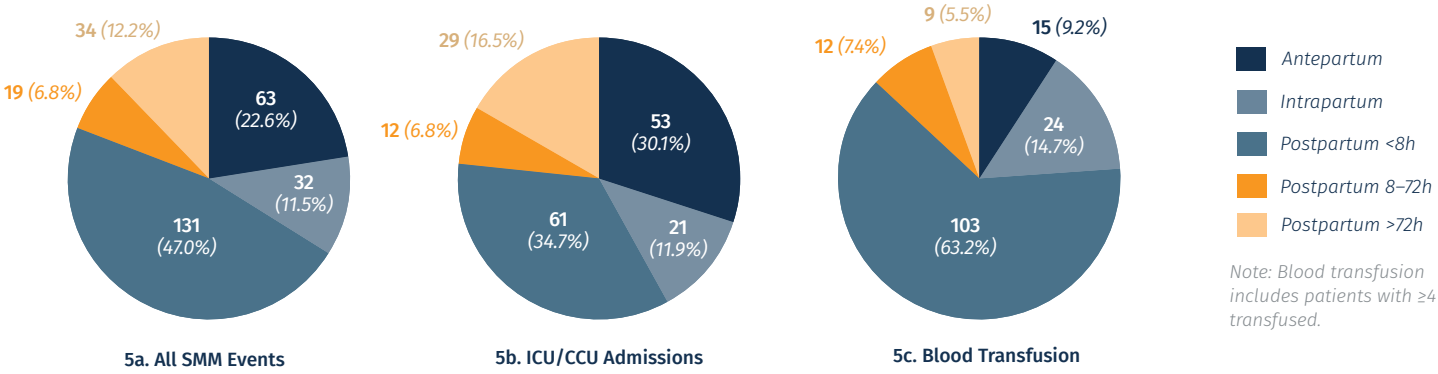
- Patients 25–34 years of age comprised the largest share of patients experiencing SMM (46.6%); 41.9% of all SMM events were in patients ≥35 years (Figure 3).
- 50.2% of patients with SMM had private insurance, 41.9% were covered by public insurance, and 4.3% had no insurance or self-paid for their hospitalization (data not shown).

SEVERE MATERNAL MORBIDITY BY RACE & ETHNICITY

- The SMM rate was highest for non-Hispanic Black patients (141.3 per 10,000 deliveries), which was double the rate of non-Hispanic White patients (70.3 per 10,000 deliveries) (Figure 4).
- Though lower than for non-Hispanic Black patients, the SMM rate among Hispanic patients (103.0 per 10,000 deliveries) was 47% higher than in non-Hispanic White patients.

FIGURE 5

TIMING OF SEVERE MATERNAL MORBIDITY EVENTS



5a. All SMM Events

5b. ICU/CCU Admissions

5c. Blood Transfusion

Note: Blood transfusion includes patients with ≥4 units transfused.

TIMING OF SEVERE MATERNAL MORBIDITY EVENTS

- Two-thirds of the SMM events occurred during the postpartum period; most occured within eight hours of delivery (Figure 5a).
- Most patients with antepartum and postpartum SMM >72 hours following delivery involved ICU admission (Figure 5b).

LENGTH OF HOSPITAL STAY

- The average length of hospital stay for patients with an SMM event was 6.5 days, ranging from 1 to 79 days.
- Among patients with SMM and an ICU admission (n=176), the average length of stay in the ICU was 2.5 days, ranging from 0 to 25 days (data not shown).

MEDICAL & OBSTETRIC HISTORY OF PATIENTS WITH SEVERE MATERNAL MORBIDITY

- The most common medical condition prior to the current pregnancy was obesity (38.7%), followed by a mental health condition (35.1%) and chronic hypertension (19.0%) (Table 1).
- Among those who reported substance use (n=45), marijuana (59.0%), cocaine (30.8%), tobacco (28.2%), and opioids (18.0%) were most frequently reported (data not shown).
- More than one in four patients with SMM did not initiate prenatal care during the first trimester, and more than 7% had no prenatal care.
- 30.5% of patients with SMM events had no prior births, 29.8% had one prior birth, 21.5% had two prior births, and 18.3% had three or more prior births (data not shown).
- About one in 10 patients (9.7%) used assisted reproductive technology to conceive the current pregnancy (data not shown).

TABLE 1

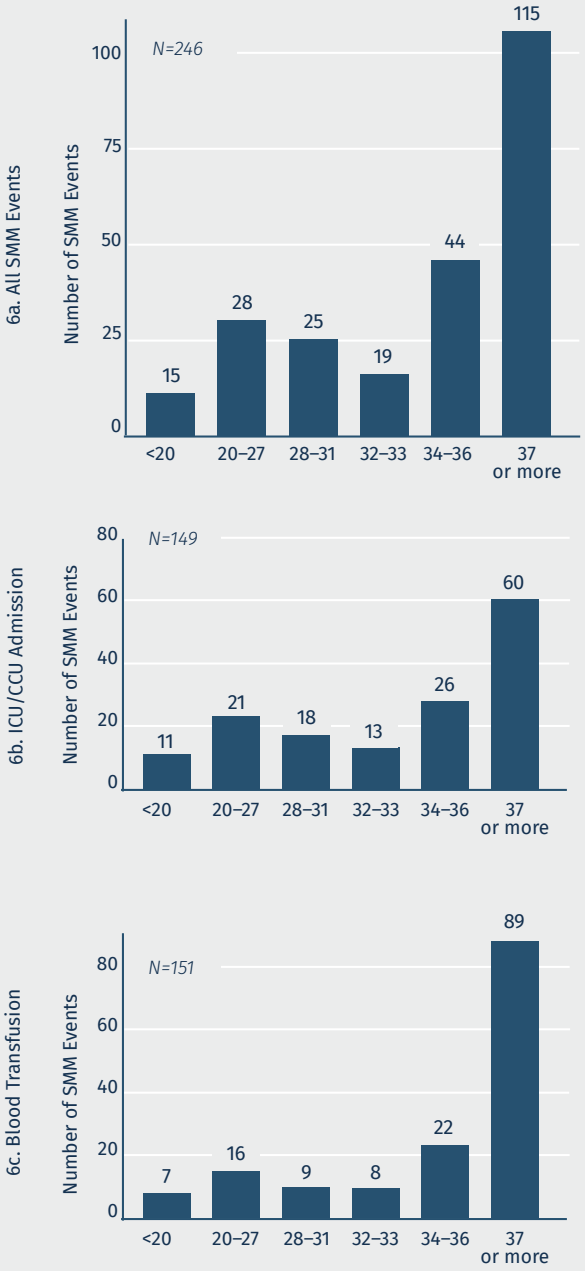
MEDICAL HISTORY AND CARE SEEKING

PATIENT CHARACTERISTICS	%	N
Significant medical history	**80.3%**	**224 of 279**
Obesity	38.7%	108 of 279
Mental health condition	35.1%	98 of 279
Chronic hypertension	19.0%	53 of 279
Anemia	18.6%	52 of 279
Asthma	17.9%	50 of 279
Substance use	16.1%	45 of 279
Cardiovascular condition	9.0%	25 of 279
Diabetes	7.9%	22 of 279
Complications in prior pregnancy	**73.1%**	**141 of 193**
Pregnancy loss	43.0%	83 of 193
Cesarean delivery	36.8%	71 of 193
Hypertensive disorder of pregnancy	19.7%	38 of 193
Gestational diabetes	7.8%	15 of 193
Complications in current pregnancy	**73.0%**	**197 of 270**
Hypertensive disorder of pregnancy	29.6%	80 of 270
Placental abnormality	15.6%	42 of 270
Gestational diabetes	12.6%	34 of 270
Prenatal care	**92.4%**	**255 of 276**
Prenatal care initiated in first trimester	73.9%	176 of 238
No prenatal care	7.6%	21 of 276

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

FIGURE 6

GESTATIONAL AGE (WEEKS) FOR ANTEPARTUM/INTRAPARTUM SEVERE MATERNAL MORBIDITY EVENTS



Note: Blood transfusion includes patients with ≥4 units of blood products transfused.

GESTATIONAL AGE FOR ANTEPARTUM/INTRAPARTUM SEVERE MATERNAL MORBIDITY EVENTS

- Of the SMM events that occurred antepartum or intrapartum (n=246), 17.5% occurred before 28 weeks, 35.8% between 28 and 36 weeks, and 46.7% at 37 weeks or more gestational age (Figure 6a).
- Over one third (40.2%) of ICU admission events and over half of blood transfusion events (58.9%) occurred at 37 weeks or more gestational age (Figure 6c).

DELIVERY OUTCOMES AMONG PATIENTS WITH SEVERE MATERNAL MORBIDITY

- 219 (78.5%) SMM events occurred during the delivery hospitalization, of which 21.0% were vaginal and 73.5% were cesarean deliveries (Table 2).
- Most deliveries were live births (90.0%), with an average gestational age of 35 weeks and 6 days (Table 2).
- Nearly half (44.7%) of infants were born preterm, 35.5% were low birthweight, and 50.3% were admitted to the neonatal intensive care unit (NICU).

DELIVERY OUTCOMES AMONG PATIENTS WITH SEVERE MATERNAL MORBIDITY

TABLE 2

SMM Event Occurred During Delivery Hospitalization	78.5%	219 of 279
Vaginal delivery	21.0%	46 of 219
Spontaneous	91.3%	42 of 46
Assisted	8.7%	4 of 46
Cesarean delivery	73.5%	161 of 219
Planned	47.2%	76 of 161
Emergency	52.2%	84 of 161
Surgical evacuation	7.5%	12 of 161
Live birth	90.0%	197 of 219
Gestational age, mean (range)	35w6d (23w6d–41w2d)	
Preterm birth	44.7%	88 of 197
Low birthweight	35.5%	70 of 197
NICU admission	50.3%	99 of 197
Stillbirth	9.5%	23 of 241
Gestational age, mean (range)	32w5d (18w6d–40w2d)	

Note: w=weeks, d=days, NICU=Neonatal intensive care unit; Reported denominators are based on events with available data for the relevant characteristic.

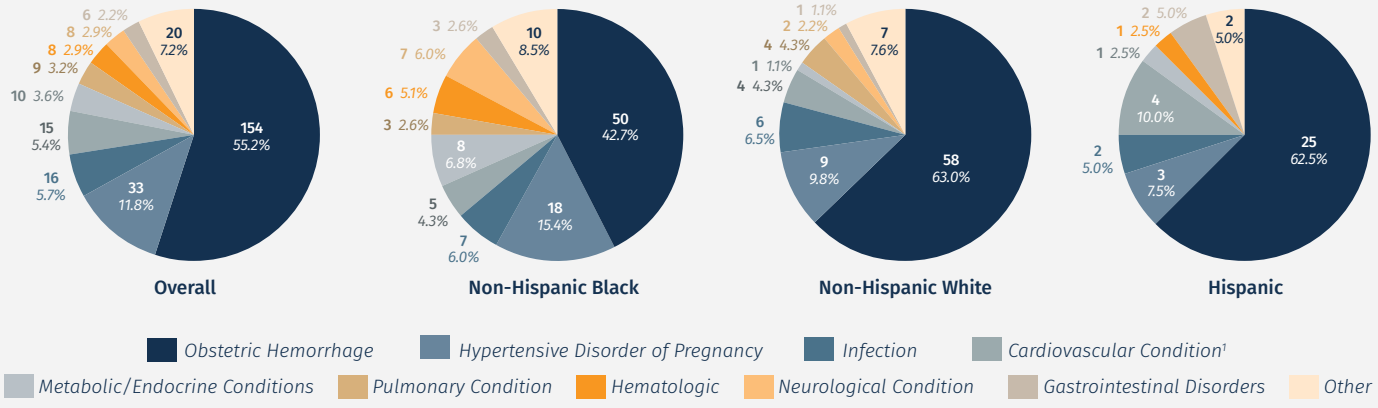
PRIMARY CAUSE OF SEVERE MATERNAL MORBIDITY

- The most common primary cause of SMM was obstetric hemorrhage (55.2%), followed by hypertensive disorders of pregnancy (11.8%), infection (non-COVID) (5.7%), cardiovascular conditions (5.4%), and metabolic/endocrine conditions (3.6%) (Figure 7).
- Among the 176 events requiring ICU admission, the top five primary causes of SMM were obstetric hemorrhage (36.4%), hypertensive disorders of pregnancy (15.9%), infection (8.6%), cardiovascular conditions (6.3%), and metabolic/endocrine conditions (5.7%) (data not shown).
- Common contributing morbidities for all types of SMM events were hypertensive disorders of pregnancy (15.8%), hematologic conditions (9.3%), obstetric hemorrhage (9.0%), pulmonary conditions (7.9%), metabolic/endocrine conditions (6.8%), infection, including COVID-19 (5.0%), and mental health conditions (5%) (data not shown).

34% OF SEVERE MATERNAL MORBIDITY EVENTS WERE **POTENTIALLY PREVENTABLE.**

PRIMARY CAUSE OF SEVERE MATERNAL MORBIDITY

FIGURE 7



Note: [1] Cardiovascular condition includes cardiomyopathy.

PREVENTABILITY OF SEVERE MATERNAL MORBIDITY

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

- Preventability was determined by a facility based multidisciplinary SMM Review Committee.
- Preventability of SMM events varied by the primary cause, ranging from 20% for cardiovascular conditions to 70% for metabolic/endocrine conditions (Table 3).
- Preventability varied by race and ethnicity with 49.0% of SMM events among non-Hispanic Black patients were considered preventable, compared to 34.4% among non-Hispanic White patients, 8.3% among Hispanic patients, and 6.3% among Asian patients (Figure 8).
- Obstetric hemorrhage was the most common primary cause of preventable SMM events for all racial and ethnic groups.

PREVENTABILITY OF SEVERE MATERNAL MORBIDITY

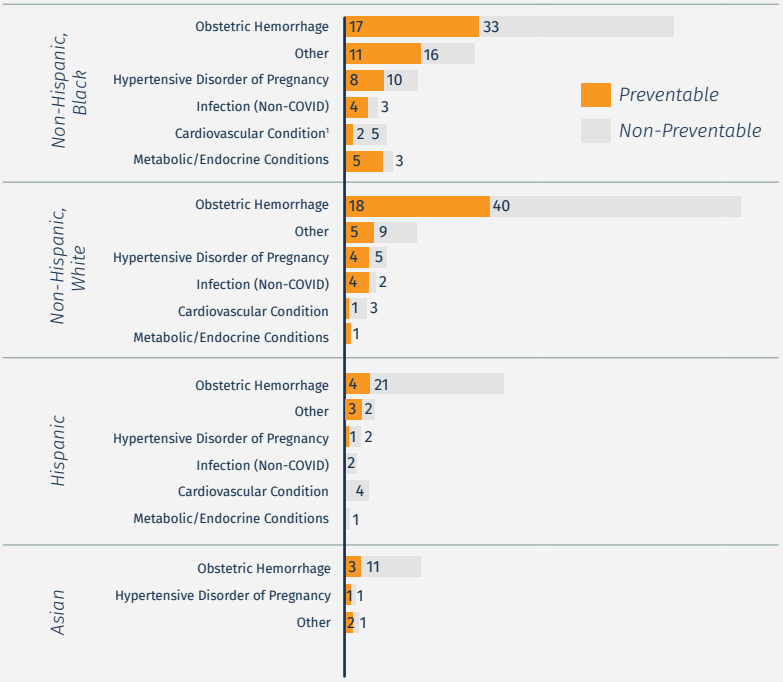
TABLE 3

CAUSE	%	N
Metabolic/endocrine condition	70.0%	7 of 10
Gastrointestinal condition	50.0%	3 of 6
Infection (non-COVID)	50.0%	8 of 16
Pulmonary condition	44.4%	4 of 9
Hypertensive disorder of pregnancy	42.4%	14 of 33
Other	40.0%	8 of 20
Hematologic condition	37.5%	3 of 8
Neurologic condition	37.5%	3 of 8
Obstetric hemorrhage	27.9%	43 of 154
Cardiovascular condition[1]	20.0%	3 of 15

Note: [1] Cardiovascular condition includes cardiomyopathy.

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

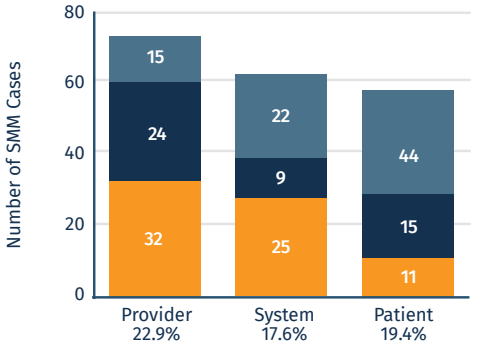
FIGURE 8



Note: Data are shown in absolute numbers; [1]Cardiovascular condition includes cardiomyopathy.

LEVEL, TIMING, AND FACTORS THAT COULD HAVE ALTERED THE SEVERE MATERNAL MORBIDITY OUTCOME

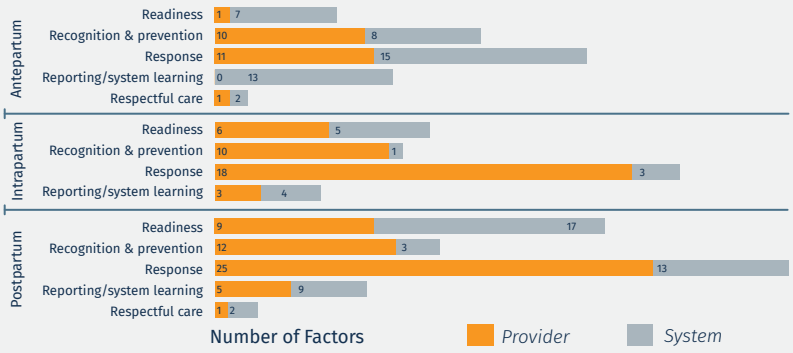
FIGURE 9



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

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

FIGURE 10



Note: Factors could apply to multiple 5Rs domains; Data are shown in 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 64 (22.9%), 49 (17.6%), and 54 (19.4%) SMM events, respectively (Figure 9).

ANTEPARTUM PERIOD

About 19.4% of SMM could have been prevented by addressing factors in the antepartum period. Most of these factors related to the Recognition, Response, and Reporting domains (Figure 10).

- Provider-level factors included enhanced monitoring of high-risk patients and diagnosis of high-risk conditions.
- System-level factors included enhanced guidelines for management of obstetric patients in emergency departments as well as improved coordination of care between emergency departments and obstetrical units.

