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

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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.

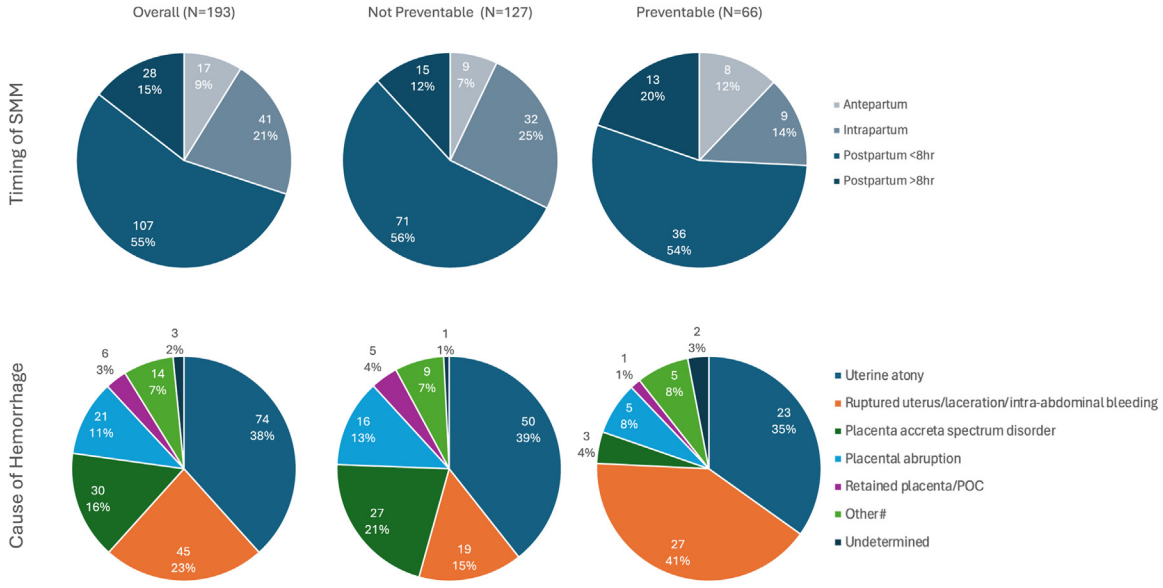
Comment

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).

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

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

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