INTRAPARTUM PERIOD

About 11.5% of SMM could have been prevented by addressing factors in the intrapartum period. Most of these factors related to the Readiness, Recognition, and Response domains (Figure 10).

- Provider-level factors included earlier identification of lacerations and bleeding or need for transfusion.
- System-level factors included availability of platelets and other resources including resources to support monitoring in patients with obesity.

POSTPARTUM PERIOD

About 12.9% of SMM could have been prevented by addressing factors in the postpartum period. Most of these factors related to the Readiness, Recognition, and Response domains (Figure 10).

- Provider-level factors included earlier initiation of appropriate treatment and more timely recognition of patient decompensation.
- System-level factors included higher readiness to address obstetric emergencies through staffing, medication, and device availability.

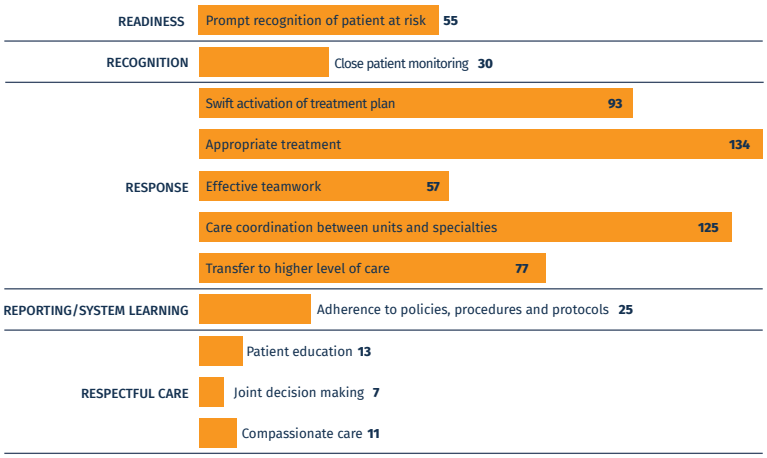
PRACTICES DONE WELL IN RELATION TO SEVERE MATERNAL MORBIDITY EVENTS

For all SMM events, hospital review committees listed up to three practices that were done well and should be reinforced in their hospitals. Eleven themes emerged from the 279 SMM events (Figure 11).

- The most commonly reported practices were appropriate treatment (mentioned in 134 reviews of SMM events, 48.0%) and care coordination between units (mentioned in 125 reviews, 44.8%).

PRACTICES DONE WELL IN RELATION TO SEVERE MORBIDITY EVENTS REVIEWED

FIGURE 11



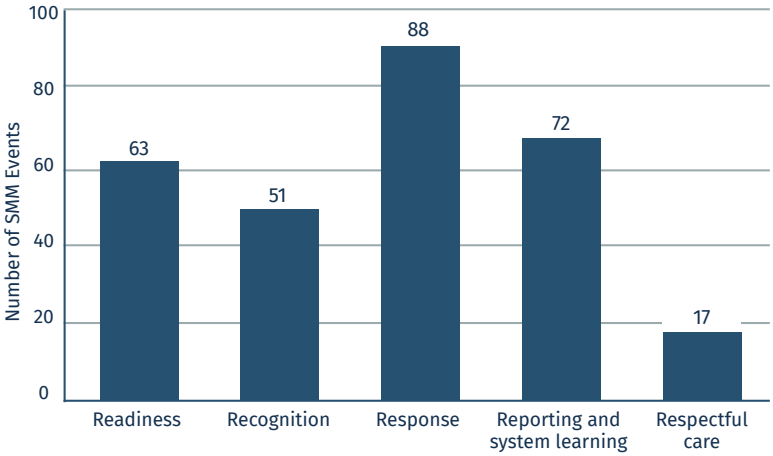
Note: Data are shown in absolute numbers; Fields for capturing this information were open-ended and unprompted; not mentioning these practices for a larger number of events does not mean that it did not occur.

KEY RECOMMENDATIONS FOR SEVERE MATERNAL MORBIDITY PREVENTION IN MARYLAND HOSPITALS

The most frequent recommendations by hospital review committees were within the Response (88), Reporting and system learning (72), and Readiness (63) domains of the "5Rs" framework (Figure 12).

RECOMMENDATIONS FOR CARE IMPROVEMENT BY QUALITY IMPROVEMENT DOMAIN

FIGURE 12



Note: Data are shown in absolute numbers. Recommendations were made in 165 SMM reviews. Hospital committees could make up to three recommendations for each event.

GENERAL RECOMMENDATIONS TO PREVENT SMM

- Establish and maintain 24/7 access to multidisciplinary teams for managing the most prevalent causes of SMM.
- Ensure clear protocols and regular trainings on early warning signs and emergency interventions for the top causes of SMM for all staff treating OB patients.
- Establish clear protocols for timely consultation, escalation of care, and transfer of OB patients based on identified risks.
- Establish linkages and assist patients with entry into outpatient services for seamless post-discharge follow-up.

RECOMMENDATIONS TO PREVENT SMM DUE TO HEMORRHAGE

- Standardize the continuous measurement, documentation, and communication of quantitative blood loss in L&D units.
- Implement regular training on early recognition of hemorrhage, use of massive transfusion protocol, use of uterine tamponade devices and intraoperative compression suturing.
- Implement training to increase the use of bedside ultrasound to identify intraabdominal bleeding and retained products of conception.

RECOMMENDATIONS TO PREVENT SMM DUE TO HYPERTENSIVE DISORDERS OF PREGNANCY

- Remove barriers to communication with patients experiencing hypertension, including ensuring 24/7 language interpretation services.
- Establish follow up procedure and flexible emergency contact systems for patients, including phone, text, and online messaging options.

RECOMMENDATIONS TO PREVENT SMM DUE TO CARDIOVASCULAR CONDITIONS

- Remove barriers to patients accessing cardiovascular medications, including using prescription home delivery services.
- Establish follow-up plan with cardiologist prior to hospital discharge.
- Ensure obstetric cardiac protocols are up to date and that all L&D staff are trained to respond to cardiac conditions.

RECOMMENDATIONS TO PREVENT SMM DUE TO INFECTION

- Review pre-discharge patient education regarding hygiene and signs of infection.

RECOMMENDATIONS TO PREVENT SMM DUE TO METABOLIC AND ENDOCRINE CONDITIONS

- Improve hospital-wide systems for OB-specific management of diabetes, including prenatal targets for glycemic control, appropriate inpatient interventions, and 24/7 access to endocrinology and subspecialists.

Note: OB=obstetric, L&D=labor and delivery, ICU=intensive care unit.

SEVERE MATERNAL MORBIDITY

SURVEILLANCE & REVIEW PROGRAM IN MARYLAND

May 2025

Severe maternal morbidity (SMM) includes potentially life-threatening conditions or complications during pregnancy, labor and delivery, and postpartum. SMM events 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]

Reviewing SMM events at the facility level allows for the:

- Characterization of causes and factors that led to morbidity.
- Determination of whether the event was preventable.

By identifying 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.

In July 2020, the Maryland Maternal Health Innovation Program (MDMOM) initiated facility-based SMM Surveillance and Review supported by Maryland House Bill 837/2020. The program began as a pilot in 6 hospitals in Maryland.[4] Following the passage of the Maternal Health Act of 2024 (HB 1051/2024), birthing hospitals in the state are required to participate in SMM surveillance and review beginning in 2025.

All SMM events in pregnant and up to 42-day postpartum patients admitted at participating hospitals are identified and reviewed using the following case definition (Figure 1):

1. Admission to an intensive/critical care unit (ICU/CCU); and/or
2. Transfusion of 4 or more units of blood products.

Trained clinical abstractors review all available maternal and newborn medical records for each SMM event using a standardized electronic, de-identified review form.

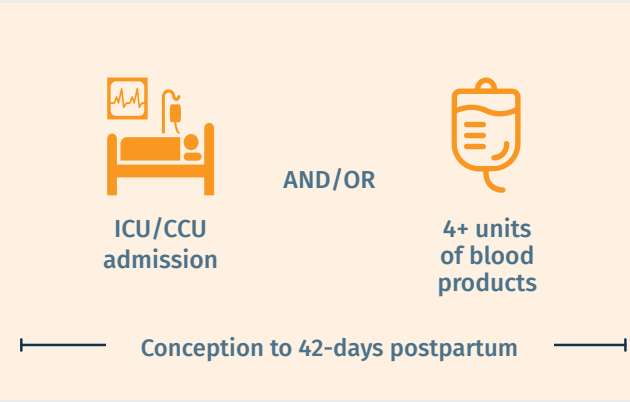
Hospital-based review committees meet regularly to review and discuss SMM events, identify primary causes of each SMM event, determine whether each event was preventable, and make recommendations for preventing similar events from occurring.

This report presents key findings from the SMM Surveillance and Review program in 2024 and includes all SMM events contributed by participating hospitals during the reporting period. 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 the following:

Readiness
Recognition and Prevention
Response
Reporting and System Learning
Respectful Care

SEVERE MATERNAL MORBIDITY SURVEILLANCE CASE DEFINITION

FIGURE 1



Notes: Adapted from ACOG's definition for facility-based SMM surveillance and informed by the Illinois SMM surveillance system and the UK Obstetric Surveillance System (UKOSS).[2,3]

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. Obstet 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.*

4 *Wolfson C, Qian J, Chin P, et al. Findings From Severe Maternal Morbidity Surveillance and Review in Maryland. JAMA Netw Open. 2022;5(11):e2244077. doi:10.1001/jamanetworkopen.2022.44077.*

FIGURE 2

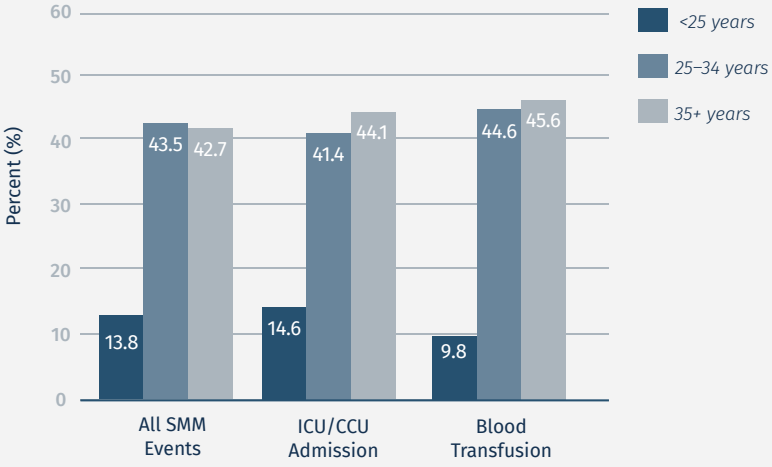
SEVERE MATERNAL MORBIDITY EVENT TYPES

ICU/CCU ADMISSION	BOTH CRITERIA	BLOOD TRANSFUSION ≥ 4 UNITS
40% (136)	24.7% (84)	35.3% (120)

340 SMM Events

FIGURE 3

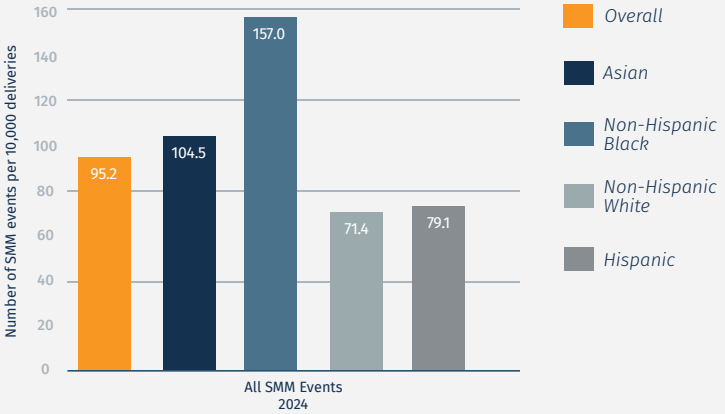
SEVERE MATERNAL MORBIDITY BY MATERNAL AGE



Note: Blood transfusion includes patients with ≥4 units transfused.

Figure 4

SEVERE MATERNAL MORBIDITY RATES BY RACE & ETHNICITY



Note: Denominators are based on 2023 births in participating 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.

SEVERE MATERNAL MORBIDITY EVENTS IDENTIFIED AND REVIEWED

- 340 SMM events were identified and reviewed in 2024.
- 40% of SMM events involved ICU/CCU admission only, 35.3% involved blood transfusion of 4+ units of blood products only, and 24.7% involved both (Figure 2).
- The average number of units of blood products transfused in events requiring transfusion was 7.5, ranging from <1 to 48 units (cases with <4 units transfused qualified as an SMM event due to ICU admission). The massive transfusion protocol was called in relation to 69 SMM events (32.9% of events requiring blood transfusion).

KEY SOCIODEMOGRAPHIC CHARACTERISTICS OF PATIENTS WITH SEVERE MATERNAL MORBIDITY

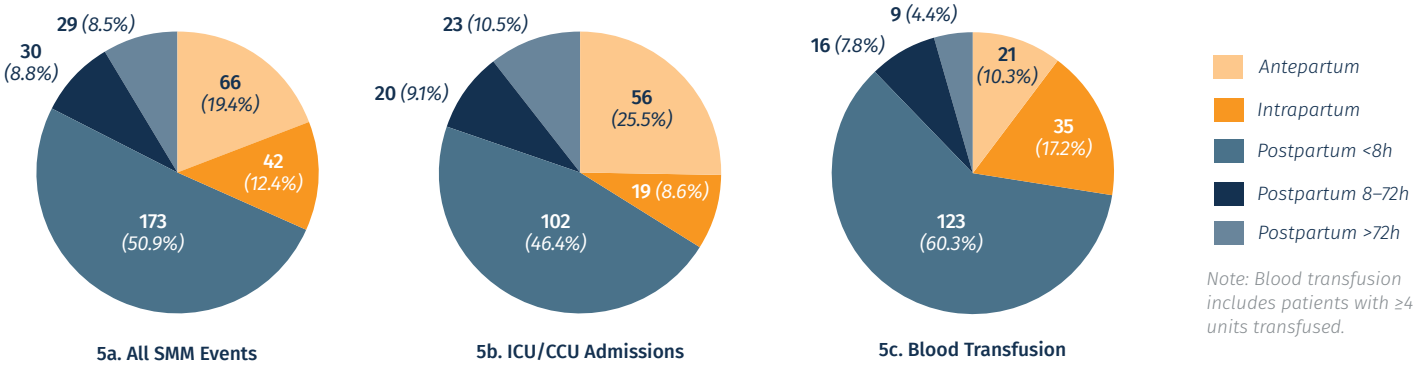
- Patients 25–34 years of age comprised the largest share of patients experiencing SMM (43.5%); 42.7% of all SMM events were in patients ≥35 years (Figure 3).
- 54.4% of patients with SMM were covered by public insurance and 41.2% had private insurance (data not shown).

SEVERE MATERNAL MORBIDITY BY RACE & ETHNICITY

- The SMM rate was highest for non-Hispanic Black patients (157.0 per 10,000 deliveries), which was more than double the rate of non-Hispanic White patients (71.4 per 10,000 deliveries) (Figure 4).
- Though lower than for non-Hispanic Black patients, the SMM rate among Asian patients (104.5 per 10,000 deliveries) was 46% higher than in non-Hispanic White patients.

FIGURE 5

TIMING OF SEVERE MATERNAL MORBIDITY EVENTS



5a. All SMM Events

5b. ICU/CCU Admissions

5c. Blood Transfusion

Note: Blood transfusion includes patients with ≥4 units transfused.

TIMING OF SEVERE MATERNAL MORBIDITY EVENTS

- More than two-thirds of the SMM events occurred during the postpartum period, most within 8 hours of delivery (Figure 5a).
- Most patients with antepartum SMM and postpartum SMM more than 72 hours after delivery involved ICU admission (Figure 5b).

LENGTH OF HOSPITAL STAY

- The average length of hospital stay for patients with an SMM event was 6.8 days, ranging from 0 to 73 days.
- Among patients with SMM and an ICU admission (n=220), the average length of stay in the ICU was 2.2 days, ranging from <1 to 18 days (data not shown).

MEDICAL & OBSTETRIC HISTORY OF PATIENTS WITH SEVERE MATERNAL MORBIDITY

- The most common medical condition prior to the index pregnancy was obesity (35.3%), followed by a mental health disorder (31.2%) and anemia (27.9%) (Table 2).
- Among those who reported substance use (n=58), marijuana (41.4%), opioids (27.5%), and tobacco (24.1%) were most frequently reported (data not shown).
- More than 1 in 3 patients with SMM did not initiate prenatal care during the first trimester, and more than 7% had no prenatal care.
- 32.9% of patients with SMM events had no prior births, 29.1% had one prior birth, 13.5% had two prior births (data not shown).
- One in ten patients (10%) used assisted reproductive technology to conceive the index pregnancy (data not shown).

TABLE 1

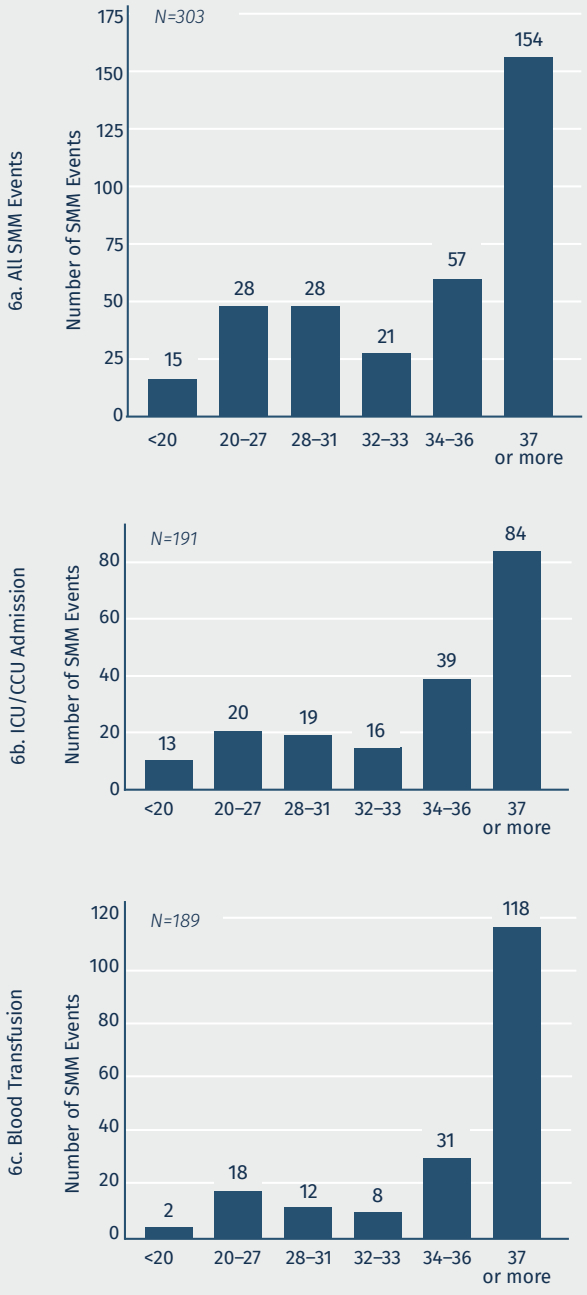
MEDICAL HISTORY AND CARE SEEKING

PATIENT CHARACTERISTICS	%	N
Significant medical history	**72.1%**	**245 of 340**
Obesity	35.3%	120 of 340
Mental health disorder	31.2%	106 of 340
Anemia	27.9%	95 of 340
Substance use	17.1%	58 of 340
Chronic hypertension	16.2%	55 of 340
Asthma	15.6%	53 of 340
Diabetes	9.1%	29 of 340
Cardiovascular condition	3.5%	12 of 340
Complications in prior pregnancy	**77.6%**	**197 of 254**
Pregnancy loss	45.7%	116 of 254
Cesarean delivery	40.9%	104 of 254
Hypertensive disorder of pregnancy	16.9%	43 of 254
Gestational diabetes	6.3%	16 of 254
Complications in current pregnancy	**77.1%**	**262 of 340**
Hypertensive disorder of pregnancy	33.8%	115 of 340
Placental abnormality	17.6%	60 of 340
Gestational diabetes	9.4%	32 of 340
Prenatal care	**91.8%**	**312 of 340**
Prenatal care initiated in first trimester	64.4%	219 of 340
No prenatal care	7.1%	24 of 340

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

FIGURE 6

GESTATIONAL AGE (WEEKS) FOR ANTEPARTUM/INTRAPARTUM SEVERE MATERNAL MORBIDITY EVENTS



Note: Blood transfusion includes patients with ≥4 units of blood products transfused.

GESTATIONAL AGE FOR ANTEPARTUM/INTRAPARTUM SEVERE MATERNAL MORBIDITY EVENTS

- Of the SMM events that occurred antepartum or intrapartum (n=303), 14.2% occurred before 28 weeks, 35% between 28 and 36 weeks, and 50.8% at 37 weeks or more gestational age (Figure 6a).
- Nearly half (44%) of ICU admission events and nearly two-thirds of blood transfusion events (62.4%) occurred at 37 weeks or more gestational age (Figure 6c).

DELIVERY OUTCOMES AMONG PATIENTS WITH SEVERE MATERNAL MORBIDITY

- 273 (80.3%) SMM events occurred during the delivery hospitalization, of which 22.7% were vaginal and 73.6% were cesarean deliveries (Table 2).
- Most deliveries were live births (90.5%), with an average gestational age of 36 weeks and 2 days.
- Nearly half (43.7%) of infants born were admitted to the neonatal intensive care unit (NICU), 40.9% were preterm (<37 weeks gestational age), and 32.4% were low birthweight (<2,500 grams).

DELIVERY OUTCOMES AMONG PATIENTS WITH SEVERE MATERNAL MORBIDITY

TABLE 2

SMM Event Occurred During Delivery Hospitalization	80.3%	273 of 340
Vaginal delivery	22.7%	62 of 273
Spontaneous	87.1%	54 of 62
Assisted	12.9%	8 of 62
Cesarean delivery	73.6%	201 of 273
Dilation & evacuation	3.7%	10 of 273
Live birth	90.5%	247 of 273
Gestational age, mean (range)	36w2d (17w3d–41w6d)	
NICU admission	43.7%	108 of 247
Preterm birth	40.9%	101 of 247
Low birthweight	32.4%	80 of 247
Stillbirth/fetal death	9.5%	26 of 273
Gestational age, mean (range)	25w3d (6w6d–38w1d)	

Note: w=weeks, d=days, NICU=Neonatal intensive care unit; Reported denominators are based on events with available data for the relevant characteristic.

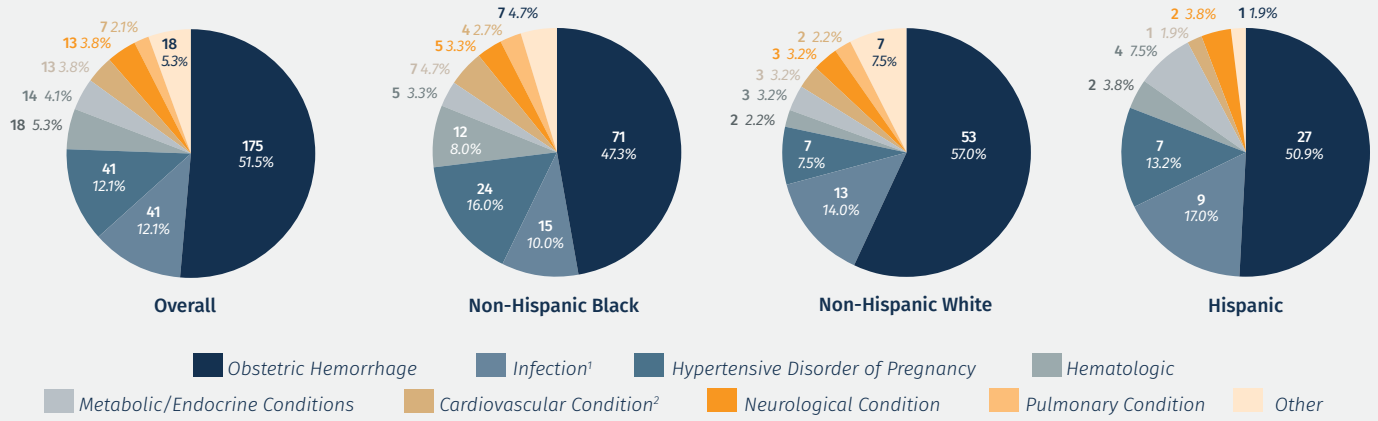
PRIMARY CAUSE OF SEVERE MATERNAL MORBIDITY

- The most common primary causes of SMM were obstetric hemorrhage (51.5%), infection (12.1%), hypertensive disorders of pregnancy (12.1%), hematologic conditions (5.3%) and metabolic/endocrine conditions (4.1%, Figure 7).
- Among the 220 events requiring ICU admission, the top 5 primary causes of SMM were obstetric hemorrhage (35%), infection (18.6%), hypertensive disorders of pregnancy (15.9%), metabolic/endocrine conditions (6.4%), and cardiovascular conditions (5.9%) (data not shown).
- Common contributing morbidities for all types of SMM events were obstetric hemorrhage (12.9%), hypertensive disorders of pregnancy (14.1%), infection (8.2%), and hematologic conditions (6.5%) (data not shown).

32% OF SEVERE MATERNAL MORBIDITY EVENTS WERE **POTENTIALLY PREVENTABLE.**

PRIMARY CAUSE OF SEVERE MATERNAL MORBIDITY

FIGURE 7



Note: [1]Infection includes COVID-19 (n=1); [2]Cardiovascular conditions include cardiomyopathy (n=2)

PREVENTABILITY OF SEVERE MATERNAL MORBIDITY

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

- Preventability was determined by a facility-based multidisciplinary SMM Review Committee.
- Preventability of SMM events varied by the primary cause, ranging from 15.4% for cardiovascular conditions to 46.2% for neurological conditions (Table 3).
- Preventability varied by race and ethnicity with 34% of SMM events among Hispanic patients considered preventable, 33.3% among non-Hispanic White patients, 30.7% among non-Hispanic Black patients and 25.7% among Asian patients (Figure 7).
- Obstetric hemorrhage was the most common primary cause of preventable SMM events for all racial and ethnic groups (Figure 8).

PREVENTABILITY OF SEVERE MATERNAL MORBIDITY

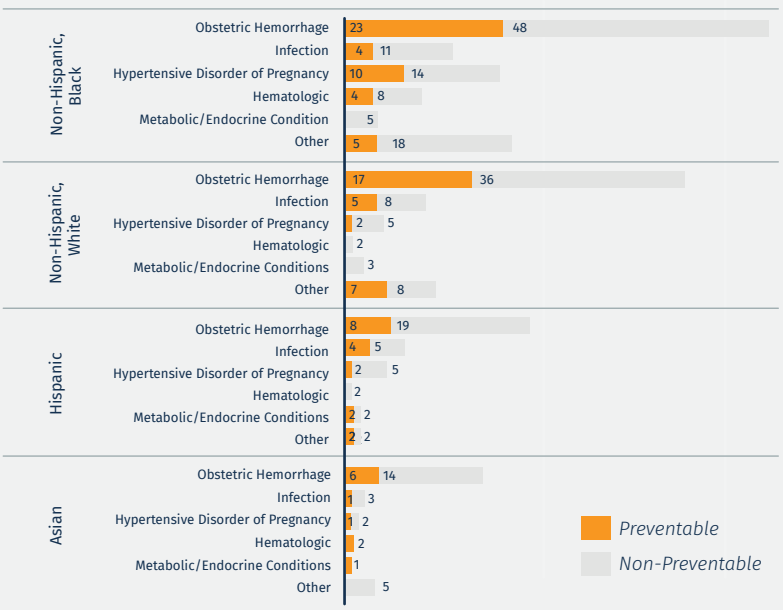
TABLE 3

CAUSE	%	N
Obstetric Hemorrhage	31.4%	55 of 175
Hypertensive Disorder of Pregnancy	36.6%	15 of 41
Infection[1]	34.1%	14 of 41
Hematologic	22.2%	4 of 18
Metabolic/Endocrine Conditions	28.6%	4 of 14
Cardiovascular Condition[2]	15.4%	2 of 13
Neurological Condition	46.2%	6 of 13
Pulmonary Condition	28.6%	2 of 7
Other	33.3%	6 of 18

[1]Infection includes COVID-19 (n=1);
[2]Cardiovascular conditions include cardiomyopathy (n=2)

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

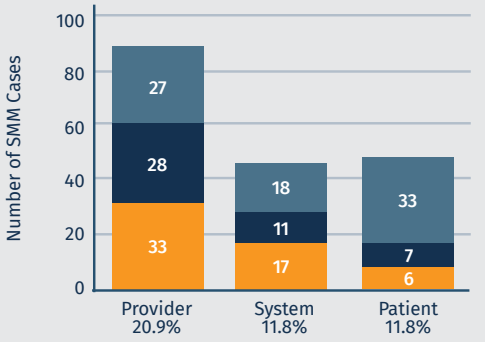
FIGURE 8



Note: Data are shown in absolute numbers; [1]Infection includes COVID-19 (n=1)

LEVEL AND TIMING OF FACTORS THAT COULD HAVE ALTERED THE SEVERE MATERNAL MORBIDITY OUTCOME

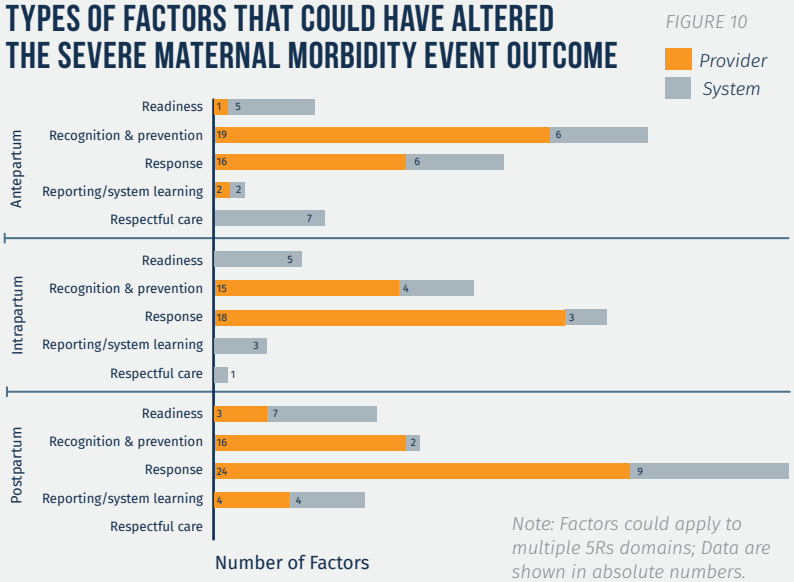
FIGURE 9



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

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

FIGURE 10



Note: Factors could apply to multiple 5Rs domains; Data are shown in 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 71 (20.9%), 40 (11.8%), and 40 (11.8%) SMM events, respectively (Figure 9).

ANTEPARTUM PERIOD

About 17.4% of SMM could have been prevented by addressing factors in the antepartum period. Most of these factors were related to the Recognition and Response domains (Figure 10).

- Provider-level factors included allowing for longer observation and obtaining additional lab work in patients presenting with abnormal symptoms.
- System-level factors included assisting patients with enrolling in health insurance and accessing prenatal care as well as implementing QBL monitoring prior to delivery.

INTRAPARTUM PERIOD

About 11.5% of SMM could have been prevented by addressing factors in the intrapartum period. Most of these factors were related to the Recognition and Response domains (Figure 10).

- Provider-level factors included more rapid activation of MTP when warranted.
- System-level factors included the need for intraoperative QBL documentation and reporting in real time.

POSTPARTUM PERIOD

About 12.7% of SMM could have been prevented by addressing factors in the postpartum period. Most of these factors were related to the Recognition and Response domains (Figure 10).

- Provider-level factors included quicker recognition of patient hemodynamic instability and implementation of uterine tamponade devices.
- System-level factors included greater readiness to address obstetric emergencies through staffing, medication, and device (e.g. JADA) availability.

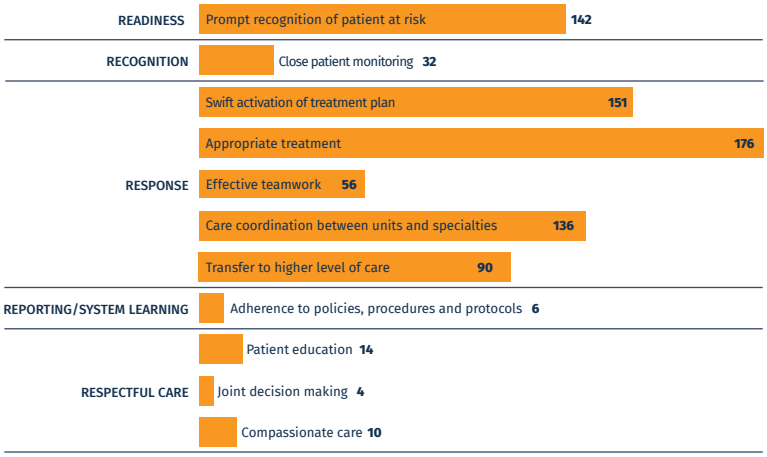
PRACTICES DONE WELL IN RELATION TO SEVERE MATERNAL MORBIDITY EVENTS

For all SMM events, Hospital Review Committees listed up to three practices that were done well and should be reinforced in their hospitals. Eleven themes emerged (Figure 11).

- The most commonly reported practices were appropriate treatment (mentioned in 176 reviews of SMM events, 51.8%) and swift activation of treatment plan (mentioned in 151 reviews, 44.4%).

PRACTICES DONE WELL IN RELATION TO SEVERE MORBIDITY EVENTS REVIEWED

FIGURE 11



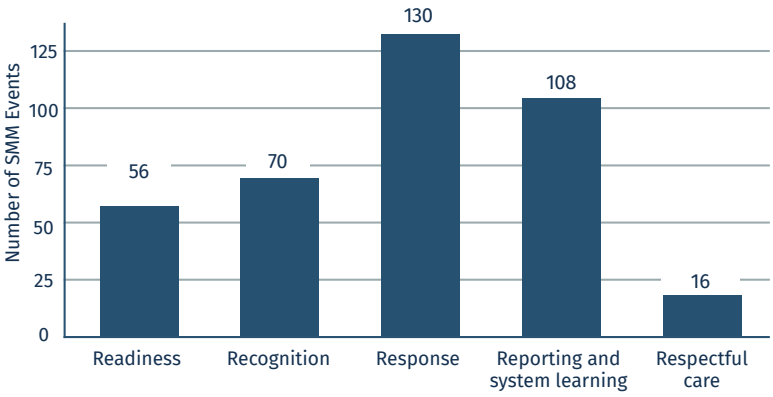
Note: Data are shown in absolute numbers; Fields for capturing this information were open-ended and unprompted; not mentioning these practices for a larger number of events does not mean that it did not occur.

KEY RECOMMENDATIONS FOR SEVERE MATERNAL MORBIDITY PREVENTION IN MARYLAND HOSPITALS

The most frequent recommendations by Hospital Review Committees were within the Response (130), Reporting and system learning (108), and Recognition (70) domains of the "5Rs" framework (Figure 12).

RECOMMENDATIONS FOR CARE IMPROVEMENT BY QUALITY IMPROVEMENT DOMAIN

FIGURE 12



Note: Data are shown in absolute numbers. Recommendations were made in 229 SMM reviews. Hospital committees could make up to three recommendations for each event.

GENERAL RECOMMENDATIONS TO PREVENT SMM

- Provider follow-up with patients to ensure understanding and feasibility/acceptability of medical guidance, including consultations, blood pressure monitoring, and medication adherence.
- Improve communications among OB providers, ORs, emergency departments, and ICUs regarding pregnant and postpartum patients.
- Develop clear policies for care escalation among OB teams, to ICUs, and for transferring patients to higher-level facilities when necessary.
- Improved documentation for obstetric patients including MTP activation, use of uterotonics, blood product administration, and QBL.

RECOMMENDATIONS TO PREVENT SMM DUE TO HEMORRHAGE

- Enhance QBL monitoring: 1) Ensure QBL is initiated upon admission and continues for at least 24 hours after obstetric hemorrhage; 2) Require real-time measurement and documentation of blood loss; 3) Integrate QBL updates into routine team communication during all obstetric procedures.
- Ensure transfusion guidelines for obstetric patients include clear specifications for blood product component ratios.
- Ensure pre-delivery planning occurs for patients who may decline blood products (e.g., for religious or personal reasons).

RECOMMENDATIONS TO PREVENT SMM DUE TO HYPERTENSIVE DISORDERS OF PREGNANCY

- Integrate daily weight and I/O measurement into the standard order set for patients with hypertensive disorders of pregnancy. Use weights to guide weight-based medication dosing effectively.
- Document blood pressure counseling at every outpatient encounter. Include information on recognizing warning signs, home monitoring, and when to seek care.

RECOMMENDATIONS TO PREVENT SMM DUE TO INFECTION

- Consider a broad list of differential diagnoses, including both obstetric and non-obstetric causes.
- Clarify policies and technique for drawing blood cultures.

POLICY RECOMMENDATIONS TO PREVENT SMM IN MARYLAND

- Reinforce documentation of a minimum set of SDoH screening questions during routine office visits for all obstetric patients.
- Support insurance coverage of iron transfusion within clear clinical guidelines and ensure insurance reimbursement for iron transfusion covers the full cost of service provision.
- Promote counseling and warm handoffs to psychological services for patients who experience birth-related trauma.

Note: OB=obstetric, ORs=operating rooms, MTP=massive transfusion protocol, QBL=quantitative blood loss, I/O=intake and output, SDoH=social determinants of health

APPENDIX D

PUBLICATIONS

JAMA Network Open

Original Investigation | Obstetrics and Gynecology

Findings From Severe Maternal Morbidity Surveillance and Review in Maryland

Carrie Wolfson, PhD, MPA; Jiage Qian, MSPH; Pamela Chin, MS, PA-C; Cathy Downey, BSN, RN, c-EFM; Katie Jo Mattingly, MSN, RN, RNC-OB, C-EFM; Kimberly Jones-Beatty, DNP, MSN, CNM; Joanne Olaku, MSN, RNC-MNN, IBCLC, C-ONQS; Sadaf Qureshi, MBBS; Jane Rhule, RN, CPHQ; Danielle Silldorff, MS, BBA, RNC-MNN; Robert Atlas, MD; Anne Banfield, MD; Clark T. Johnson, MD; Donna Neale, MD; Jeanne S. Sheffield, MD; David Silverman, MD; Kacie McLaughlin, MPH; Güneş Koru, PhD; Andreea A. Creanga, MD, PhD

Abstract

IMPORTANCE In the US, more than 50 000 women experience severe maternal morbidity (SMM) each year, and the SMM rate more than doubled during the past 25 years. In response, professional organizations called for birthing facilities to routinely identify and review SMM events and identify prevention opportunities.

OBJECTIVE To examine SMM levels, primary causes, and factors associated with the preventability of SMM using Maryland's SMM surveillance and review program.

DESIGN, SETTING, AND PARTICIPANTS This cross-sectional study included pregnant and postpartum patients at 42 days or less after delivery who were hospitalized at 1 of 6 birthing hospitals in Maryland between August 1, 2020, and November 30, 2021. Hospital-based SMM surveillance was conducted through a detailed review of medical records.

EXPOSURES Hospitalization during pregnancy or within 42 days post partum.

MAIN OUTCOMES AND MEASURES The main outcomes were admission to an intensive care unit, having at least 4 U of red blood cells transfused, and/or having COVID-19 infection requiring inpatient hospital care.

RESULTS A total of 192 SMM events were identified and reviewed. Patients with SMM had a mean [SD] age of 31 [6.49] years; 9 [4.7%] were Asian, 27 [14.1%] were Hispanic, 83 [43.2%] were non-Hispanic Black, and 68 [35.4%] were non-Hispanic White. Obstetric hemorrhage was the leading primary cause of SMM (83 [43.2%]), followed by COVID-19 infection (57 [29.7%]) and hypertensive disorders of pregnancy (17 [8.9%]). The SMM rate was highest among Hispanic patients (154.9 per 10 000 deliveries), primarily driven by COVID-19 infection. The rate of SMM among non-Hispanic Black patients was nearly 50% higher than for non-Hispanic White patients (119.9 vs 65.7 per 10 000 deliveries). The SMM outcome assessed could have been prevented in 61 events (31.8%). Clinician-level factors and interventions in the antepartum period were most frequently cited as potentially altering the SMM outcome. Practices that were performed well most often pertained to hospitals' readiness and adequate response to managing pregnancy complications. Recommendations for care improvement focused mainly on timely recognition and rapid response to such.

CONCLUSIONS AND RELEVANCE The findings of this cross-sectional study, which used hospital-based SMM surveillance and review beyond the mere exploration of administrative data, offers opportunities for identifying valuable quality improvement strategies to reduce SMM. Immediate strategies to reduce SMM in Maryland should target its most common causes and address factors associated with preventability identified at individual hospitals.

Key Points

Question What are the severe maternal morbidity (SMM) levels, primary causes, and factors associated with its preventability in birthing hospitals in Maryland?

Findings This cross-sectional study of hospital-based SMM surveillance in Maryland identified 192 SMM events, with obstetric hemorrhage (43%), followed by severe COVID-19 infection (30%) and hypertensive disorders of pregnancy (9%), being the most common causes. Nearly two-thirds of SMM events reviewed were deemed preventable, with changes in clinician-level factors and interventions in the antepartum period having the largest potential to alter the SMM outcome.

Meaning Immediate strategies to reduce SMM in Maryland should target its most common causes and address factors associated with SMM preventability identified at individual hospitals.

+ Supplemental content

Author affiliations and article information are listed at the end of this article.

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Introduction

More than 50 000 women experience severe maternal morbidity (SMM) annually in the US. Moreover, the SMM rate more than doubled during the past 25 years and is 2 times higher for non-Hispanic Black than non-Hispanic White women.[1] The Centers for Disease Control and Prevention (CDC) defines SMM as potentially life-threatening conditions or complications resulting from labor and delivery that can significantly affect a woman's health.[2] Severe maternal morbidity events, which are 100 times more prevalent than maternal mortality, can be considered near-misses for maternal deaths.[3] Reviews of SMM events can provide more learning opportunities than reviews of maternal deaths alone. The reduction of preventable SMM may also stem increasing maternal mortality rates because they share similar risk factors.[4]

Prior examination of SMM using mainly administrative hospital data[5] demonstrated that approximately half of adverse maternal outcomes in the US are attributable to preventable harm or unintended consequences from clinical practice and system of delivering perinatal care.[6,7] The CDC, American College of Obstetricians and Gynecologists (ACOG), and Society for Maternal-Fetal Medicine (SMFM) recommend that birthing facilities routinely identify and review SMM events.[3,8,9] Reviewing SMM allows for characterization of circumstances leading to SMM and determination of whether SMM was preventable. By identifying potentially preventable SMM and associated factors, facilities can recommend and implement specific practice changes or quality improvement initiatives to prevent future adverse outcomes.

The case definition for hospital-based SMM identification proposed by ACOG/SMFM includes admission to an intensive care unit (ICU) and/or transfusion of 4 U or more of blood.[3] This 2-factor criterion identified a significant number of SMM events and offered critical learning opportunities for clinicians and hospitals in prior studies.[10-12]

Until 2020, the only data on SMM in Maryland were from administrative hospital discharge databases.[7] Such data, primarily collected for billing purposes, are prone to coding errors and lack clinical nuance needed for real-time, in-depth reviews to inform SMM prevention efforts.[5,9,13] In July 2020, the Maryland Maternal Health Innovation Program (MDMOM) piloted an SMM surveillance and review program working with 6 of the 32 birthing hospitals in Maryland, covering approximately one-quarter of the more than 60 000 births in the state annually. This initiative is a component of a series of interventions implemented in 2020 to reduce maternal mortality in Maryland. The surveillance and review program examined factors that contribute to SMM and identified prevention strategies through the systematic and comprehensive review process recommended by ACOG/SMFM. This study examines SMM levels, primary causes, factors associated with its preventability, and recommendations for care improvement.

Methods

The SMM surveillance and review program in Maryland was designed to identify and review life-threatening conditions in pregnant and postpartum patients admitted to participating hospitals. The SMM definition was adapted from ACOG/SMFM's proposal for hospital-based surveillance during pregnancy or within 42 days post partum: patients admitted to an ICU or critical care unit (CCU) and/or with 4 U or more of red blood cells (RBCs) transfused and/or affected by emerging public health threats during the year that required hospital care (eFigure 1 in the Supplement). During the pilot study, a confirmed COVID-19 infection that required inpatient hospital care met the case definition. The institutional review board at the Johns Hopkins Bloomberg School of Public Health deemed the study exempt from review because it does not qualify as human subjects research as defined by the US Department of Health and Human Services; therefore, patient informed consent was not required. This cross-sectional study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Severe maternal morbidity events were identified as close to real time as possible, typically within 1 month, by trained nurse or physician assistant abstractors (P.C., C.D., K.J.M., K.J.-B., J.O., S.Q., J.R., and D.S.). Collected data included structured elements, summary case narratives with a timeline of key events, and unstructured information on preventability and recommendations from each event. Abstractors reviewed the electronic health record and any other maternal and newborn records (eg, birth certificate) to document information about the patient, including race and ethnicity, and SMM event using a standardized electronic form developed for the pilot. Racial and ethnic categories were defined by the hospitals' electronic health software and were specified in the abstraction form as Asian, Black or African American, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, White, other (specify), and unknown. Ethnicity was specified as Hispanic or Latina, not Hispanic or Latina, and unknown. Each event was reviewed by a hospital-based perinatal review committee, typically consisting of a lead obstetrician, quality improvement specialist(s), and data abstractor(s). The committee determined the primary (ie, underlying) cause of morbidity and contributing conditions through review of the abstracted information and case narrative. The abstraction form provided checkboxes for the top morbidity causes and an "other" open-ended field for rare causes. The committee collaboratively used a standardized guide adapted from the model of preventability proposed by Geller et al[14] to assess whether the event was preventable, note factors that influenced the outcome, and identify opportunities for improvement. Events were considered preventable if a change to 1 or more condition(s) or situation(s) related to the clinician, system, or patient during the antepartum, intrapartum, and/or postpartum period could have prevented the SMM event or made the outcome less severe. Review committees also identified practices that were performed well and made recommendations for care improvement.

Data are from the pilot phase of Maryland's SMM surveillance and review program conducted over 16 months (August 1, 2020, to November 30, 2021) in 6 birthing hospitals. Hospitals were selected to represent a range in maternity care levels (ie, 1 level IV, 4 level III, and 1 level I hospital), delivery volume, and geographic spread, including urban and rural locations, and comprised more than 25% of births in the state. All invited hospitals elected to participate, and data on all events within participating hospitals that met the SMM case definition were abstracted and reviewed (N = 192).

Statistical Analysis

The MDMOM program researchers (C.W. and J.Q.) cleaned and analyzed case data using Stata software, version 15 (StataCorp LLC). Rates of SMM were calculated overall and by race and ethnicity per 10 000 deliveries in pilot hospitals in 2019 from the Agency for Health Care and Quality State Inpatient Databases; rates were compared using 2-tailed, unpaired *t* tests.[15,16] When data were available, using χ^2 tests, we compared characteristics of patients with SMM and their delivery to those who had live births in Maryland during 2020; also, fetal deaths in patients with SMM were compared against the corresponding 2019 Maryland rate. A 2-sided $P < .01$ was considered statistically significant. Birth data were obtained from CDC WONDER (Wide-ranging Online Data for Epidemiologic Research).[17] Using univariate analyses, we assessed levels, primary causes, timing, preventability (overall and by race and ethnicity), and patient, clinician, and health system factors associated with SMM. The SMM rates and preventability were stratified by race and ethnicity because of the large racial and ethnic disparities that are well documented in adverse maternal health outcomes. Analyses were conducted for the full sample and excluding COVID-19 infection cases (for comparison with prior SMM research). Excluded cases were those in which COVID-19 infection was the primary cause of morbidity or that met the SMM criteria because of COVID-19 only (n = 58).

Data collected via text fields (eg, preventability factors, recommendations, and practices performed well) were analyzed using content analysis techniques.[18] Recommendations were coded according to the 5Rs framework proposed by ACOG's Alliance for Innovation on Maternal Health for patient safety bundles and commonly used for maternity care quality improvement initiatives: readiness, recognition and prevention, response, reporting/system learning, and respectful,

equitable, and supportive care.[19-21] Two independent researchers (C.W. and J.Q.) analyzed text-field data to reach consensus.

Results

Patient Characteristics

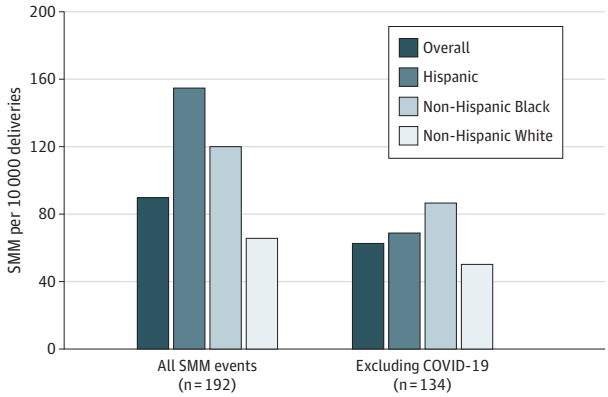
Across the 6 hospitals, 192 SMM events were identified and reviewed. Patients with SMM had a mean (SD) age of 31 (6.49) years; 9 (4.7%) were Asian, 27 (14.1%) were Hispanic, 83 (43.2%) were non-Hispanic Black, and 68 (35.4%) were non-Hispanic White. More than half of the SMM events involved ICU/CCU admission (107 [55.7%]), 92 (47.9%) involved transfusion of 4 U or more of RBCs, and 60 (31.3%) involved severe COVID-19 infections. Some events had overlapping criteria: 39 (20.3%) involved both ICU/CCU admission and blood transfusion, 24 (12.5%) involved ICU/CCU admission and severe COVID-19 infection, and 2 (1.0%) involved all 3 criteria. The most common timing was ante partum (83 [43.2%]), followed by post partum within 8 hours of delivery (54 [28.1%]) (eFigure 2 in the Supplement). Of antepartum or intrapartum SMM (n = 109), approximately one-quarter occurred in patients at 20 to 27 weeks' gestation (n = 26) and one-quarter in patients at 37 weeks' gestation or later (n = 27) (eFigure 3 in the Supplement). When COVID-19 cases were excluded (eFigure 2 in the Supplement), the most common timing of SMM was post partum within 8 hours of delivery (53 [39.6%]). Among this group with antepartum or intrapartum SMM, 35 cases (63.6%) occurred at 34 weeks' gestation or later.

The SMM rate was highest among Hispanic patients (154.9 per 10 000 deliveries), mainly driven by COVID-19 infections (**Figure 1**). The rate for non-Hispanic Black patients was nearly 50% higher than for non-Hispanic White patients (119.9 vs 65.7). Exclusion of COVID-19 events reduced the rate to 62.7 per 10 000 deliveries. Differences between non-Hispanic Black and White patients were significant with and without COVID-19 cases. Compared with the 2020 Maryland live-birth cohort, patients with SMM were more often non-Hispanic Black (43.2% vs 30.5%).

Patients in our series differed significantly from the full 2020 live-birth cohort in Maryland in all measured patient and delivery characteristics (**Table 1**). Notably, patients with SMM were older and more likely to be uninsured. Higher proportions of patients with SMM who experienced a live birth (n = 138) delivered infants who were preterm (58 of 128 [45.3%] vs 6941 of 68 554 [10.1%]), had low birth weight (41 of 127 [32.3%] vs 5792 of 68 554 [8.4%]), and were admitted to the neonatal ICU (54 of 126 [42.9%] vs 5540 of 68 554 [8.1%]). In addition, patients with SMM had pregnancies that resulted in stillbirth more frequently than among all births in Maryland during 2019 (10 of 138 [7.2%] vs 466 of 69 020 [0.7%]).

Among the 192 patients with SMM, more than three-quarters had a significant medical history, including obesity (74 [38.5%]), a mental health disorder (58 [30.2%]), asthma (37 [19.3%]), and

Figure 1. Severe Maternal Morbidity (SMM) Rates by Race and Ethnicity



Data are from the Maryland SMM Surveillance and Review Database; denominators are based on 2019 deliveries in pilot hospitals.

Table 1. Characteristics and Delivery Outcomes Among Patients With SMM Events (August 1, 2020, to November 30, 2021) and Live Births (January 1 to December 31, 2020) in Maryland[a]

Characteristic	All SMM (N = 192)	Excluding COVID-19 (n = 134)	Statewide births (n = 68 554)
Maternal age, y			
<20	5 (2.6)	5 (3.7)	2469 (3.6)
20-24	26 (13.5)	18 (13.4)	9414 (13.7)
25-29	37 (19.3)	24 (17.9)	17 628 (25.7)
30-34	63 (32.8)	43 (32.1)	22 596 (33.0)
35-39	41 (21.4)	29 (21.6)	13 234 (19.3)
≥40	20 (10.4)	15 (11.2)	3213 (4.7)
Maternal race and ethnicity[b]			
Asian	9 (4.7)	6 (4.5)	4603 (6.7)
Hispanic	27 (14.1)	12 (9.0)	13 034 (19.0)
Non-Hispanic			
Black	83 (43.2)	60 (44.8)	20 937 (30.5)
White	68 (35.4)	52 (38.8)	28 120 (41.0)
Other or unknown[c]	5 (2.6)	4 (2.9)	1860 (2.7)
Insurance type			
Private	103 (53.7)	72 (53.7)	38 998 (56.9)
Public	75 (39.1)	54 (13.3)	27 044 (39.4)
Self-pay or no insurance	14 (7.3)	8 (6.0)	2188 (3.2)
Prior births			
0	49 (25.5)	34 (25.4)	26 040 (38.0)
1	50 (26.0)	30 (22.4)	22 897 (33.4)
2	49 (25.5)	34 (25.4)	11 732 (17.1)
3	22 (11.5)	19 (7.0)	4684 (6.8)
≥4	22 (11.5)	17 (12.7)	3201 (4.7)
Timing of prenatal care initiation[d]			
First trimester	128 (66.7)	90 (67.2)	49 581 (72.3)
Second trimester or later	32 (16.7)	26 (19.4)	15 480 (22.6)
No prenatal care	5 (2.6)	4 (3.0)	929 (1.4)
Significant medical history	145 (75.5)	108 (80.6)	NA
Obesity	74 (38.5)	49 (36.6)	19 054 (27.8)
Mental health disorder	58 (30.2)	46 (34.3)	NA
Asthma	37 (19.3)	25 (18.7)	NA
Chronic hypertension	34 (17.7)	23 (17.2)	2557 (3.7)
Substance use	29 (15.1)	25 (18.7)	NA
Anemia	26 (13.5)	21 (15.7)	NA
Sexually transmitted infection	17 (8.9)	13 (9.7)	NA
Diabetes	15 (7.8)	11 (8.2)	750 (1.1)
Cardiovascular conditions	11 (5.7)	8 (6.0)	NA
Complications in current pregnancy	108 (56.3)	83 (61.9)	NA
HDP	20 (10.4)	18 (13.4)	6026 (8.8)
Placental abnormality	19 (9.9)	18 (13.4)	NA
Anemia	13 (6.8)	10 (7.5)	NA
Complications in prior pregnancy[e]	81 (55.1)	59 (58.4)	NA
Fetal death or stillbirth	70 (47.6)	47 (46.5)	NA
HDP	19 (12.9)	14 (13.9)	NA
Delivery during hospitalization with SMM event	138 (71.9)	122 (91.0)	NA
Delivery mode[f]			
Vaginal delivery	40 (29.0)	34 (27.9)	45 427 (66.3)
Spontaneous	36 (90.0)	31 (91.2)	43 615 (96.0)

(continued)

Table 1. Characteristics and Delivery Outcomes Among Patients With SMM Events (August 1, 2020, to November 30, 2021) and Live Births (January 1 to December 31, 2020) in Maryland[a] (continued)

Characteristic	All SMM (N = 192)	Excluding COVID-19 (n = 134)	Statewide births (n = 68 554)
Assisted	4 (10.0)	3 (8.8)	1812 (4.0)
Cesarean delivery[g]	98 (71.0)	88 (72.1)	23 114 (33.7)
Planned	35 (61.2)	32 (36.4)	NA
Emergency	60 (35.7)	53 (43.4)	NA
Live birth[f,h]	128 (92.8)	113 (92.6)	NA
PTB (<37 wk gestation)	58 (45.3)	50 (44.3)	6941 (10.1)
Early (<32 wk)	15 (11.7)	13 (11.5)	1150 (1.7)
Moderate (32-33 wk)	9 (7.0)	6 (5.3)	797 (1.2)
Late (34-36 wk)	34 (26.6)	31 (27.4)	4994 (7.3)
LBW (<2500 g)	41 (32.3)	34 (30.4)	5792 (8.4)
NICU admission	54 (42.9)	47 (41.6)	5540 (8.1)
Fetal death or stillbirth[f,i]	10 (7.3)	9 (7.4)	NA
Gestational age, mean (range)			
Weeks	31 (24-39)	33 (24-39)	NA
Days	2 (2-2)	6 (2-2)	NA

Abbreviations: HDP, hypertensive disorders of pregnancy; LBW, low birth weight; NA, not available; NICU, neonatal intensive care unit; PTB, preterm birth; SMM, severe maternal morbidity.

[a] Data are from the Maryland SMM Surveillance and Review Database and the natality (2016-2020, expanded) and fetal deaths (2014-2019, expanded) records of the Centers for Disease Control and Prevention WONDER (Wide-ranging Online Data for Epidemiologic Research) database. The SMM events include patients during pregnancy or within 42 days post partum who are admitted to an intensive care unit or critical care unit and/or with 4 U or more of red blood cells transfused and/or admitted to a hospital for treatment of COVID-19 infection. All *P* values assessing differences in group distributions of all SMM vs statewide births are statistically significant at a 2-sided $P < .01$, and all characteristics were compared using χ^2 analyses for which there was corresponding statewide data.

[b] Race and ethnicity for statewide deliveries are from the birth certificate, which is self-reported.

[c] Other includes American Indian or Alaska Native and Native Hawaiian or other Pacific Islander.

[d] Timing of prenatal care missing for 27 patients with SMM (14.1%) and 2564 live births (3.7%).

[e] Calculated from SMM events in which patients had a prior pregnancy (n = 147).

[f] Calculated from SMM events that occurred during the delivery hospitalization (n = 138).

[g] Cesarean delivery type missing for 3 cesarean deliveries.

[h] Preterm, low birth weight, and NICU admission for SMM patients calculated out of live-birth deliveries with non-missing values for relevant characteristics (birth weight missing for 1 and NICU status missing for 2 live-birth deliveries).

[i] Stillbirth data for statewide cohort are based on 2019 fetal deaths, and the percentage is the number of stillbirths in 2019 per all 2019 births (live birth and stillbirth combined).

chronic hypertension (34 [17.7%]). More than half had a complication in the current pregnancy, most commonly a hypertensive disorder of pregnancy (HDP) (20 [10.4%]), placental abnormality (19 [9.9%]), or anemia (13 [6.8%]). Nearly half of patients with SMM (70 of 147 [47.6%]) who had been previously pregnant experienced a fetal death or stillbirth in 1 or more previous pregnancies.

Primary Cause of SMM and Blood Loss Detail

Obstetric hemorrhage was the most frequent primary cause of SMM (83 [43.2%]), followed by severe COVID-19 infection (57 [29.7%]), HDP (17 [8.9%]), cardiovascular conditions (11 [5.7%]), and non–COVID-19 infections (10 [5.2%]) (**Table 2**). Obstetric hemorrhage was the most common cause of SMM among non-Hispanic Black (33 [39.8%]) and non-Hispanic White patients (35 [51.5%]), followed by COVID-19 infection (22 [26.5%] for non-Hispanic Black patients and 16 [23.5%] for non-Hispanic White patients) and HDP (10 [12.0%] for non-Hispanic Black patients and 4 [5.9%] for non-Hispanic White patients).

The mean (SD) quantitative blood loss among 101 patients with abnormal blood loss was 3360.1 (2131.9) mL (eTable 1 in the Supplement). These patients received a mean of 9.4 U of blood products

(range, 1-46 units; 6 patients received <4 U of RBCs but met other SMM inclusion criteria). A massive transfusion protocol was initiated for 34 of 101 SMM events with abnormal blood loss (all received ≥4 U of RBCs).

SMM Preventability, Practices Performed Well, and Recommendations

Hospital review committees determined that nearly one-third (61 [31.8%]) of SMM events were preventable with changes to clinician, system, and/or patient factors (without COVID-19 cases, the preventability rate was similar at 32.8%) (**Figure 2**). Clinician-level factors had the potential to alter the outcome in 60 of the 61 SMM events deemed preventable (31.3% of overall events), system-level factors in 19 events (9.9% overall), and patient-level factors in 24 events (12.5% overall). Changes in the antepartum period were identified as having the highest chance to alter the SMM outcome (31 [16.1%] of overall events). By race and ethnicity, 4 events (14.8%) among Hispanic patients were deemed preventable, 26 (31.3%) among non-Hispanic Black, and 27 (39.7%) among non-Hispanic White patients. Without COVID-19 cases, 3 cases (25.0%) were preventable among Hispanic patients, 18 (30.0%) among non-Hispanic Black patients, and 20 (38.5%) among non-Hispanic White patients. Clinician-, system-, and patient-level factors were noted as contributing factors at similar rates among non-Hispanic Black and White patients, but clinician factors were noted at lower rates among Hispanic patients.

Through qualitative analyses, 9 groups of effective practices were identified and grouped by the 5Rs framework domains (**Figure 3**A). Review committees noted the practice of evidence-based care (response domain) in 77 events (40.1%), transfer to a higher level (response domain) in 55 events (28.6%), and early identification of the problem (readiness domain) in 45 events (23.4%). Most recommendations from this SMM series related to recognition and prevention as well as response (Figure 3B). Specific recommendations related to recognition included timely assessment, screening for and diagnosis of pregnancy complications, enhancing vital sign monitoring during hospitalization, and follow-up on abnormal tests (eTable 2 in the Supplement). Response recommendations included timely initiation of treatment for patients with severe range blood pressure values and abnormal bleeding, implementation of surgical care per clinical guidance, strengthening teamwork and communication within labor and delivery units, timely engagement with specialized care, coordination of care within and across hospital systems, and warm handoff of patients.

Discussion

Maryland's SMM surveillance and review program is the first to apply the method proposed by ACOG/SMFM to all SMM events identified in a state-level project. Obstetric hemorrhage was the main cause of SMM, followed by severe COVID-19 infection and HDP. Findings regarding non–COVID-19 primary causes of SMM are like those reported in the few prior studies[22,23] applying

Table 2. Primary Cause of SMM Events and Distribution Overall and Excluding COVID-19 Events[a]

Primary cause of SMM	No. (%) of patients	
	All SMM (N = 192)	Excluding COVID-19 (n = 134)
Obstetric hemorrhage	83 (43.2)	82 (61.2)
COVID-19 infection	57 (29.7)	NA
Hypertensive disorders of pregnancy	17 (8.9)	17 (12.7)
Cardiovascular condition	11 (5.7)	11 (8.2)
Infection (non-COVID-19)	10 (5.2)	10 (7.4)
Hematologic[b]	3 (1.6)	3 (2.2)
Asthma	2 (1.0)	2 (1.5)
Neurologic conditions[c]	2 (1.0)	2 (1.5)
Pulmonary embolism	2 (1.0)	2 (1.5)
Other[d]	5 (2.6)	5 (3.7)

Abbreviations: NA, not applicable; SMM, severe maternal morbidity.

[a] Data are from the Maryland SMM Surveillance and Review Database.

[b] Sickle cell anemia (n = 1), iron deficiency anemia (n = 1), and blood clotting disorder (n = 1).

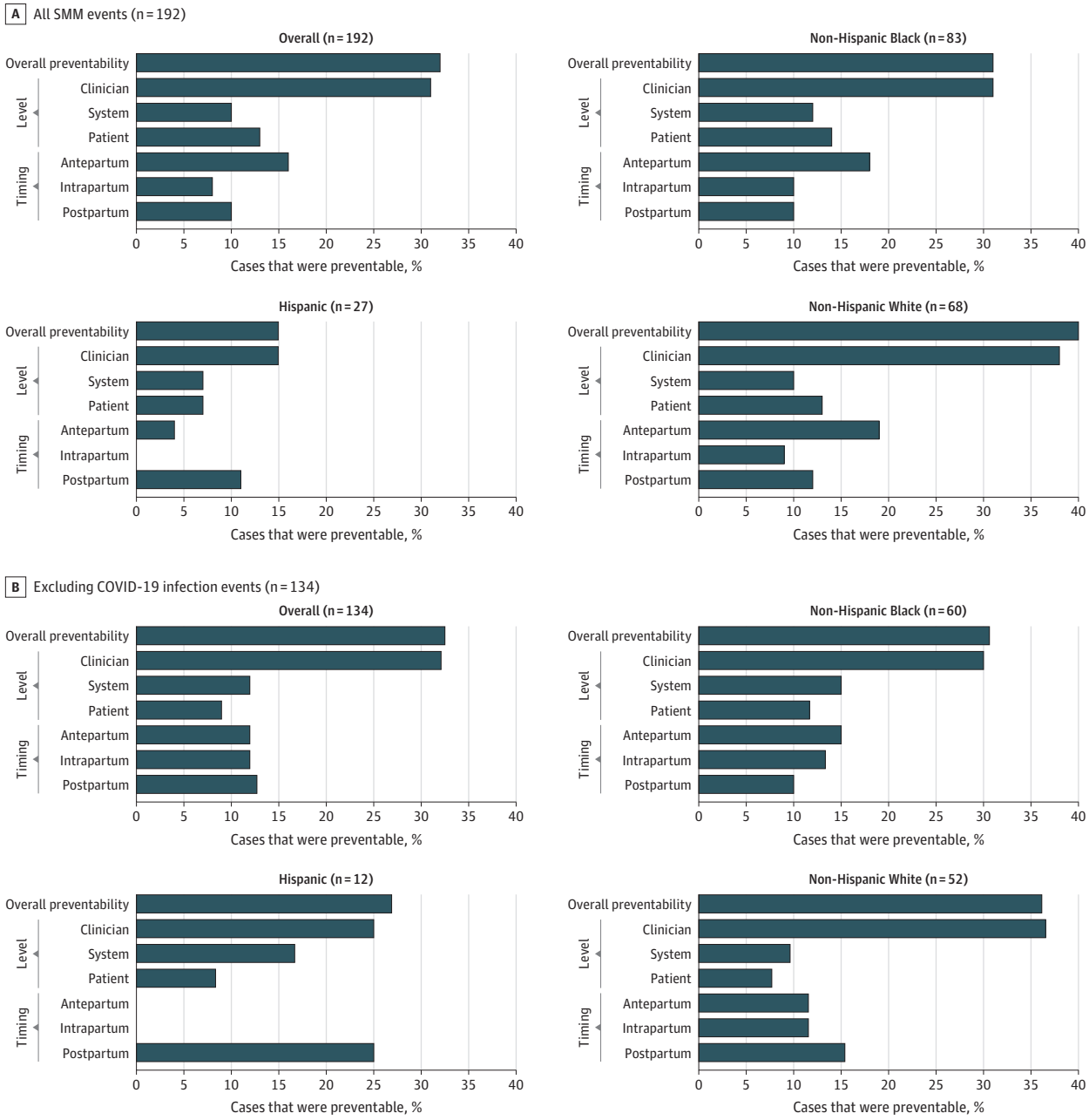
[c] Seizure disorder (n = 1) and stroke (n = 1).

[d] Anaphylaxis (n = 1), brain tumor (n = 1), cervical cancer (n = 1), motor vehicle injury (n = 1), and type 1 diabetes (n = 1).

similar criteria for SMM identification. The high proportion of patients with COVID-19 infection is noteworthy; COVID-19 infection is associated with other pregnancy complications, such as HDP, postpartum hemorrhage, and other infections.[24] In our data, nearly half of patients with severe COVID-19 infection were either admitted to an ICU or received a blood transfusion. Of note, 54 SMM events (28.1%) occurred during nondelivery hospitalizations, a level that is higher than previously reported,[25] and contributed to by COVID-19.

Patients with SMM were more likely to be 35 years or older and non-Hispanic Black, lack insurance coverage, and have obesity compared with the Maryland cohort with live births. These findings are similar to those reported in Illinois's SMM surveillance with similar criteria for event

Figure 2. Preventability and Factors That Could Have Altered the Severe Maternal Morbidity (SMM) Outcome by Race and Ethnicity



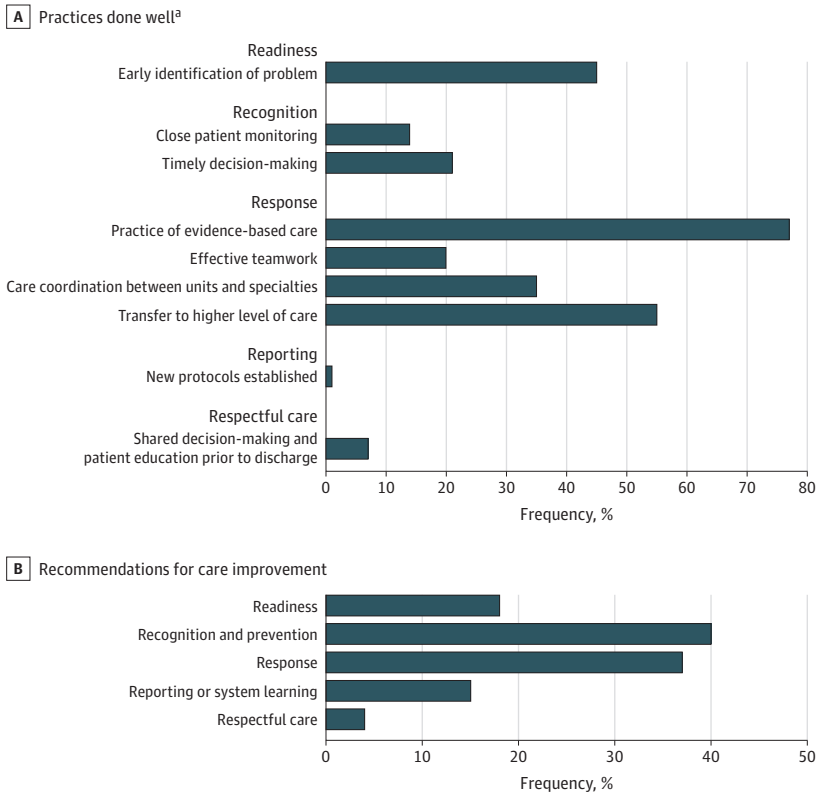
Multiple factors could be provided by data abstractors for each case. The SMM events can have factors that could have altered the outcome at multiple levels and timings. Data are from the Maryland SMM Surveillance and Review Database.

identification[22] and in a sample of patients with SMM across the US identified using hospital discharge data.[1] Our data account for 25.1% of all births and 29.5% of SMM cases in Maryland based on hospital discharge data. These characteristics are also more common among patients with maternal deaths.[26] In addition, more than half of patients with SMM in our series had a complication during the index pregnancy, and more than half with a previous pregnancy experienced pregnancy complications in a previous pregnancy. This finding speaks to the importance of recognizing and closely monitoring high-risk obstetric patients.

As expected, characteristics and delivery outcomes are similar for patients with SMM in our surveillance and those with pregnancy-associated or pregnancy-related deaths in Maryland in recent years (2010-2018).[27] Notably, delayed or no prenatal care accompanied approximately 15.0% to 20.0% of SMM events in the present study and pregnancy-associated deaths according to prior research; a mental health diagnosis was present in 30.2% of patients with SMM and 34.7% among those with pregnancy-associated deaths; rates of fetal death were 7.3% among patients with SMM and 6.7% among pregnancy-related deaths.[20] There were also important differences: hemorrhage was much more common among individuals with SMM (43.2% vs 15.0%). Severe maternal morbidity was observed more frequently during the antepartum period, whereas pregnancy-related deaths were more frequent post partum. These differences stem, in part, from the surveillance definition, identifying SMM within 42 days and mortality up to 1 year after pregnancy, and highlight the merit of surveillance and review of both SMM and maternal deaths—and go beyond the mere identification of adverse maternal events in administrative hospital data.

In our study, nearly two-thirds of SMM events were preventable. Clinician factors contributed to 31.3% of SMM events, system factors to 9.9%, and patient factors to 12.5%. Clinician factors were noted in nearly every event that was deemed preventable. Other facility-based SMM review projects have reported similar rates of preventability and an even higher contribution of clinician

Figure 3. Practices Performed Well and Recommendations for Care Improvement Using the 5Rs Framework Noted Among the 192 Severe Maternal Morbidity (SMM) Events



The 5Rs are readiness, recognition and prevention, response, reporting/system learning, and respectful, equitable, and supportive care. Multiple practices and recommendations were allowed and could be provided by data abstractors for each case. Data shown are absolute numbers of SMM events. Data are from the Maryland SMM Surveillance and Review Database.

[a] 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.

factors.[22,23,28] In tandem with previous studies reporting that clinician-level factors are associated with more severe SMM outcomes,[6] quality improvement initiatives should focus on clinician-level interventions for maximum impact. In addition, in our series, recommendations for care improvement were most often focused on the recognition and prevention and response domains within the 5Rs framework.

Of importance, non-Hispanic Black and Hispanic patients had disproportionately high rates of SMM compared with non-Hispanic White patients, but a higher proportion of SMM events in non-Hispanic White patients were deemed preventable. This finding may be due to differences in the proportion of cause of SMM by race and ethnicity, with non-Hispanic White patients experiencing the highest proportion of obstetric hemorrhage. Quality improvement initiatives that address racial disparities in SMM and focus on interventions that target preventable outcomes can reduce disparities and the incidence of adverse outcomes overall.[29]

The current study demonstrates the value of hospital-based surveillance of SMM and the feasibility of the standardized SMM surveillance method proposed by ACOG/SMFM. Hospital-based surveillance identifies fewer false-positive cases than administrative hospital discharge data and provides more nuanced information to identify strategies for prevention.[10] Data from the 6 hospitals participating in the pilot appear to be representative of the state of Maryland. Through sensitivity analysis using statewide hospital discharge data and *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* codes, we compared the primary cause of morbidity in the pilot hospitals vs the 26 hospitals that did not participate; no significant difference was found in the distribution of primary morbidity causes (eTable 3 in the Supplement). Our data account for 25.1% of all births and 29.5% of SMM cases in Maryland based on hospital discharge data. The higher proportion of SMM events in pilot hospitals was expected because level III and IV hospitals are overrepresented in our program.

Limitations

This study has some limitations. Despite using a standardized surveillance definition and data abstraction form, reports and overall assessment of SMM event preventability are subject to differential misclassification across hospitals because each has its own review committee. Contemporaneous data on patients without SMM were not available for comparison with patients with SMM, and the 2020 live-birth cohort used for comparison excludes non–live-birth pregnancy outcomes. In addition, our findings may not be generalizable to other states.

Conclusions

Hospital-based SMM surveillance and review offered important opportunities for identifying impactful quality improvement strategies to reduce the burden of SMM. Immediate strategies to reduce SMM in Maryland should target its most common causes and address factors associated with SMM preventability identified at individual hospitals. On the basis of findings from the pilot program, the MDMOM program is developing new initiatives to reduce SMM in Maryland and has expanded the SMM surveillance and review in June 2022 to include 20 hospitals, covering nearly three-quarters of births in the state. This program can be used as a model by other states interested in learning how to best prevent SMM.

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Corresponding Author: Andreea A. Creanga, MD, PhD, Department of International Health, Johns Hopkins University Bloomberg School of Public Health, 615 N Wolfe St, Room E8138, Baltimore, MD 21205 (acreanga@jhu.edu).

Author Affiliations: Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland (Wolfson, Creanga); Department of Population, Family and Reproductive Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland (Qian, Creanga); Mercy Medical Center, Baltimore, Maryland (Chin, Atlas); Howard County General Hospital, Columbia, Maryland (Downey, Neale); MedStar St Mary's Hospital, Leonardtown, Maryland (Mattingly, Banfield); Department of Gynecology and Obstetrics, Johns Hopkins School of Medicine, Baltimore, Maryland (Jones-Beatty, Johnson, Sheffield, Creanga); Sinai Hospital of Baltimore, Baltimore, Maryland (Olaku, Silldorff, Johnson, Silverman); Luminis Health Anne Arundel Medical Center, Annapolis, Maryland (Qureshi); Independent researcher (Rhule); Department of Obstetrics and Gynecology, George Washington School of Medicine and Health Sciences, Washington, DC (Johnson); Maternal and Child Health Bureau, Health Resources and Services Administration, Rockville, Maryland (McLaughlin); Department of Health Policy and Management, University of Arkansas for Medical Sciences, Fayetteville (Koru).

Author Contributions: Drs Creanga and Wolfson had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Concept and design: Chin, Johnson, Neale, Sheffield, McLaughlin, Koru, Creanga.

Acquisition, analysis, or interpretation of data: Wolfson, Qian, Chin, Downey, Mattingly, Jones-Beatty, Olaku, Qureshi, Rhule, Silldorff, Atlas, Banfield, Johnson, Neale, Sheffield, Silverman, Koru, Creanga.

Drafting of the manuscript: Wolfson, Jones-Beatty, Rhule, Johnson.

Critical revision of the manuscript for important intellectual content: Qian, Chin, Downey, Mattingly, Olaku, Qureshi, Silldorff, Atlas, Banfield, Johnson, Neale, Sheffield, Silverman, McLaughlin, Koru, Creanga.

Statistical analysis: Wolfson, Qian.

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Administrative, technical, or material support: Wolfson, Chin, Jones-Beatty, Olaku, Rhule, Silldorff, Atlas, Johnson, Sheffield, McLaughlin, Koru, Creanga.

Supervision: Sheffield, Silverman, Creanga.

Development of severe maternal morbidity database: Koru.

Data abstractor: Mattingly.

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SUPPLEMENT.

Evaluating a pilot, facility-based severe maternal morbidity surveillance and review program in Maryland—an American College of Obstetricians and Gynecologists and Society for Maternal-Fetal Medicine Rx at work

OBJECTIVE: Severe maternal morbidity (SMM) includes potentially life-threatening pregnancy complications and can have long-term health consequences for women.[1] In the United States, SMM events are most frequently identified through an algorithm of the International Classification of Diseases, 10th Revision (ICD-10) codes developed by the Centers for Disease Control and Prevention (CDC) using administrative hospital discharge data.[2,3] Although important for deriving population-level SMM trends, these data are primarily collected for billing and are prone to coding errors.[1–3] The American College of Obstetricians and Gynecologists (ACOG) and the Society for Maternal-Fetal Medicine (SMFM) recommend that, in addition to reviewing maternal deaths, birthing facilities should routinely identify and review SMM events to characterize circumstances that led to SMM and to determine if the outcome was preventable.[1] Subsequently, facilities can implement practice changes and quality improvement (QI) initiatives to prevent future adverse outcomes. In July 2020, the Maryland Maternal Health Innovation Program (MDMOM) piloted facility-based SMM surveillance and review in 6 of 32 birthing hospitals in Maryland, representing approximately 25% of births in the state, using specific ACOG/SMFM guidance.[4] We evaluated the key attributes and usefulness of this program to inform its scale-up.

STUDY DESIGN: This facility-based SMM surveillance and review system in Maryland was designed to identify and review life-threatening conditions in pregnant and postpartum patients admitted to the participating hospitals. Hospitalizations during pregnancy or <42 days postpartum that required intensive care unit admission, transfusion of ≥4 units of red blood cells, and/or hospitalization for COVID-19 infection met the SMM surveillance case definition. These events were identified by trained abstractors using the electronic health record (EHR) system, automated reports, and staff alerts, were abstracted into an electronic database, and were reviewed by multidisciplinary, facility-based review committees to assess underlying SMM causes (eg, obstetrical hemorrhage, hypertension), contributors, and preventability and to make recommendations for care improvement. We conducted a mixed-methods evaluation of the pilot program using the CDC's guidelines for evaluating public health surveillance systems.[5] Data were collected through in-depth, semi-structured interviews with 20 program stakeholders, including ≥1 representative from each pilot hospital, through analyses of 192 SMM events that were abstracted during August 1, 2020 to November 30, 2021, and of 2019 data from the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project and the Maryland State Inpatient Database, as well as program implementation data. Interviews and analyses were conducted by the MDMOM program investigators. The institutional review board at the Johns Hopkins Bloomberg School of Public Health deemed the study exempt from review.

RESULTS: SMM event identification and data abstraction were done mainly through the EHR system (Table). With MDMOM training and regular hospital check-in sessions, data abstraction, entry, and review were found to be simple and flexible to changes. The surveillance and review processes were highly accepted by hospital representatives, with strong engagement by clinical leadership and recognized value for identifying QI opportunities. Because there were no outages during the pilot phase, the surveillance system was judged to be stable and timely despite competing priorities for staff during the COVID-19 pandemic. Various verification processes ensured data quality, and data completeness was reported to be high except for data elements not routinely available in the EHR system. All SMM events identified were determined to be true SMM cases during hospital-level reviews. SMM cases may have been missed, and given the lack of gold-standard data, we could not assess the surveillance system's sensitivity and specificity. We found a similar distribution of underlying SMM causes in pilot and nonpilot hospitals for cases identified using the CDC's ICD-10 algorithm and hospital discharge data, suggesting state-representativeness of the pilot hospitals. Overall, our SMM surveillance and review program was found to be useful and allowed participating hospitals to assess SMM causes, contributing factors, and preventability and to generate actionable recommendations that were disseminated statewide to prevent future SMM events.

CONCLUSION: The facility-based SMM surveillance and review program piloted in Maryland met the CDC's criteria

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TABLE 1
Evaluation results for performance attributes of the severe maternal morbidity surveillance and review system in Maryland

Attributes	Evaluation measure	Source[a]	Assessment
Simplicity	Method used to identify SMM cases		• Identified by trained abstractors using multiple data sources (eg, EHR system; automated reports such as maternal complications reports, blood bank reports; staff alerts) • Simpler for hospitals also identifying and reviewing other perinatal adverse events
	Amount and type of data collected		• Detailed information on patient demographics, medical and obstetrical history, SMM events • Not all information of interest was available in the EHR system (eg, maternal marital status, education, and nativity)
	Ease of abstracting and entering data		• Each case took 1–3 h to abstract, less over time with increased data familiarity • Data entry perceived as simple
	Training and learning requirements		• Training (1 h group webinar & 2 h hospital-specific training) and learning (45 min group sessions every 6 wk) offered by MDMOM program deemed effective and sufficient
	Ease of managing, cleaning, and analyzing data		• Real-time tracking of data entry allowed for continuous data checking and cleaning • Data were easy to export and analyze by qualified MDMOM investigators
Flexibility	Adaptability of the data entry system		• Data entry system allowed for changes and updates as needed • Accommodated EHR system changes and modified case definition in lower-level hospital
	Composition of the abstraction team and review committees at hospital level		• Typically included lead obstetrician, quality improvement specialists, and data abstractor(s) • Size and composition tailored to individual hospital needs
	Tracking emerging public health threats		• Tracked hospitalization of COVID-19 infection well despite virus variant characteristics
Acceptability	Hospital engagement		• All pilot hospitals fully participated in case abstraction and regular check-in meetings • Strong physician and nursing leadership engagement and meeting and learning participation
	Perceived value of SMM surveillance and review		• Recognized value of SMM surveillance and review for quality improvement • All pilot hospitals elected to continue surveillance activities beyond the pilot period
Timeliness	Time between SMM event and recording in the data system		• Usually within 1 mo, but some up to 3 mo • Delays owing to untimely event identification reports and limited staff capacity
	Time between SMM event and hospital review meetings		• Monthly to quarterly
	Time between hospital reviews and data entry completion for cases reviewed		• Within a few days following the review meeting
	Time between completion of data entry and data analysis		• Data analyses conducted at the midpoint and at the end of the pilot phase • With more events available for analysis, quarterly analyses are possible and valuable

(continued)

TABLE 1
Evaluation results for performance attributes of the severe maternal morbidity surveillance and review system in Maryland *(continued)*

Attributes	Evaluation measure	Source[a]	Assessment
Stability	Time when system is fully operating		• System experienced no outages and no staff turn-over during pilot period
Data quality	Completeness		• High for structured data elements available in the EHR system • Some missing information related to certain patient demographic (eg, education, nativity), obstetrical history (eg, prenatal care), and COVID-19 history (eg, treatment) • Adequate for unstructured data informing practice change needs and recommendations
	Data validity		• Abstractors verified data in external sources (eg, birth certificates, CRISP, CareEverywhere) • Monitoring and data quality checks incorporated in data entry system and completed by MDMOM investigators
Predictive value positive	Proportion of reported SMM events that are true severe morbidity		• All SMM events identified during the pilot phase were determined to be true SMM cases during hospital reviews
Representativeness	Cause-specific morbidity		• Six pilot hospitals accounted for ~25% of all births and 30% of SMM events identified in the 2019 hospital discharge data from the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project/Maryland State Inpatient database using CDC's ICD-10 code SMM identification algorithm • Included facilities with a range in levels of maternity care (ie, 1 level I; 4 level III; 1 level IV) • SMM causes in hospital discharge data not statistically different in 6 pilot hospitals vs the 26 hospitals not participating in SMM surveillance & review pilot phase based on a chi-square analysis
Usefulness	Actual and perceived usefulness of the SMM surveillance data		• The systematic review of SMM events led to reported actionable recommendations • Findings from 6-hospital pooled analysis were disseminated to stakeholders statewide

CDC, Centers for Disease Control and Preventaion; *CRISP*, Chesapeake Regional Information System for our Patients in Maryland; *EHR*, electronic health records; *ICD*, International Classification of Diseases; *MDMOM*, Maryland Maternal Health Innovation Program; *SMM*, severe maternal morbidity.

[a] Data source legend: Program implementation monitoring; Qualitative interviews; MOMDM investigators; SMM surveillance data.

Qian. Pilot of facility-based severe maternal morbidity surveillance and review. Am J Obstet Gynecol MFM 2023.

for useful and effective public health surveillance programs. The process was simple to follow by participating hospitals, was highly flexible, acceptable, and stable, was of good quality, and was representative of the state with timeliness and usefulness dependent on data and human resource availability for abstraction, review, and analysis. While validating the feasibility of the ACOG/SMFM–proposed approach for SMM surveillance and review, this pilot program informs practices to improve maternal health in Maryland by providing critical data on SMM levels, causes, contributing factors, and ways to prevent similar adverse events from occurring. Our findings support the wider implementation of facility-based SMM surveillance and review in Maryland and beyond with special attention paid to ensure engagement by clinical leadership. Based on findings from the pilot phase, the MDMOM program is developing new initiatives to reduce SMM in Maryland and has expanded SMM surveillance and review to include 20 hospitals, covering nearly 75% of births in the state. ■

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Jiage Qian, MSPH
Department of Population
Family and Reproductive Health
Johns Hopkins Bloomberg School of Public Health
Baltimore MD

Carrie Wolfson, PhD
Department of International Health
Johns Hopkins Bloomberg School of Public Health
Baltimore MD

Donna Neale, MD
Howard County General Hospital
Columbia MD

Clark T. Johnson, MD
Sinai Hospital of Baltimore
Baltimore MD
Department of Gynecology and Obstetrics
Johns Hopkins School of Medicine
Baltimore MD
Department of Obstetrics and Gynecology
George Washington School of Medicine and Health Sciences
Washington DC

Robert Atlas, MD
Mercy Hospital
Baltimore MD

Jeanne S. Sheffield, MD
Department of Gynecology and Obstetrics
Johns Hopkins School of Medicine
Baltimore MD

Elizabeth Zadzielski, MD
Sinai Hospital of Baltimore
Baltimore MD

Monica M. Jones, MD
Luminis Health Anne Arundel Medical Center
Annapolis MD

Andreea A. Creanga, MD*
Department of International Health
Johns Hopkins Bloomberg School of Public Health
Baltimore MD
Department of Gynecology and Obstetrics
Johns Hopkins School of Medicine
Baltimore MD
Department of Population
Family and Reproductive Health, Johns Hopkins Bloomberg School of Public Health
615 N Wolfe St, Room E8138
Baltimore MD 21205
acreanga@jhu.edu

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Severe maternal morbidity contributed by obstetric hemorrhage: Maryland, 2020-2022

Carrie Wolfson, PHD; Jessica Tsipe Angelson, MS, CNM; Robert Atlas, MD; Irina Burd, MD, PHD; Pamela Chin, MS, PA-C; Cathy Downey, BSN, RN; Jenifer Fahey, CNM, PhD; Susan Hoffman, BSN; Clark T. Johnson, MD; Monica B. Jones, MD; Kimberly Jones-Beatty, DNP, MSN, CNM; Jennifer Kasirsky, MD; Daniel Kirsch, MD; Ichchha Madan, MD; Donna Neale, MD; Joanne Olaku, MSN; Michelle Phillips, BSN; Amber Richter, MSN; Jeanne Sheffield, MD; Danielle Silldorff, MS; David Silverman, MD; Hannah Starr, BSN; Rhoda Vandyck, MD; Andreea Creanga, MD, PHD; Maryland SMM Surveillance and Review Group

BACKGROUND: Obstetric hemorrhage is the leading cause of maternal mortality and severe maternal morbidity (SMM) in Maryland and nationally. Currently, through a quality collaborative, the state is implementing the Alliance for Innovation on Maternal Health (AIM) patient safety bundle on obstetric hemorrhage.

OBJECTIVE: To describe SMM events contributed by obstetric hemorrhage and their preventability in Maryland.

STUDY DESIGN: This cross-sectional study used data from hospital-based SMM surveillance and review program in Maryland. Hospital-based SMM criteria include admission to an intensive care unit and/or transfusion of 4 or more units of blood products (of any type) during pregnancy or within 42 days postpartum. A total of 193 obstetric hemorrhage events that met the surveillance definition were identified in hospitals participating in SMM surveillance since inception on August 1, 2020 until December 31, 2022. We compared patient and delivery characteristics, practices done well, and recommendations for care improvement among patients with severe obstetric hemorrhage deemed preventable and non-preventable by hospital-based review committees. For obstetric hemorrhage events deemed preventable, we further identified factors that contributed to the SMM outcome at the provider, system, and patient levels.

RESULTS: Uterine atony was the leading cause of obstetric hemorrhage events (37.8%), followed by uterine rupture, laceration and intra-abdominal bleeding (23.8%). Sixty-six (34.2%) obstetric hemorrhage events were preventable. Patients with preventable obstetric hemorrhage were significantly more likely to have an emergency than planned cesarean delivery and less likely to have a placental complication or >1500 mL blood loss volume. Hospital-based review committees determined that 81.8%, 30.3%, and 22.7% of preventable events could have been prevented or made less severe through changes to provider, system, or patient factors, respectively. Recommendations following event reviews aligned with the Alliance for Innovation on Maternal Health Obstetric Hemorrhage Patient Safety Bundle, particularly regarding elements in the Recognition and Prevention and Response domains.

CONCLUSION: About one-third of SMM events contributed by obstetric hemorrhages were deemed preventable. Of AIM bundle elements, assessing hemorrhage risk on admission to labor and delivery, peripartum, and upon transition to postpartum care together with rapid, unit-standardized management of hemorrhage are likely to benefit more than half of patients with preventable SMM contributed by obstetric hemorrhage.

Key words: severe maternal morbidity, obstetric hemorrhage, quality improvement, surveillance, preventability

Introduction

Obstetric hemorrhage is the leading cause of maternal mortality during delivery and through the first week postpartum and the leading cause of severe maternal morbidity (SMM)[1] in the United States.[2-5] State-level maternal mortality reviews show that more than half of maternal deaths due to obstetric hemorrhage are preventable[6-9] and, similarly, recent SMM reviews in Illinois[10] and Maryland[11] demonstrated that approximately one-third of SMM events contributed by obstetric hemorrhage are preventable.[10,11] Moreover, evaluations of quality improvement initiatives documented reductions in adverse hemorrhage-related outcomes after implementation of the Alliance for Innovation on Maternal Health (AIM) patient safety bundle on obstetric hemorrhage, which was recently updated.[12-14]

In 2020, the Maryland Maternal Health Innovation program (MDMOM) established hospital-based surveillance and review of SMM working with 6 hospitals for the first year and adding 7 additional hospitals by the end of 2023.[11] These data are considered gold-standard for understanding SMM and offer a unique opportunity to review SMM events contributed by obstetric hemorrhage and discern underlying factors that could be addressed to reduce their burden. By comparison, administrative hospital discharge data do not provide sufficient clinical detail to ascertain preventability aspects related to SMM. More specifically, in relation to obstetric hemorrhage, they do not contain specific information about blood transfusions needed to distinguish between sentinel events representing SMM versus less severe outcomes.[15]

Using a statewide quality collaborative model, Maryland is currently implementing AIM's obstetric hemorrhage bundle. The overarching objective

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AJOG MFM at a Glance

Why was this study conducted?

To better understand severe maternal morbidity contributed by obstetric hemorrhage in a way that can inform quality improvement strategies for reduction of preventable obstetric hemorrhage.

Key findings

More than one-third of severe maternal morbidity events contributed by obstetric hemorrhage were preventable.

Uterine atony was the leading cause of obstetric hemorrhage, followed by uterine rupture, laceration and intra-abdominal bleeding.

Assessing hemorrhage risk on admission to labor and delivery, peripartum, and upon transition to postpartum care together with rapid, unit-standardized management of hemorrhage are likely to benefit more than half of patients with preventable SMM contributed by obstetric hemorrhage.

What does this add to what is known?

This study relies on serve maternal morbidity data which is clinically nuanced and considered the gold standard for understanding severe maternal morbidity and contributing factors.

Delayed or absent treatment and delays in diagnosis of high-risk status were the most common factors cited in relation to preventable SMM events contributed by obstetric hemorrhage.

of this study is to inform this process by providing information from SMM surveillance on obstetric hemorrhage events and their preventability in Maryland.

Materials and methods

Data in this analysis are from hospitals voluntarily participating in Maryland's SMM surveillance and review program between August 1, 2020, and December 31, 2022: 6 hospitals contributed data for the entire period; 1 hospital beginning in January 2022; 4 hospitals in April 2022; 1 hospital in June 2022; and 1 in October 2022. Birth volumes in participating hospitals range from approximately 600 to >5500 annual deliveries. The SMM surveillance case definition was adapted from the American College of Obstetricians and Gynecologists (ACOG) and the Society for Maternal and Fetal Medicine's (SMFM) recommendation for hospital-based surveillance during pregnancy or within 42-days postpartum and included patients: (a) admitted to an intensive or critical care unit (ICU/CCU); and/or (b) with ≥4 units of blood products transfused.[16] This definition of SMM has been demonstrated to have higher positive predictive value than measures based on diagnosis codes, being less complicated for facilities to operationalize.[15-17]

Data on all SMM events contributed by obstetric hemorrhage within participating hospitals are included in this study. We searched the database for all obstetric hemorrhage events reported as primary or contributing cause of SMM in structured or unstructured (i.e., narrative) data.

Detailed information about Maryland's hospital-based SMM Surveillance and Review program are available elsewhere.[11,18] Briefly, SMM events are identified as close to real-time as possible, typically within one month, by trained nurse-data abstractors in each hospital using the Electronic Health Record (EHR) and any other available information sources; and reviewed by hospital-based review committees, typically consisting of obstetrician(s), quality improvement specialist(s), nursing staff, and data abstractor(s). Data collected on each event (i.e., structured data elements, summary case narratives, unstructured data from case preventability assessments done by hospital-review committees, practices done well, and recommendations) are entered in a common electronic database. Review committees determine primary and contributing causes of morbidity, and use a standardized guide adapted from the model of preventability proposed by Geller et al[19] to assess whether the event was preventable, note factors that could have altered the outcome, identify practices done well and opportunities for improvement. Events are considered preventable if review committees determine that a change to one or more condition(s) or situation(s) related to providers, the overall health system, or patient during the antepartum, intrapartum, and/or postpartum period could have prevented the SMM event or made the outcome less severe such that it does not meet the SMM case definition.

We first compared patient and delivery characteristics for patients with SMM contributed by obstetric hemorrhage to all those who had live births in Maryland during 2020 to 2022. Stillbirth rates in SMM patients with obstetric hemorrhage and across Maryland were also compared. Live birth and fetal death data for Maryland were obtained from CDC WONDER, an online public access data compiler with information on all births by state.[20]

We used chi-square tests to compare characteristics of patients with SMM contributed by obstetric hemorrhage deemed preventable versus nonpreventable, selecting characteristics that previous literature identified as associated with obstetric hemorrhage. Specifically, we compared maternal age (<25 years, 25−34 years, 35 years or older), race and ethnicity (non-Hispanic Asian, non-Hispanic Black, non-Hispanic White, Hispanic, other/unknown), comorbidities (presence of anemia, prepregnancy obesity, chronic or gestational hypertension, placental complications),[21] parity (0, 1−2, ≥3 prior births), prior cesarean delivery, prior obstetric hemorrhage, and timing of prenatal care initiation (first trimester or later). We further compared delivery and fetal/infant characteristics, including induction of labor, mode of delivery (vaginal, cesarean), planned versus

emergency cesarean delivery, macrosomia (birthweight >4000 grams), and stillbirth; blood loss volume >1,500 mL, initiation of massive transfusion protocol, as well as >4 or >10 units of blood products transfusion as indicators of hemorrhage severity; types of blood products transfused (packed red blood cells, platelets, fresh frozen plasma, cryoprecipitate, whole blood); and ICU/CCU admission. Finally, we compared the underlying cause of hemorrhage and the timing of hemorrhage (antepartum, intrapartum, postpartum within 8 hours, 8−72 hours, or >72 hours of delivery). We also review alignment of policy and practice changes that have been made in response to hospital's review of hemorrhage events with AIM obstetric hemorrhage bundle elements.

Structured data on SMM events were analyzed using Stata version 15. Data collected via text-fields (i.e., preventability factors, recommendations, and practices done well) were analyzed using content analysis techniques and key themes were identified using inductive coding.[22] We quantified the number and percentage of SMM events that matched an identified theme for each field. Recommendations were further compared to elements in the AIM Obstetric Hemorrhage patient safety bundle. Three independent researchers, one of which was an experienced nurse (JR), another of which was an experienced midwife (JA), and the third, a perinatal epidemiologist (CW) analyzed text field data and inductively identified key themes to reach consensus. Given use of deidentified data, our Institutional Review Board deemed the study exempt from review.

Results

Of 374 SMM events identified during the study period, obstetric hemorrhage was the most common primary cause of SMM, reported in 178 patients (47.6% of patients with SMM). An additional 15 patients experienced obstetric hemorrhage as a contributing, but not primary cause of SMM, for a total of 193 patients with SMM contributed by obstetric hemorrhage in this series. The primary cause of morbidity for these 15 patients included hypertensive disorders of pregnancy, infection, hematologic conditions, and cancer. Patients with obstetric hemorrhage had a mean age of 33 years (SD 6.4); 14 (7.3%) were non-Hispanic Asian, 84 (43.5%) non-Hispanic Black, 70 (36.3%) non-Hispanic White, and 18 (9.3%) were Hispanic (Table 1). Compared to those with live births in Maryland during 2020 to 2022, patients with SMM contributed by obstetric hemorrhage were older, in higher percentage non-Hispanic Black (43.5% vs. 30.1%), with a higher rate of prior cesarean delivery (41.4% vs. 23.4%), chronic or gestational hypertension (33.7% vs. 13.4%), and cesarean delivery during the index pregnancy (74.1% vs. 34.1%). While stillbirth accompanied 0.6% of births in Maryland during 2020 to 2022, 8.7% of patients in our series experienced a stillbirth.

Within this series, uterine atony was the leading cause of obstetric hemorrhage (37.8%), followed by uterine rupture/laceration/intra-abdominal bleeding (23.8%), and placenta accreta spectrum disorder (PAS, 15.6%; Figure). Hospital review committees determined that 34.2% SMM events contributed by obstetric hemorrhage were preventable. Ruptured uterus/laceration/intra-abdominal bleeding was the most common cause of preventable hemorrhage (40.9%), while uterine atony was the most common cause of non-preventable hemorrhage (39.4%). Nearly 70% of cases occurred in the postpartum period. Though not significant, a higher proportion of preventable than non-preventable hemorrhage occurred more than 8 hours following delivery, 19.7% vs. 11.8%, respectively.

Nearly 17% of preventable hemorrhage events had a documented placental complication compared to 43.3% of non-preventable events ($p<.001$) (Table 2). Among patients with obstetric hemorrhage delivered by cesarean (n=137), 71.7% of those with preventable SMM had an emergency cesarean compared to 51.7% of those with nonpreventable hemorrhage ($p=.03$). Finally, patients with non-preventable hemorrhage were more likely than those with preventable hemorrhage to have >1500 mL blood loss volume (84.3% vs 71.2%, respectively, $p=.03$) and receive cryoprecipitate (47.2% vs 27.3%, respectively, $p<.01$). Though not statistically significant, patients with nonpreventable obstetric hemorrhage were more likely to have had a prior cesarean delivery, anemia diagnosis in index pregnancy, receive >10 units of blood products, and be admitted to an ICU/CCU.

Among the 66 preventable hemorrhage events, hospital review committees determined that 54 (81.8%) could have been prevented through changes to provider factors, 20 (30.3%) through changes to system factors, and 15 (22.7%) through changes to patient factors (Table 3). The most noted provider-related factors were delayed, inappropriate or absent treatment (n=45, 68.2%), delayed or no diagnosis of high risk (n=21, 31.8%), and delay or denial of assessment or preventive care (n=8, 12.1%). The most noted system-related factor was policies and procedures not in place or not followed (n=10, 15.2%), and the most noted patient-related factor was barriers to seeking, obtaining, maintaining healthcare (n=8, 12.1%).

Across both preventable and non-preventable hemorrhage events in this series, appropriate treatment was the most frequently noted practice done well (69.9%), followed by prompt recognition of patients at risk of hemorrhage (45.1%), and clinical team communication and collaboration (35.8%) (data not shown). Review committees made recommendations for care improvement in response to reviews of 92 SMM events. These recommendations most frequently aligned with AIM obstetric hemorrhage patient safety bundle domains of recognition and prevention (44 specific recommendations) and response (39 specific recommendation) (Table 4). Combined, these two recommendations were made in 40 (60.6%) of preventable SMM events. Based on reviews, 8 participating hospitals have implemented 13 specific policy and/or practice changes to improve response to

TABLE 1
Maternal and delivery characteristics among women with SMM events contributed by obstetric hemorrhage and women with live-births in Maryland

	Obstetric hemorrhage SMM Events (n=193)		Live births (n=205,621)	
	#	%	#	%
Maternal characteristics				
Age (years)				
<25	20	10.4	34,519	16.8
25-34	90	46.6	120,090	58.4
35+	83	43.0	51,012	24.8
Race				
Asian (NH)	14	7.3	13,549	6.6
Black (NH)	84	43.5	61,924	30.1
White (NH)	70	36.3	83,804	40.8
Hispanic	18	9.3	40,596	19.7
Other/unknown	7	3.6	5748	2.8
Obstetric history				
Prior cesarean delivery[a]	60	41.4	34,648	23.4
Parity				
0	47	24.4	57,206	27.8
1-2	91	47.2	96,814	47.1
3+	55	28.5	51,509	25.1
Select comorbidities				
Obesity[b]	70	36.3	58,801	29.2
Hypertension[c]	65	33.7	27,628	13.4
Delivery/fetal characteristics				
Prenatal care initiated in 1st trimester[d]	132	76.7	148,619	75.4
Induction	55	28.5	63,802	31.0
Mode of delivery[e]				
Vaginal	48	26.0	135,421	65.9
Cesarean	137	74.1	70,164	34.1
Birthweight >4,000 grams[f]	9	5.0	16,444	8.0
Stillbirth[g]	16	8.7	1289	0.6

Sources: Maryland hospital-based severe maternal morbidity surveillance and review, August 1, 2021-December 31, 2022; CDC Wonder Natality 2020-2022; CDC Wonder Fetal Deaths, 2020-2022.

NH, non-Hispanic; *ICU*, intensive care unit.

[a] Among those with prior deliveries; [b] Obesity missing for 4,361 livebirths; [c] Includes chronic and pregnancy induced; [d] Timing of prenatal care initiation missing for 13 SMM events and 8399 livebirths; [e] Mode of delivery missing for 36 livebirths; [f] Birthweight missing for 4 deliveries with obstetric hemorrhage and 95 livebirths; [g] Stillbirth rate calculated as the number of stillbirths per 100 livebirths.

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obstetric hemorrhage: 2 changes improve readiness, specifically related to processes for managing patients with hemorrhage; 5 changes are related to recognition and prevention, including improvements related to assessment and communication of hemorrhage risk and measurement of quantitative blood loss (QBL); 2 are related to response and modify the obstetric hemorrhage emergency management plan; and 4 are related to reporting and systems learning, specifically related to improving multidisciplinary planning and debriefing.

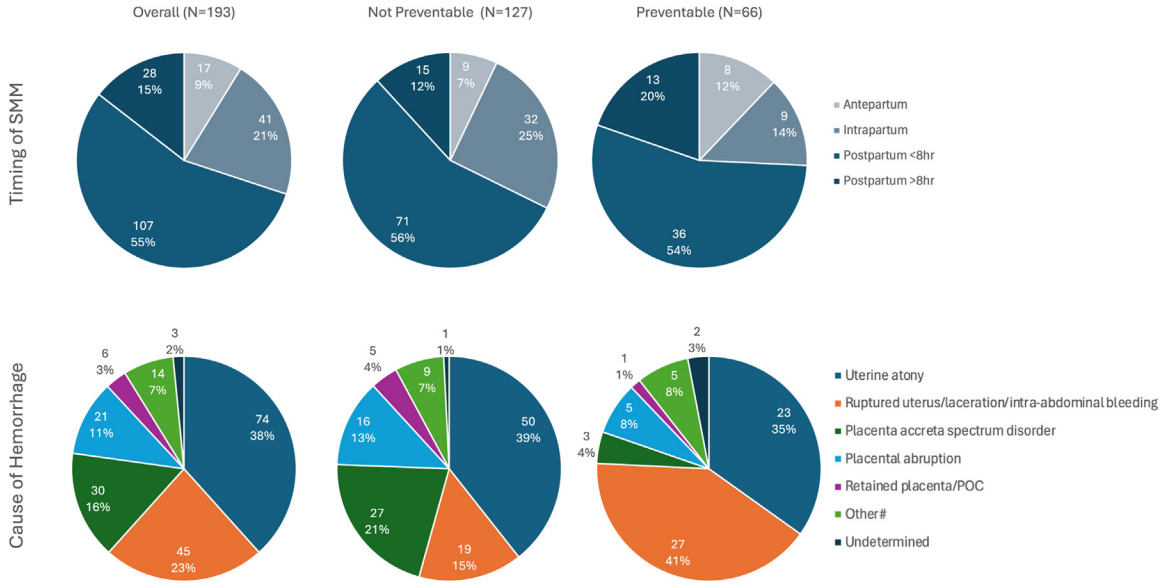
Comment

Principal Findings

Obstetric hemorrhage was the most prevalent cause of SMM among

FIGURE

Timing and cause of obstetric hemorrhage among patients with non-preventable vs. preventable SMM. #Other includes ruptured ectopic pregnancy (N=3), placenta previa (N=3), HELLP/DIC (N=4), uterine inversion (N=3); cervical cancer (N=1). *P*-value for difference in timing of SMM between not preventable and preventable=.119 and for difference in cause of hemorrhage=.002.



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hospitals participating in Maryland's SMM surveillance (47.6%), and more than one-third (34.2%) of these SMM events were deemed preventable. Patients with preventable SMM were more likely to have hemorrhage due to uterine rupture, laceration, or intra-abdominal bleeding, while those with hemorrhage deemed nonpreventable were more likely to have placental complications, such as placenta accreta spectrum (PAS), and greater blood loss.[23,24] As expected, compared to patients with non-preventable SMM contributed by obstetric hemorrhage, patients with preventable events were more often delivered via emergency cesarean and experienced hemorrhage at >8 hours after delivery. Review committees deemed fewer hemorrhages associated with planned than emergency cesareans as preventable likely because planned procedures offer fewer opportunities for unexpected events. Conversely, preventable hemorrhages associated with emergency cesareans generally occur during labor or at times when planned cesareans are not scheduled (i.e., weekends and nighttime) — in such cases, review committees can more easily identify factors affecting the outcome, such as a provider delays in recognizing high-risk patients or insufficient resources available. Hemorrhages >8 hours after delivery may be categorized as preventable because the longer postpartum duration offers more opportunity for recognition of the underlying issue and intervention. Lower volume blood loss (<1500 mL) and infrequent use of cryoprecipitate, which is generally used as part of the massive transfusion protocol and in patients with a massive hemorrhage, suggests preventable SMM contributed by obstetric hemorrhage tended to be less severe than non-preventable SMM.

Results

Patients in this series shared similar risk factors for obstetric hemorrhage identified by prior research. Compared to the general birthing population in Maryland, patients with obstetric hemorrhage were more likely to be 35 years or older, non-Hispanic Black, have a prior cesarean delivery, and deliver via cesarean.[25] Patients with obstetric hemorrhage were also more likely to have a stillbirth compared to the rate of stillbirth among all deliveries in Maryland.[25] These findings are consistent with literature documenting a higher risk of SMM among patients with stillbirth.[26,27] We did not find higher rates of delivery induction or macrosomia among patients with obstetric hemorrhage as has been documented.[25]

Our findings on preventability and associated factors are similar to those reported in Illinois and other high-income countries. For example, a study in New Zealand that used an expert review panel to assess 120 obstetric hemorrhage cases found a similar rate of preventability (36%) with 91% of preventable hemorrhage events, compared to 81.8% in our study, preventable upon addressing provider related factors associated with readiness and response elements in the AIM bundle for obstetric hemorrhage.[12]

TABLE 2
Maternal, delivery, and treatment characteristics of patients with non-preventable vs. preventable SMM events contributed by obstetric hemorrhage

	Overall (n=193)		Not preventable (n=127)		Preventable (n=66)		
	N	%	N	%	N	%	*p*-value[a]
Maternal characteristics							
Age (years)							.860
<25	20	10.4	13	10.2	7	10.6	
25-34	90	46.6	61	48	29	43.9	
35+	83	43.0	53	41.7	30	45.5	
Race							.593
Non-Hispanic Asian	14	7.3	9	7.1	5	7.6	
Non-Hispanic Black	84	43.5	56	44.1	28	42.4	
Non-Hispanic White	70	36.3	42	33.1	28	42.4	
Hispanic	18	9.3	15	11.8	3	4.6	
Other/unknown	7	3.6	5	3.9	2	3.0	
Anemia	40	20.7	28	22.1	12	18.2	.530
Obesity	70	36.3	43	33.9	27	40.9	.334
Hypertension	65	33.7	45	35.4	20	30.3	.474
Placental complication[b]	66	34.2	55	43.3	11	16.7	<.001
Prior cesarean delivery	60	41.4	42	43.3	18	37.5	.505
Prior obstetric hemorrhage	13	6.7	9	7.1	4	6.1	.767
Parity							.751
0	47	24.4	29	22.8	18	27.3	
1-2	91	47.2	62	48.8	29	43.9	
3+	55	28.5	36	28.4	19	28.8	
Prenatal care in 1st trimester[c]	132	76.7	85	75.9	47	78.3	.718
Delivery/fetal characteristics							
Induction	55	28.5	37	29.1	18	27.3	.786
Mode of delivery[d]							.574
Vaginal	48	26.0	34	27.2	14	23.3	
Cesarean	137	74.1	91	72.8	46	76.7	.025
Planned	56	41.5	43	48.3	13	28.3	
Emergency	79	58.5	46	51.7	33	71.7	
Birthweight >4000 grams	9	5.0	6	5.0	3	4.9	.990
Stillbirth[e]	16	8.7	11	8.9	5	8.2	.866
Blood loss and treatment							
>1500 mL blood loss[f]	154	79.8	107	84.3	47	71.2	.032
Blood loss volume, mean (SD)	3310	(2172)	3462	(2113)	3016	(2268)	.176
MTP activated	81	50.3	53	52.5	28	46.7	.476
>4 units of blood products transfused	183	94.8	122	96.1	61	92.4	.279
>10 units of blood products transfused	75	38.9	51	40.2	24	36.4	.608
Type of blood product transfused[g]							
Packed red blood cells	189	97.9	125	98.4	64	97.0	.501
Platelets	84	43.5	58	45.7	26	39.4	.404
Fresh frozen plasma	147	76.2	101	79.5	46	69.7	.128

(continued)

TABLE 2
Maternal, delivery, and treatment characteristics of patients with non-preventable vs. preventable SMM events contributed by obstetric hemorrhage *(continued)*

	Overall (n=193)		Not preventable (n=127)		Preventable (n=66)		
	N	%	N	%	N	%	*p*-value[a]
Cryoprecipitate	78	40.4	60	47.2	18	27.3	.007
Whole blood	1	0.5	1	0.8	0	0	.466
ICU/CCU admission	93	48.2	65	51.2	28	42.4	.213

MTP, massive transfusion protocol; CCU, Critical Care Unit; ICU, intensive care unit.

[a] P-value based on chi-square analysis of difference in distribution between not preventable and preventable OH events for categorical variables and t-tests for means; [b] Placental complications include placenta previa (n=17), placenta accreta spectrum (n=31), and placental abruption (N=23); [c] Timing of prenatal care initiation missing for 13 SMM events; [d] Calculated out of 185 OH events that occurred during the delivery hospitalization, this excludes 3 obstetric hemorrhages that were antepartum, 3 that involved ectopic pregnancies, 1 that involved a ruptured uterus, and 1 that involved a patient transferred to a participating facility following delivery; [e] Fetal status missing for 2 deliveries; [f] Blood loss volume estimated in 32 (26.0%) and 25 (42.4%) non-preventable and preventable OH events, respectively (p=0.026); [g] Type of blood product transfused missing for 2 SMM events.

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TABLE 3
Factors related to SMM events contributed by obstetric hemorrhage and deemed preventable

Factors that, if addressed, could have altered the outcome	N	%
Provider related factors	54	81.8
Delayed, inappropriate, or absent treatment	45	68.2
Delayed or no diagnosis of high risk	21	31.8
Delayed or denial of assessment or preventive care	8	12.1
Need for provider education/training related to surgical technique	5	7.6
Inappropriate discharge, counseling, or follow-up	5	7.6
Inadequate communication between providers	5	7.6
Inadequate documentation of patient risk factors, QBL & laboratory values	3	4.5
Lack of supervision or consultation with supervisor	2	3.0
Delay in or non-referral to specialist	2	3.0
System related factors	20	30.3
Policies and procedures not in place or not followed	10	15.2
Delay in lab work and/or initiating care	7	10.6
Healthcare services unavailable or inaccessible	7	10.6
Communication issue across units	6	9.1
Patient related factors	15	22.7
Barriers to seeking, obtaining, or maintaining healthcare	8	12.1
Patient choice related to treatment	5	7.6
Previous obstetric complications	4	6.1
Pre-pregnancy medical conditions	3	4.5
Index pregnancy obstetric complications	2	3.0
Nonobstetric complications during index pregnancy	1	1.5
Substance use disorder	1	1.5

Each event can have multiple associated factors listed. Percentage is calculated out of all preventable obstetric hemorrhage events identified (n=66).

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Clinical Implications

Implementation of the AIM Obstetric Hemorrhage patient safety bundle was initiated in Maryland in January 2023. The focus of this bundle includes improving readiness for responding to hemorrhage by having immediate and practiced access to hemorrhage carts, first- and second-line hemorrhage medications following team-based drills. The bundle also focuses on recognition and prevention of hemorrhage through standardized, repeated assessment and communication of patient hemorrhage risk. In our study, provider factors were identified in the largest percentage of preventable SMM events contributed by obstetric hemorrhage, by and large related to delayed, inappropriate, or absent treatment as well as delayed or absent high-risk patient designation. Given AIM's focus on readiness and recognition elements in the obstetric hemorrhage bundle and the demonstrated success of its implementation in other localities, we expect to see improvements in preventable hemorrhage among participating hospitals in Maryland.[12-14] Based on their reviews of obstetric hemorrhage cases, hospitals have already implemented specific policy and practice changes that directly relate to elements in the AIM patient safety bundles. These changes include revisions to the stage-based obstetric hemorrhage management plans that enhance observation of patients identified as at higher risk for hemorrhage

TABLE 4
Alignment of recommendation for improvement with AIM obstetric patient safety bundle

Domain	Recommendations related to the following elements
Readiness *17 recommendations*	• Develop processes for the management of patients with obstetric hemorrhage *(10 recommendations)*
	• Maintain a hemorrhage cart or equivalent with supplies, checklists, and instruction cards for devices or procedures where antepartum, laboring, and postpartum patients are located *(2 recommendations)*
	• Ensure immediate access to first- and second-line hemorrhage medications in a kit or equivalent per unit's obstetric hemorrhage emergency management plan *(3 recommendations)*
	• Conduct interprofessional and interdepartmental team-based drills with timely debriefs that include the use of simulated patients *(2 recommendations)*
Recognition & prevention *44 recommendations*	• Assess and communicate hemorrhage risk to all team members as clinical conditions change or high-risk conditions are identified *(36 recommendation)* • Measure and communicate cumulative blood loss to all team members *(1 recommendations)*
	• Actively manage the third stage of labor per department-wide protocols *(1 recommendation)*
	• Provide ongoing education to all patients on obstetric hemorrhage risk and causes, early warning signs, and risk for postpartum complications *(6 recommendations)*
Response *39 recommendations*	• Utilize a standardized, facility-wide, stage-based, obstetric hemorrhage emergency management plan, with checklists and escalation policies for management of patients with obstetric hemorrhage *(39 recommendations)*
Reporting & system learning *7 recommendations*	• Establish a culture of multidisciplinary planning, huddles, and post-event debriefs for every obstetric hemorrhage *(4 recommendations)* • Establish processes for data reporting and the sharing of data with the obstetric rapid response team, care providers, and facility stakeholders to inform care and change care systems *(3 recommendations)*
Respectful, equitable & supportive care *0 recommendations*	• Not applicable (0 *recommendations*)

Note: In relation to each event, hospital-based review committees could identify up to three open ended recommendations for care improvement. Recommendations shown resulted from 92 SMM events contributed by obstetric hemorrhage. Review committees did not identify specific recommendations for improvement from remaining SMM events contributed by hemorrhage.

Domains and elements are from the Alliance for Innovation on Maternal Health Obstetric Hemorrhage Patient Safety Bundle available at: https://saferbirth.org/psbs/obstetric-hemorrhage/.

Wolfson. Severe maternal morbidity contributed by obstetric hemorrhage: Maryland, 2020-2022. Am J Obstet Gynecol MFM 2024.

and expanding multidisciplinary post-event debriefs to include additional representatives such as the blood bank, quality improvement and the Rapid Response committee.

Research Implications

SMM and maternal mortality share similar risk factors.[28] SMM occurs approximately 100 times more frequently than maternal mortality,[16] so identifying factors that lead to preventable morbidity provides more learning opportunities than reviewing maternal deaths alone and can help elucidate strategies for preventing both adverse outcomes. Our study demonstrates the value of SMM surveillance for engaging hospitals in learning from adverse events and identifying opportunities for practice and policy changes to prevent future such events from occurring.

Strengths and Limitations

The primary strength of this study is using gold-standard SMM surveillance data to identify and review obstetric hemorrhage events. All 32 birthing hospitals in the state were invited to participate in the SMM surveillance and review. Hospitals participating during the study period represent a range in levels of maternity care (i.e. two level-IV, six level-III, two level-II, and three level-I hospitals), delivery volume, and geographic spread (i.e. urban and rural locations), comprising about 40% of births in Maryland. While a prior analysis suggest these hospitals are broadly representative of other hospitals in the state,[11] hospitals participating in SMM surveillance may differ from those that do not. Moving forward, in light of Maryland HB-1051 passed in May 2024, all hospitals in the state will be required to participate in this SMM surveillance project.[29]

Hospital review committees determine SMM event preventability within their own institutions. Garland et al. found that external reviewers determined a higher proportion of SMM events in Illinois as preventable compared to internal hospital review groups reviewing the same cases (35.8% vs 22.2%, respectively).[10] Therefore, our assessment of the proportion of preventable obstetric hemorrhage events may be conservative. Additionally, preventability was only assessed in the antepartum, intrapartum, and 42-day postpartum period for the index pregnancy and delivery. One of the most common risk factors for a condition like placenta accreta is history of prior cesarean delivery.[30] The vast majority of SMM events involving PAS were

deemed non-preventable, but this may have changed if the window to assess preventability was increased to include prior pregnancies. Therefore, prevention of a prior cesarean delivery among low-risk women may have been out of scope for consideration of review committees but may be an important strategy in reducing obstetric hemorrhage. Due to sample size limitations, we were not able to separately analyze subgroups of events by underlying cause of hemorrhage and co-occurring conditions such as hypertensive disorders or pregnancy. Future studies should fill this gap in the literature.

Conclusions

This research indicates that more than one-third of obstetric hemorrhages, the leading cause of SMM in Maryland, are preventable. Delayed or absent treatment and delays in diagnosis of high-risk status were the most common factors cited in relation to SMM events contributed by obstetric hemorrhage and deemed preventable. Our findings suggest that Maryland hospitals will greatly benefit from the implementation of AIM's patient safety bundle for obstetric hemorrhage.[13,14,31] Given the legislative mandate for all birthing hospitals in the state to participate in SMM surveillance as of October 2024, we will be able to adequately and timely evaluate the results of this bundle's implementation.

Tweetable Statement

More than 1 in 3 severe maternal morbidity events contributed by obstetric hemorrhages are preventable. ■

CRediT authorship contribution statement

Carrie Wolfson: Writing – review & editing, Writing – original draft, Project administration, Formal analysis, Conceptualization. **Jessica Tsipe Angelson:** Writing – original draft, Formal analysis. **Robert Atlas:** Writing – review & editing, Supervision, Investigation. **Irina Burd:** Writing – review & editing, Supervision, Investigation. **Pamela Chin:** Writing – review & editing, Investigation, Data curation. **Cathy Downey:** Writing – review & editing, Investigation, Data curation. **Jenifer Fahey:** Writing – review & editing, Investigation, Data curation. **Susan Hoffman:** Writing – review & editing, Investigation, Data curation. **Clark T. Johnson:** Writing – review & editing, Supervision, Investigation. **Monica B. Jones:** Writing – review & editing, Supervision, Investigation. **Kimberly Jones-Beatty:** Writing – review & editing, Investigation, Data curation. **Jennifer Kasirsky:** Writing – review & editing, Supervision, Investigation. **Daniel Kirsch:** Writing – review & editing, Supervision, Investigation. **Ichchha Madan:** Writing – review & editing, Supervision, Investigation. **Donna Neale:** Writing – review & editing, Supervision, Investigation. **Joanne Olaku:** Writing – review & editing, Investigation, Data curation. **Michelle Phillips:** Writing – review & editing, Investigation, Data curation. **Amber Richter:** Writing – review & editing, Investigation, Data curation. **Jeanne Sheffield:** Writing – review & editing, Supervision, Investigation. **Danielle Silldorff:** Writing – review & editing, Investigation, Data curation. **David Silverman:** Writing – review & editing, Supervision, Investigation. **Hannah Starr:** Writing – review & editing, Investigation, Data curation. **Rhoda Vandyck:** Writing – review & editing, Supervision, Investigation. **Andreea Creanga:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Conceptualization. ■

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Maryland SMM Surveillance and Review Group: Cynthia Argani, Maryland, Johns Hopkins Bayview Medical Center, Baltimore, Maryland; Anne Banfield, MD, MedStar St Mary's Hospital, Leonardtown, Maryland; Amy Blunt, MD, MedStar Montgomery Medical Center, Olney, MD; Megan Carey, RN, Luminis Health Anne Arundel Medical Center, Annapolis, Maryland; Jan Chiang, BSN, RN, C-EFM, Luminis Health Anne Arundel Medical Center, Annapolis, Maryland; Robyn Duafala, BSN, RN, RNC-OB, Sinai Hospital of Baltimore, Baltimore, Maryland; Barbara Estes, MD, CalvertHealth Medical Center, Prince Frederick, Maryland; Kim Hall, BSN, RNC-OB, C-EFM, MedStar Montgomery Medical Center, Olney, MD; Alyssa Irons, MSN, RN, UPMC Western Maryland, Cumberland, Maryland; Beth Jelinek, MD, UPMC Western Maryland, Cumberland, Maryland; Eva Kelly, BS, Johns Hopkins Bayview Medical Center, Baltimore, Maryland; Kelly Krout, RN, MSN, DNP, Johns Hopkins Bayview Medical Center, Baltimore, Maryland; Carole Louis, MSN, CNS, RN, RNC-OB, C-ONQS, EBP-C, Sinai Hospital of Baltimore, Baltimore, Maryland; Katie Jo Mattingly, MSN, RN, RNC-OB, C-EFM, MedStar St Mary's Hospital, Leonardtown, Maryland; Sarah Meyerholz, Maternal and Child Health Bureau, Health Resources and Services Administration, Rockville, Maryland; Ashley McKinney, RN, CalvertHealth Medical Center, Prince Frederick, Maryland; Cathy Moir, RN, Luminis Health Anne Arundel Medical Center, Annapolis, Maryland; Tina Raab, RN, Luminis Health Anne Arundel Medical Center, Annapolis, Maryland; Elizabeth Zadzielski, Sinai Hospital of Baltimore, Baltimore, Maryland.

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Author and article information

From the Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD (Wolfson and Creanga); Department of Population, Family and Reproductive Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD (Angelson); Mercy Medical Center, Baltimore, MD (Atlas and Chin); University of Maryland Medical Center, Baltimore, MD (Burd, Fahey, and Jones-Beatty); Johns Hopkins Howard County Medical Center, Columbia, MD (Downey, Madan, and Neale); Carroll Hospital, Carroll County, MD (Hoffman and Kirsch); George Washington School of Medicine and Health Sciences, Washington, DC (Johnson and Jones and Vandyck); Sinai Hospital of Baltimore, Baltimore, MD (Johnson, Olaku, Silldorff, and Silverman); Luminis Health Anne Arundel Medical Center, Annapolis, MD (Johnson and Jones and Vandyck); Adventist HealthCare Shady Grove Medical Center, Rockville, MD (Kasirsky, Richter, and Starr); Department of Gynecology and Obstetrics, Johns Hopkins School of Medicine, Baltimore, MD (Creanga, Johnson, Phillips, and Sheffield).

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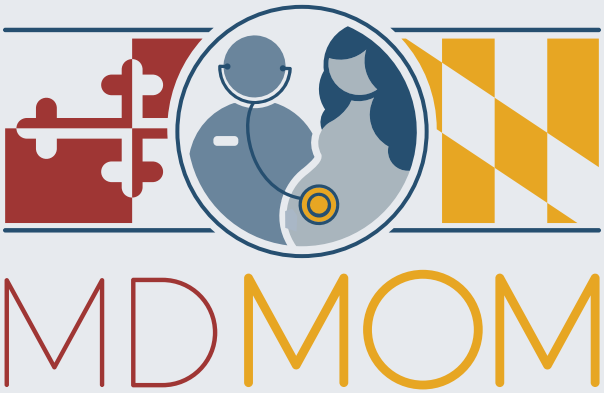
Corresponding author: Carrie Wolfson, PHD Cwolfso2@jhu.edu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